Effect of Sodium Benzoate and Storage Periods on Nutrient, Phytochemical and Organoleptic Attributes of Mature Unripe Pawpaw (Carica papaya) Fruit Juice

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Abstract: This study determined the effect of preservative and storage periods on the nutrient, phytochemical and organoleptic attributes of mature unripe Carica papaya fruit juice. The juice was prepare and sodium benzoate was added to the juice as a preservative. The juice was pasteurized at 70-80°C for 4 min, filled in sterilized bottles, corked and stored at room temperature (25±2°C). The nutrient, phytochemical and organoleptic attributes of the juice were determined daily for two weeks using standard methods. The data was analyzed using Duncan’s multiple range test to separate and compare the means. The effect of the preservative was less on the macronutrient composition. There was a significant reduction in the minerals and phytochemicals as storage duration increases. The preservative generally reduced the rate of nutrient loss in the juice when compared with other studies without preservatives.

Key words: Nutrient, phytochemical, organoleptic attributes, sodium benzoate, mature unripe pawpaw fruit juice

INTRODUCTION
In the tropics, fruits grow in abundance in home gardens and in the wild. They are rich in micronutrients and phytochemical (Potter and Hotchkiss, 1997; Nakasone and Paul, 1998). Fruits, increase interest for diet consumption as well as variety, colour, taste and aroma (Potter and Hotchkiss, 1997; Nakasone and Paul, 1998). Food products undergo spoilage and deterioration during storage due to growth and activities of microorganisms, food enzymes and other chemical reactions within the food itself. The effect of infestation by pests, storage temperature, moisture, oxygen, light and physical stress or abuse (Potter and Hotchkiss, 1997) on seasonal and perishable agricultural products varies. When fruits are in season, they are in abundance and many are wasted due to poor storage. This poses a challenge to fruit producers. There is a growing trend towards adding values and varieties to raw agricultural products such as fruits (Nakasone and Paul, 1998). Preservatives are substances added to foods to extend their keeping quality and increase nutritive value (Marrian, 1999). Shelf life is a time food products remain safe, to retain desirable sensory, chemical, physical and microbiological characteristics. These foods must comply with any label declaration for nutritional potentials and storage under recommended conditions (IFST, 2000).

Many extrinsic and intrinsic factors operate and interact to inhibit or stimulate a number of processes to limit shelf life (IFST, 2000). This interaction inhibits or stimulates a number of processes to adversely affect shelf life. The shelf life of a food product depends on a number of factors such as processing method, preservative, packaging and storage condition. Shelf life is time within which a product remains stable (Potter and Hotchkiss, 1997). The chemical composition of commercial juice is dependent on the processing and storage conditions (Mears and Shenton, 1998). Consumers are increasingly interested in both nutrition and health benefit of foods. Consumers growing concerns are on basic nutritional benefits of food associated with disease prevention and health enhancing compounds contained in many foods (Hasler, 1998).

The objective of the study is to assess the effects of preservatives on nutrient, phytochemical and organoleptic attributes of mature unripe Carica papaya juice stored at various periods.

MATERIALS AND METHODS
Preparation and production of sample: The mature unripe pawpaw fruits (4.5 kg) were harvested from a specific pawpaw tree in a farmland to ensure homogeneity of the sample (fruits). The sample were sorted for wholesomeness, washed with clean water and salt to remove contaminants from the surface of the fruit. The washed pawpaw fruit (sample) were peeled and cut using sterile stainless knife. The fruits were grated to tiny particles using local grater. The juice was squeezed out with muslin cloth. Preservative (sodium benzoate 500 mg/L) was added to the juice, pasteurized at 70-80°C for 4 min, filled into sterile bottles, corked, stored at room temperature 25±2°C and was analyzed weekly for two weeks.

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Chemical analysis: The sample was subjected to chemical analysis to determine the macro and micro nutrients composition as well as the phytochemicals. The proximate content of the juice at various storage periods were analyzed in triplicates. Fat composition was determined by solvent extraction; Protein was determined using micro Kjedahl method; moisture, ash and crude fibre were determined according to AOAC (2005) procedures and total carbohydrate was determined by difference (Pearson Chemical Analysis of Food, 1976).

Vitamin B₁ and ascorbic acid were determined as described by AOAC (2005). About 5 g sample was dissolved in distilled water, 2 ml of trichloro-acetate was added, colour was developed with 2, 6-dichloroindophenol. The colour was read with spectrophotometer (Model 3030 Perkin Elmer, Nortwalk, USA).

The samples were wet-digested with concentrated nitrate and perchlorate for mineral determination. Sodium (Na) and potassium (K) were determined by flame photometer AOAC (2005). Iron (Fe) and zinc (Zn) were determined by atomic absorption spectrophotometer (Model 3030 Perkin Elmer, Nortwalk, USA) (AOAC, 2005). Iodine (I) was determined as described by AOAC (2000) method. Flavonoids, tannins, saponins and terpenoids were determined using standard methods (Boham and Kocipai, 1974; Van-Burden and Robison, 1981; Obadin and Ochuko, 2001; Subhadhirakul and Pechpongs, 2005).

Sensory evaluation: The organoleptic characteristics were determined by a panel of 30 judges comprising of staff members and students of Home Science, Nutrition and Dietetics Department, University of Nigeria Nsukka, Enugu State, Nigeria. A 9 point hedonic scale were 9 represented the highest score and 1 the lowest was developed as an instrument for the sensory evaluation as described by Derek and Richard (Derek and Richard, 1982). The organoleptic attributes evaluated were colour, flavour, taste, mouth feel and general acceptability of the juice. The products were appropriately coded before presentation.

Statistical analysis: Data from the study were analyzed using Analysis of Variance (Steel and Torrie, 1960) and T-test. Means were separated using Least of significant difference and Duncan Multiple range test. Significance was accepted at 5% probability.

RESULTS AND DISCUSSION
Table 1 presents the effect of sodium benzoate and storage periods on proximate composition of mature unripe pawpaw fruit juice. The moisture value varied. The variation was from 90.64 to 93.01%. The W₁ sample had the least (90.84%) and W₈ sample had the highest value (93.01%). The W₁ and W₈ sample had 90.64 and 90.85%, each. The preservative and pasteurization reduced microflora degradation. Fruit juice had high moisture (Enwere, 1998). The high moisture value for the juice did not ensure storage stability regardless of low pH (4.75 to 5.10). The low pH did not support proliferation of pathogenic and spoilage microorganism in the juice. The moisture levels for the juice increased as the storage periods increased. This was due to degradation of carbohydrate to produce mild acidic condition due to microbial enzymes. The high moisture value for the unripe pawpaw fruit juice was attributed to low total soluble solids (Adepoju et al., 2006). The protein values ranged from 3.72 to 4.07%. The W₁ sample had the least value (3.72%) and W₈ sample had the highest value (4.07%) and W₈ sample had 4.02%. The protein value for the pasteurized juice at 70°C for 4 min and addition of sodium benzoate at varying storage periods were slightly higher relative to the fresh juice. The fat values ranged from 1.01 to 1.64%. The W₁ and W₈ had high and comparable values (1.67 and 1.54%). The W₈ had the least fat (1.01%). The ash values for the three samples (W₁, W₈ and W₈) were 0.40, 0.72 and 0.97%, respectively. The W₈ had the highest value (0.97%) the W₁ had (0.72%). The W₈ had the least ash (0.40%). The three samples had no fibre. The protein, fat and ash values for juice were higher relative to some of the lesser-known tropical fruits such as black plum (Egbekun et al., 1998; Abo, 2000), dillium guineense (Okegbile and Taiwo, 1990) and sour sop (Onimawo, 2002; Obizoba et al., 2004). The total carbohydrate value varied. It ranged from 1.29 to 3.22%. The W₁ had the least value (1.29%) and W₈ had the highest value (3.22%) W₈ had 2.87%. The carbohydrate value for the juice was lower relative to other fruit juice. Pineapple juice had 14% and sour sop had 15%. The absence of fibre in the juice is not a surprise. This is because it was removed during processing. The values for protein, fat and ash were higher relative to some fruit juices. It is also known that fruits are generally poor sources of these nutrients (Obizoba et al., 2004; Akabor, 1996; Okaka, 1997; Ihekonye and Ngoddy, 1985).

Table 2 presents the effect of sodium benzoate and storage times on micronutrients composition of mature unripe pawpaw fruit juice. The vitamin C increased. The variation ranged from 36.66 to 38.59 mg. The W₁ sample had the least value (36.66 mg) and the W₈ sample had the highest value (38.59 mg) followed by W₈ sample which had 38.05 mg. The decrease in vitamin C was from 0.54 and 1.93 mg for W₁-W₈. The vitamin C content of the W₁-W₈:juices did not vary significantly (p>0.05; 38.59 and 38.05 mg). The values were higher (36.66-38.59 mg/100 ml) relative to 18, 24, 25 and 26 mg/100 ml each recorded for banana (Mephia and Akpanunam, 1990), pineapple (Onimawo, 2002; Obizoba et al., 2004) mango (Badifu, 2000; Badifu et al., 2000) and sour sop (Onimawo, 2002).
Table 1: Effect of preservative and storage on proximate composition of mature unripe pawpaw (Carica papaya) fruit juice (wt %)

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>W₀</th>
<th>W₁</th>
<th>W₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>99.6±0.01</td>
<td>99.8±0.00</td>
<td>99.1±0.02</td>
</tr>
<tr>
<td>Protein</td>
<td>4.07±0.01</td>
<td>4.02±0.01</td>
<td>3.72±0.01</td>
</tr>
<tr>
<td>Fat</td>
<td>1.67±0.01</td>
<td>1.54±0.01</td>
<td>1.01±0.00</td>
</tr>
<tr>
<td>Ash</td>
<td>0.40±0.01</td>
<td>0.72±0.01</td>
<td>0.97±0.01</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
<td>0.05±0.00</td>
</tr>
<tr>
<td>Total carbohydrate</td>
<td>3.22±0.01</td>
<td>2.87±0.01</td>
<td>1.26±0.01</td>
</tr>
</tbody>
</table>

Means ± SD of 3 determinations.
W₀: Day 1, W₁: Week 1, W₂: Week 2

Table 2: Effect of preservative and storage periods on the micronutrient composition of mature unripe pawpaw (Carica papaya) fruit juice

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>W₀</th>
<th>W₁</th>
<th>W₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin C</td>
<td>38.5±0.70</td>
<td>38.0±0.00</td>
<td>30.6±0.07</td>
</tr>
<tr>
<td>Thiamin</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>Iron</td>
<td>4.86±0.00</td>
<td>3.57±0.01</td>
<td>2.03±0.02</td>
</tr>
<tr>
<td>Iodine</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>Zinc</td>
<td>9.30±0.11</td>
<td>6.10±0.11</td>
<td>1.95±0.01</td>
</tr>
<tr>
<td>Sodium</td>
<td>38.57±0.52</td>
<td>30.46±0.01</td>
<td>22.13±0.02</td>
</tr>
<tr>
<td>Potassium</td>
<td>42.0±0.00</td>
<td>28.0±0.02</td>
<td>18.15±0.01</td>
</tr>
</tbody>
</table>

Means ± SD of 3 determinations.
Mean values with * in the same row are different (p<0.05) from W₀, W₁: Day 1, W₂: Week 1, W₂: Week 2

Table 3: Effect of preservative and storage time on the phytochemical composition (%) of mature unripe pawpaw (Carica papaya) treated fruit juice

<table>
<thead>
<tr>
<th>Phytochemicals</th>
<th>W₀</th>
<th>W₁</th>
<th>W₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terpenoids</td>
<td>4.22±0.03</td>
<td>4.16±0.01</td>
<td>4.35±0.01</td>
</tr>
<tr>
<td>Sapopidals</td>
<td>3.13±0.02</td>
<td>2.44±0.04</td>
<td>0.88±0.04</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>5.07±0.02</td>
<td>4.98±0.04</td>
<td>3.37±0.01</td>
</tr>
<tr>
<td>Tannins</td>
<td>1.47±0.02</td>
<td>0.32±0.01</td>
<td>3.55±0.02</td>
</tr>
</tbody>
</table>

Means ± SD of 3 determinations.
Mean values with * in the same row are different (p<0.05) from W₀, W₁: Day 1, W₂: Week 1, W₂: Week 2

Table 4: Organoleptic attributes of mature unripe pawpaw (Carica papaya) treated fruit juice

<table>
<thead>
<tr>
<th>Parameter</th>
<th>W₀</th>
<th>W₁</th>
<th>W₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>7.37±0.23</td>
<td>7.20±0.21</td>
<td>7.18±0.13</td>
</tr>
<tr>
<td>Flavour</td>
<td>6.70±0.20</td>
<td>5.03±0.19</td>
<td>4.03±0.22</td>
</tr>
<tr>
<td>Taste</td>
<td>6.23±0.26</td>
<td>4.53±0.23</td>
<td>2.47±0.18</td>
</tr>
<tr>
<td>Mouthfeel</td>
<td>6.23±0.27</td>
<td>5.81±0.24</td>
<td>3.46±0.21</td>
</tr>
<tr>
<td>General acceptance</td>
<td>7.10±0.18</td>
<td>5.10±0.15</td>
<td>2.87±0.21</td>
</tr>
</tbody>
</table>

Means ± SD of 3 determinations.

The decreases in vitamin C were not a surprise. It is known that oxidation occurs in foods containing ascorbate. Increase in storage periods decreased the vitamin C in the juice. Vitamin C retention is often used as an estimate for the overall nutrient retention in a food product. This is because it is by far the least stable nutrient. It is highly sensitive to oxidation and degrades steadily during long periods (Davey et al., 2000) even in frozen products (Rickman et al., 2007). The Vitamin C plays important role in general body metabolism, synthesis of haemoglobin, wound healing, intracellular cement substance and stress (Shubhangini, 2008). There was no thiamin in the juice stored at various periods. The vitamin C content of the juice could enhance absorption of iron. Ascorbate reduces and chelates nutrients during food digestion (Hurrel and Egile, 2007). Ascorbate in foods destroys iron inhibitors to increase absorption of iron two to three-fold (Sorgenberg et al., 1991; Stekel et al., 1968). It also enhances iron absorption by reducing ferric III to ferrous (Fe²⁺), a form of iron readily absorbed. An intake of 100 ml of the juice daily is sufficient to provide 15-60 mg vitamin C as recommended for humans (Fox and Cameron, 1980). However recommended daily allowance for ascorbate varies with age, sex and physiological status (Fox and Cameron, 1980). The juice contained high iron, zinc, sodium and potassium. Storage periods caused significant reduction in these minerals. Iron values ranged from 1.47±0.02 mg to 2.47±0.18 mg. The variation was influenced by time and preservation. The addition of sodium benzoate caused a progressive decrease in iron values weekly. The W₀ had the highest value (4.88 mg) and the W₂ sample had 3.57 mg and the W₁ had 2.03 mg. The differences in ascorbic values of the W₀ and the W₂ samples are relative to each other when compared and was 2.08 mg (4.88 to 2.03 mg). The iron values for the juice for W₀ and the W₁ samples differed (p<0.05) from that of the W₂ juice sample. The iron values for the W₀ and the W₂ samples decreased progressively. This could be that phytate or tannins chelated iron in juice. Iron exists mainly as haemoglobin of the red blood cells. It plays an important role in many parts of the body including immune function, cognitive development, temperature regulation and work performance (Groff et al., 1995). The addition of benzoate and storage had varied effects on zinc value for the juice. Benzoate decreased zinc from 9.30±0.10 mg in W₀ and W₁ samples. The W₂ sample had the least value (1.95 mg). The difference in zinc value for the W₀ and the W₂ was 7.15 mg. The W₀ and the W₂ values for zinc varied. The slight decrease in zinc regardless of increased storage showed that long storage has little or no adverse effect on zinc. The W₂ juice that had the highest decrease (1.95 mg/100 mg) relative to the W₀ sample might have been attributed to increased microflora population usage for metabolism as well as high tannins level in the W₂ sample (3.55%). Sodium values for the W₀ and the W₂ juice samples varied significantly. The range was from 22.13±0.21 mg to 38.97 mg. The decrease was (8.25 mg). The high sodium content of the juice under varying storage periods was associated with the addition of...
sodium benzoate as a preservative. Sodium benzoate prevents sodium loss in foods. Potassium values differed. The range was from 18.15 to 42.09 mg. The W:juice had much more decreases (16.15 mg) relative to W: (28.03 mg). The decrease was 11.88 mg when the samples were compared (28.03 is 16.15 mg) (11.88 mg). The potassium values for W: and W: samples were significantly (p<0.05) different from the sample W: sounds. The high potassium in the juice was due to sodium benzoate that reduced the rate of loss during storage periods. Regardless of the preservative, potassium was lost due to low carbohydrate value for the juices. It is a commonly observed phenomenon that potassium deficiency is associated low carbohydrate diet (Shubhangini, 2008). Consumption of potassium in diet increases protein retention and protect against hypertension in patients sensitive to high sodium intake (Anderson Young, 2008).

The effect of sodium benzoate and storage time on phytochemical value for mature unripe pawpaw juice (Carica papaya) is presented in Table 3. There were both significant reduction and increase in phytochemical values for juice as the storage periods increased. The terpenoids values were a function of time and added preservative. Treatments had varied effects on the terpenoids value for the juice. The addition of sodium benzoate to W: sample decreased its terpenoids (4.22-4.16%) as the storage increased. On the other hand, as the storage time increased the W: sample value increased from 4.22 to 4.35%. The differences were 0.15 and 0.19% (4.35-4.22 and 4.16%, each). The terpenoids values for juices, W: to W: were slightly significantly (p<0.05) different. Saponins values differed. The range was from 0.89 to 3.13%. Saponins are known to reduce risk for cancer (Vegetarian Nutrition, 1998). Most terpenoids and polyphenol in Carica papaya were reported for their antimicrobial properties (Odibeyi and Sofowora, 1979). This property for terpenoids protected the phytochemical value for the entire juice samples regardless of fermentation and microflora spoilage at the various storage periods. Sodium benzoate decreased saponins differently. The W: sample had much more decrease (0.89%) reductive to that of W: sample (2.44%). The decrease was 2.24% when the samples were compared (3.13-0.89%). The saponins values for the juices, W: to W: were significantly (p<0.05) lower relative to the W:. The decreases in saponins during zero periods to W: and W: were attributed to storage and addition of sodium benzoate. It is an established fact that saponins inhibit the Na⁺ efflux by the blockage of the Na⁺ out of the cell. This causes higher concentrations in cells, activating Na⁺/Ca²⁺ antiporter to produce elevated cystosolic Ca²⁺ which strengthens the concentration of the heart muscle and reduces congestive heart failure (Schneider and Wolffing, 2004). Flavonoids value was a function of both storage time and preservation. The addition of sodium benzoate caused a progressive decrease in flavonoids value for the juice on weekly basis. The zero time (W:sample had the highest value (5.07%) relative to those of W: and W: values 4.66 and 3.37%. The differences in flavonoids between W: and W: samples were 0.41% (5.07-4.66%). The W: and W: flavonoids values for these samples varied relative to the W: sample, respectively. The decrease in flavonoids values for preserved juice as the weeks of storage increased (from 5.07-3.37%) for W: and W: were due to fermentation and production of other compounds related to flavonoids. Flavonoids were reported to have anti-viral, anti-allergic, anti-inflammatory, anti-tumor and anti-oxidant activities (Donald, 2000). The treatments had varied effects on tannins content of the juice as the week increased. Tannins decreased from 1.47-0.32% for W: and W: samples, respectively. On the other hand, the tannins value for W: sample increased its value to 3.55%. The differences were 2.08 and 3.23% (3.55-1.47 and 0.32%, each). The tannins content of the juice from W:-W: varied significantly that of W:. The increase in tannins might be associated with microbial fermentation that produced increased levels of tannic acid in the juice.

Table 4 presents organoleptic attributes for juice samples from W:-W: The colour value for the samples ranged from 7.19-7.37. The W: sample had the highest value (7.37) and the W: had the least (7.19). The W: had the highest value relative to the W: and the W: the difference was not significant (p<0.05). The W: and W: had comparable colour (7.20 and 7.19). The flavour score for the W: sample was the highest (6.70). The W: had the least (4.03). There was significant change (p<0.05) in flavour of the samples as the time of exposure increased. The mean taste score decreased significantly as the time of exposure increased. The W: had the highest taste score (6.23) and the W: had the least (2.47). The decrease was much more for the W: (2.47). The mean mouth feel score for the juice was highest for the W: (6.23) and decreased progressively to 3.45 for the W:. The W: had a mouth feel score of 5.81. The mouth feel score varied significantly with time. The mean general acceptability score varied from 2.87 to 7.10 with time. The W: sample had the highest value (7.10) and W: had 5.10 and 2.87, respectively. Panel responses showed that the juice differed significantly (p<0.05) in colour, flavour, mouth feel, taste and general acceptability. The panelist preferred the W: juice to any other. The decrease in colour, flavour, mouth feel taste and general acceptability might be that during storage, fermentation occurred to produce undesirable microflora spoilage that caused deterioration of the sensory attributes.

Table 5 presents the effect of storage and preservation on the microflora content of mature and unripe pawpaw fruit juice exposed for various weeks. The increased
Table 5: Effect of preservative and storage time on the microflora content of mature unripe pawpaw fruit stored for various weeks

<table>
<thead>
<tr>
<th>Week</th>
<th>Total viable count (cfu/ml)</th>
<th>Coliform cfu/ml</th>
<th>Mould cfu/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>W₀</td>
<td>0.30 x 10²±0.33 x 10</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>W₁</td>
<td>3.48 x 10²±0.16 x 10³*</td>
<td>0.31 x 10±0.03 x 10¹*</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>W₂</td>
<td>3.13 x 10²±0.16 x 10³*</td>
<td>0.10 x 10±0.02 x 10¹*</td>
<td>0.00±0.00</td>
</tr>
</tbody>
</table>

Means ± SD of 3 determinations.
Mean values with * in the same column are different (p<0.05) from W₀, W₁: Day 1, W₁: Week 1, W₂: Week 2.

Microflora value for the juice was directly attributed to storage temperature coupled with the high moisture that formed suitable breeding ground for microbial growth and spoilage. The total viable count of the juice ranged from 0.30 x 10²-3.13 x 10³. The W₀ sample had the least value for total viable count. The values for W₁ and W₂ samples for total viable count varied significantly (p<0.05) from that of the W₀ sample. The level of coliform was a function of the preservative and storage time. There was no coliform in the W₀ juice sample. The W₁ sample had a sharp increase in coliform levels (0.31 x 10¹ cfu/ml) relative to that of the W₀ sample. The W₂ sample had a sharp decrease in coliform value (0.10 x 10¹ cfu/ml). The coliform values for W₁ to W₂ varied significantly from that of the W₀ sample. There was no mould in the juice. This was due to the effect of preservation and storage time. The W₁ and W₂ samples (0.31 and 0.10 cfu/ml, each) supported coliform growth. This was due to synergistic effects of acidic medium and preservative that mitigated against its growth. The same explanation might be true for no mould growth in the preserved juices. The levels of TVC (0.30 x 10²-3.13 x 10³ cfu/ml), coliform (0.00-0.10 x 10 cfu/ml) and mould (0.00-0.00 cfu/ml) for W₁-W₂ samples were below the maximum levels requirement for NAFDAC and SON, specifications/standards (TVC 3.0 x 10⁵ cfu/ml, coliform 5.0 x 10² cfu/ml and mould 1 x 10 cfu/ml) for fruit and fruit juices (NAFDAC and SON, 2005).

Conclusion: This study evaluated the effect of preservation and storage time on nutrients, phytochemicals and organoleptic attributes of mature unripe pawpaw fruit juice. Storage at room temperature for 2 weeks precipitated significant reduction in the nutrient, phytochemical and organoleptic attributes of the juice. The keeping quality of the juice with preservative was good within two weeks (W₂). The organoleptic attributes of the juice decreased rapidly during storage and microflora enzymes storage during fermentation. Much more nutrition education is needed to sensitize the public on the nutritional and medicinal properties of mature unripe pawpaw fruit juice. Mature unripe pawpaw juice might be an alternative source for fluid and electrolyte replacement in diarrhea, vomiting and fever. The preservative generally reduced the rate of nutrient loss in the juice. It is recommended that advance level of juice processing should be employed to extend shelf life of the juice and as well as maintain its nutrition profile.

Authors' contributions: This study was carried out in collaboration between all the authors. J.N. Chikwendu and R.O. Edede designed and supervised the study while O. Ugwuanyi analyzed and did the write up. All authors read and approved the final manuscript.

Competing interests: Authors have declared that no competing interests exist.

Ethical clearance: No ethical clearance was required in our local setting for this study.

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REFERENCES


