

Post harvest physicochemical properties of soursop (*Annona muricata* L.) fruits of Coast region, Tanzania

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Abstract: The physicochemical composition of harvested soursop (*Annona muricata* L.) fruits from Coast region, Tanzania, during open-air storage was determined. The ash, titratable acidity, crude fat, crude fiber, moisture and sugars content were determined by proximate analysis. Ascorbic acid contents were determined using the 2,6-dichlorophenol-indophenol dye method while macro-nutrients and heavy metals were determined by Flame Atomic Absorption Spectrophotometry (FAAS). The fruits were harvested at the mature ripe stage and kept in open air storage over several days. The determinations were done immediately after fruit arrival at the laboratory and thereafter at intervals of two days from the day of harvest. The results showed that soursop fruits had high moisture content (73.1% – 82.1%), low titratable acidity (0.10 – 1.25% ca), low crude fat (0.42 mg/100 g-fw), moderate ash content (0.87 mg/100 g-fw) and crude fibre content (6.09 mg/100 g-fw), high ascorbic acid content (34.0 – 19.7 mg/100 g-fw), high total sugars content (34.3% – 45.3%), reducing sugar content (18.9% – 39.2%) and sucrose content (15.5% – 30.0%). Of the macroelements Na, Ca and K, the average content were 895.6, 870.3 and 367.5 mg/100 g-fw respectively. Heavy metals (Fe, Zn, Cu, Pb and Cd) content was very low in the soursop fruits, ranging between <0.0015 mg/100 g-fw for Cd and 0.82 mg/100 g-fw for Fe. During storage, the moisture content, titratable acidity level and sugars content in the fruit were all increasing whereas the ascorbic acid content was decreasing. There were no significant changes during storage for levels of crude fat, fiber, ash, mineral elements and heavy metals. The findings from this study suggest that this fruit from coast region of Tanzania can contribute nutritionally to the health of the consumer.

Keywords: Soursop, *Annona Muricata*, Physicochemical, Proximate Analysis, Storage, Macronutrients, AAS, Post-Harvest, Tanzania

1. Introduction

Information on the nutrient composition of locally available foods especially fruits is of immense importance because of the need to supply foods according to their nutritive values to the people. Dietary supplements are now made using different fruits, vegetables and also herbs in order to provide natural curative as well as preventive methods for combating diseases and poor health. For Tanzania, as it is for other developing countries, there exists very limited information on the nutritive value of its many natural foods especially it's wild and underutilized fruits so that these may be utilized for such purposes. Soursop (*Annona muricata* L.) fruits are important fruits as they are not only a good source of

vitamins, dietary fiber and minerals and provide flavor, aroma and texture to the pleasures of eating food but also are claimed have anticancer and antioxidant capabilities [1]. Studies [2, 3] suggest that compounds from soursop tested on breast cancer cells in culture were more effective than chemotherapy in destroying these cells. The soursop fruits are normally eaten fresh or as fresh soursop juice. There is growing interest in this fruit because it is considered to be a functional product of great benefit to the human diet as it contains several groups of substances that have anti-cancer and antioxidant properties that are useful in disease risk reduction. The soursop fruit and fruit juice are taken as medicine for worms and parasites, to

cool fevers, to increase mother's milk after childbirth, and as an astringent for diarrhea and dysentery [4].

Because of the importance of fruits as valuable food resources many studies are being undertaken to establish the quality, physicochemical characteristics and storage ripening changes of the properties of fruits. Several research studies have been undertaken on the physicochemical composition of Tanzanian fruits and a few reports include those on mangoes [5], pineapples [6], papaya [7] and oranges [8]. So far little attention has been paid to less common fruits such as sugarapple, baobab, pomegranate and soursop. Heavy metal pollution of foods has provoked considerable research in the analysis of food and food products [9]. Some metals like cadmium, lead and mercury are major contaminants of food supply and may be considered the most dangerous elements to our environment while others like iron, zinc and copper are essential for biochemical reactions in the body [10]. Post harvest studies on fruits provide information that shows variation of fruit properties and the best beneficial time for consumption of the fresh fruit.

This study therefore reports on the post-harvest proximate composition (moisture, acidity, sugars, ash, crude fibers and crude fat content), ascorbic acid content, mineral elements and heavy metals content of soursop fruits from the Coast Region, Tanzania.

2. Materials and Methods

2.1. Reagents

The following analytical grade reagents were used in this study: hydrochloric acid (assay 37 w/v, specific gravity 1.2), sulphuric acid (assay 95-98 w/v, specific gravity 1.840) and standard ascorbic acid (assay 99.7%) as supplied by Aldrich Chemical Company Ltd, England. Copper sulphate (99%) was obtained from Lab Tech chemicals Ltd and sodium hydroxide pellets (assay 97%) were obtained from Techno Pharmchem India. 2,6-dichlorophenol-indophenol A.C.S. reagent and phenolphthalein indicator used were supplied by LOBAL Chemie Company. Potassium and sodium tartrate (assay 99%) and citric acid (monohydrate) assay 99.8% were supplied by Riedel-de Haen AG and ethanol (assay 95% pure) was supplied by CARLO ERBA reagents of Italy. Acetic acid (glacial assay 99.5%), nitric acid, perchloric acid, metaphosphoric acid (assay 88% w/w) and methylene blue indicator as obtained from B.D.H Ltd, England, Lead acetate (assay < 99%), potassium oxalate (assay 99.5%) and phenolphthalein indicator (pH range 8.3-10) were obtained from May & Baker Ltd. Dagenham, England. Petroleum-ether (bp 60-80 °C) was obtained from the Central Drug House Ltd. of India. Deionized distilled water was used for all needed dilutions.

2.2. Instruments and Equipment

An electronic balance Mettler Toledo model B 303-S, a Genlab oven supplied by Wideness Cheshire Ltd. having a

temperature range of 0 to 250 °C and a muffle furnace, Gallenkamp Rapid Model, from Gallenkamp Ltd, having a heating temperature range up to 1000 °C were used. The Gallenkamp Centrifuge model 200 with frequency of 50 Hz from Gallenkamp Ltd, Osterizer blender model 867-66A, an IKAMAG-RET type hot plate, a HANNA waterproof pH-meter, a heating mantle of one litre, a soxhlet apparatus and the Flame Atomic Absorption Spectrophotometer, model iCE 3000 v1.3 instrument were also used.

2.3. Fruit Sample Collection

Samples of soursop fruits were collected from farms in Mkuranga, Coast Region. Fully matured fruits that had no signs of wound or damage were picked directly from trees and were transported to the Chemistry Department laboratory, University of Dar es Salaam, for open-air, room temperature storage experiments and for further preparations and analysis.

2.4. Analysis

The following determinations were done in triplicate immediately after arrival of the fresh fruits at the laboratory and thereafter at intervals of two days from the day of harvest to the 8th day. Moisture content, ash, crude fat, total sugars, ascorbic acid, other sugars and crude fibre were determined using standard methods (925.90, 923.03, 920.39, 977.20, 967.21, 932.12 and 935.53 respectively) of AOAC [11]. Titratable acidity was conducted following the method described by Rangana [12].

2.5. Mineral Elements and Heavy Metals

2.5.1. Sample Preparation

1.0 g of a well dried and powdered fruit sample was placed in a digestion bottle followed by addition of 8 mL conc. nitric acid and 2 mL perchloric acid. The solution was then heated for about 4 hours with slow addition of drops of perchloric acid until a clear solution was obtained. The solution was then transferred to a 50 mL volumetric flask and made up to the mark by distilled water. Appropriate dilutions were done for elements present at high concentrations.

2.5.2. Atomic Absorption Spectrophotometry (AAS)

All determinations of metals were performed with the iCE 3000 v1.3 AAS instrument. Hollow cathode lamps of the different metals were used as radiation sources for the instrument. The instruction manual of the instrument was used as guide for all measurements. Calibration standards were first aspirated into the AAS to calibrate the instrument and check its linearity response. After all necessary set up, standardization and calibration procedures had been completed then the above treated fruit juice sample solutions were aspirated into the AAS instrument for precise measurement of metal concentration. All determinations, in triplicate, were performed at the laboratory of the Chemistry Department, University of Dar es Salaam.

3. Results and Discussion

3.1. Initial Proximate Composition

The proximate composition (moisture, acidity, reducing sugars, total sugars, sucrose) and ascorbic acid content of soursop (*Annona muricata* L.) fruits immediately after collection from trees are presented in Table 1. All results are average results of triplicate determinations.

The average moisture content of the fruit was high at 73.1% but lower than the level of 82.8% reported by [13] and 81% reported by [14] for soursop fruits from Nigeria. The total sugars content of 34.3% makes the fruit sweet when fresh as compared to fruits from Brazil with a content of 14.6% [15]. The average reducing sugar content was 18.9% while the sucrose content was 15.5 % which was much higher than the value of 1.02% reported by [16]. The titratable acidity value of 0.19% was lower than that reported by [13] and by Onimawo [14]. The ascorbic acid level of 34 mg/100 g-fw was similar to the value of 34.7% reported by [17] for soursop from south eastern Nigeria and 37.25% reported for soursop of Brazil [15].

Table 1. Initial proximate composition (moisture, acidity, total sugars, reducing sugars, sucrose content) and ascorbic acid content of fresh soursop fruits from Coast Region, Tanzania

Fresh fruit average proximate composition (n = 3)	
Parameter	Value
Moisture (%)	73.1 ± 3.1
Titratable acidity (%)	0.19 ± 0.02
Total sugars (%)	34.3 ± 1.5
Reducing sugars (%)	18.9 ± 3.2
Sucrose (%)	15.5 ± 0.8
Ascorbic acid (mg/100 g-fw)	34.0 ± 1.2

3.2. Changes in Proximate Composition

Open air storage results of proximate composition (moisture, titratable acidity, total sugars, reducing sugars, sucrose) and ascorbic acid level of soursop (*Annona muricata* L.) fruits from Coast Region, Tanzania are presented in Table 2 and Table 3.

3.2.1. Moisture Content of the Fruit

During storage ripening of the soursop fruits an increase in moisture content from 73.1% when harvested to 82.1% by the 6th day of storage was observed but decreased to 80.5% on the 8th day (Table 2). The above results are similar to values reported by [16] and Onimawo [14]. Such an increase in moisture level with open air storage has also been reported for Tanzanian pineapple fruits [6]. Increase in moisture content is beneficial as it makes the fresh fruit juicier and more palatable to the consumer. The decrease on the 8th day may be due to drying up process of the fruit suggesting that soursop should only be stored for 6 days to get maximum juicy effect.

3.2.2. Titratable Acidity

Acidity in fruits plays an important role in taste, color, and microbial stability of the fruit juice and determines maturity.

Increase in titratable acidity from 0.19% to 1.25% was observed during the eight days of storage of the soursop fruits (Table 2). This behavior has also been reported for soursop fruits by [18] and for pineapple fruits by [6]. Normally high acidity makes fruits unacceptable to consumers even if they meet minimum sugar standards. However, the values of titratable acidity obtained make these fruits acceptable to consumers.

Table 2. Moisture, titratable acidity and total sugars content of soursop (*Annona muricata* L.) fruits during ambient storage

Storage days	Moisture (%)	Titratable acidity (%)	Total sugars (%)
0	73.1 ± 3.1	0.19 ± 0.02	34.3 ± 1.5
2	77.9 ± 2.1	0.29 ± 0.05	38.0 ± 2.5
4	80.1 ± 4.2	0.60 ± 0.04	41.6 ± 2.6
6	82.1 ± 1.1	1.11 ± 0.02	44.1 ± 1.5
8	80.5 ± 2.2	1.25 ± 0.06	45.3 ± 3.6

3.2.3. Total Sugars

During storage of a soursop fruits, there was an increase in total sugars and reducing sugars and sucrose content in the fruits. Soursop had an initial total sugar content of 34.3% at harvest and 45.3 % by the 8th day of storage (Table 2). These values are high when compared to the values of 7.6%, 14.6% and 10.1% reported by [13], [16] and [19] respectively. When sugars are consumed in large amounts they can easily lead to weight gain and other sugar-related health problems. Since soursop fruits have high amounts of vitamins, minerals, antioxidants and acetogenins they can still be consumed beneficially even though they have high amount of sugars.

3.2.4. Reducing Sugar and Sucrose

The reducing sugar content of soursop fruits increased from 18.9% at harvest to 39.2% by the 8th day of storage and the sucrose content also increased from 15.5% at harvest to 30.0% on the 8th day of open air storage (Table 3). These values are higher than the values of 9.91% for reducing sugars and 0.21% sucrose reported by [19]. The increase in sucrose might be due to enzymatic break down of polysaccharides into sugars [20]. This increase in sucrose is very important as it improves the sweetness of the fruit, a very important factor for the fruit consumers.

3.2.5. Ascorbic Acid

The average ascorbic acid content of the soursop fruits during storage ripening decreased from 34.0 mg/100 g-fw at harvest to 19.7 mg/100 g-fw by the 8th day (Table 3). Soursop from the southern part of Nigeria showed an average ascorbic acid content of 70 mg/100 g [21]. Other reports show ascorbic acid content of soursop at 29.6 mg/100 g [13], 22.6 mg/100 g [16] and 62.5 mg/100 g for soursop pulp from Ghana [22]. The high values of ascorbic acid in soursop signify the potential use of the fruit as a good antioxidant. High ascorbic acid levels of 51.8 mg/100 g-fw have also been reported for papaya fruits of Hawaii [23]. The recommended daily intake (RDI) [24] of ascorbic acid is about 30 mg/day for adults and 17 mg/day for children.

Therefore, these fruits could be considered as good sources of ascorbic acid for purposes of human nutrition.

Table 3. Reducing sugars, sucrose and ascorbic acid content of soursop (*Annona muricata L.*) fruits during ambient storage

Storage days	Reducing sugars (%)	Sucrose (%)	Ascorbic acid (mg/100 g-fw)
0	18.9 ± 3.5	15.5 ± 0.8	34.0 ± 1.4
2	23.2 ± 2.4	18.2 ± 0.4	29.1 ± 2.1
4	30.9 ± 4.4	19.4 ± 2.6	26.5 ± 2.6
6	35.4 ± 3.2	21.4 ± 1.9	23.1 ± 3.1
8	39.2 ± 1.6	30.0 ± 1.4	19.7 ± 1.9

A comparative look at the data from reports of studies on physicochemical parameters of soursop by other researchers is presented in Table 4. The results show a wide variation of the values for the different parameters as the fruits are grown in different soils, climates and geographical locations. The percent moisture levels are similar in soursop fruits from different environments. The percent acidity varies from 0.19 (Tanzania) [this study] to 3.43 (Nigeria) [23] and the percent total sugars content varies from 7.5 (Ghana) [22] to 45.2 (Tanzania) [this study]. The reducing sugars content varies from 7.8% (Hawaii) [23] to 39.2% (Tanzania) [this study] whereas the sucrose varies from 0.21% (Brazil) [19] to 30.0% (Tanzania) [this study]. The ascorbic acid content varies from 19.7 mg/100 g (Tanzania) [this study] to 65.2 mg/100 g-fw (Ghana) [22].

Table 4. Comparison of globally reported proximate composition and ascorbic acid content of soursop (*Annona muricata L.*) fruits

Parameter	This study	Soursop literature
Moisture (%)	73.1	82.8 [13], 81.0 [14], 80.6 [25],
Titrateable acidity (%)	0.19	1.02 [13], 3.43 [14], 0.19 [15]
Total sugars (%)	34.3	7.59 [13], 15.6 [25], 20 [28], 15 [30]
Reducing sugars (%)	18.9	9.91 [19], 7.8 [23], 11 [30]
Sucrose (%)	15.5	0.21 [19], 1.02 [34]
Ascorbic acid (mg/100 g)	34.0	34.2 [15], 34.7 [17], 62.5 [22], 29 [32]

3.3. Ash, Crude Fat and Crude Fibre

The results on determinations of ash, crude fat and crude fibre content are presented in Table 5.

3.3.1. Ash

Ash is the inorganic residue remaining after heating to remove all the water and organic matter that provides a measure of the total amount of minerals in a food. The main purpose of ash determination is to assess the quality of the food materials. High total ash content for a food material signifies the presence of adulterants [8]. The soursop fruits from Coast Region, Dar es Salaam, had an average ash content of 0.87 ± 0.04 mg/100 g-fw (Table 5). This value is higher than that reported by [30] and [32], compares well to the value of 0.73 mg/100 g-fw reported by Moos [25] but is lower than the value of the ash content reported for soursop from Ghana [22]. The results in this study suggest that the

fruits have high deposits of mineral elements.

Table 5. Ash, crude fat and crude fibre content of soursop (*Annona muricata L.*) fruits of Coast region, Tanzania

	This study	Soursop literature
Parameter	(mg/100 g-fw)	(mg/100 g-fw)
Ash	0.87 ± 0.04	2.44 [22], 0.73 [25], 0.58 [30], 0.60 [32]
Crude fat	0.42 ± 0.02	2.60 [22], 0.31 [25], 0.97 [32], 0.30 [34]
Crude fibre	6.09 ± 0.61	11.50 [22], 1.63 [25], 3.2 [30], 3.3 [34]

fw - fresh weight

3.3.2. Crude Fat

Crude fat represents the true fat and other materials such as phospholipids, sterols, essential oils and fat soluble pigments in the fruit. Generally fruits have low levels of fat content and this suggests that they are not good sources of energy. The average fat content in soursop fruits obtained in this study was 0.42 ± 0.02 g/100 g-fw (Table 5). This value is higher than the value of 0.31 g/100 g-fw for soursop fruits as reported by Moos [25] and 0.22 g/100 g-fw for Tanzanian mangoes [5]. The low level of fat in the fruits means that these fruits are not good source of energy [22] and are recommended for loss or maintaining of weight, supply of nutrients and lowering of blood pressure [26, 27].

3.3.3. Crude Fiber

In Tanzania's soursop fruits the crude fibers observed in this study was 6.09 ± 0.61 mg/100 g-fw (Table 5). This value is higher than the values of 1.63 mg/100 g-fw for soursop fruit reported by Moos [25] and lower than 11.5 mg/100 g reported for soursop from Ghana [22]. Fiber is essential to the human body as it helps to maintain the health of the gastrointestinal tract and in weight regulation [29] but if consumed in excess it may bind trace elements, leading to deficiency of iron and zinc in the body. The observed level of crude fibre in Tanzanian soursops is moderate and thus good for body maintenance.

3.4. Mineral Elements and Heavy Metals

The contents of the selected mineral elements (macroelements)-Ca, Na, and K and heavy metals – Fe, Zn, Cu, Pb and Cd in the soursop fruits from Coast region are summarized in Table 6.

Table 6. Macronutrients and heavy metal content of soursop (*Annona muricata L.*) fruits of Coast region, Tanzania

	This study	Soursop literature
Macronutrients	(mg/100 g-fw)	(mg/100 g-fw)
Calcium	870 ± 29	10.3 [30], 14 [34]
Sodium	895 ± 56	23 [25], 14 [34]
Potassium	367 ± 49	745.8 [25], 270 [30]
Heavy metal		
Iron	0.82 ± 0.06	0.64 [32], 47 [25], 0.6 [34]
Zinc	0.32 ± 0.09	
Copper	0.13 ± 0.04	
Lead	0.11 ± 0.05	<0.0015 [15]
Cadmium	<0.0015	

3.4.1. Mineral Elements

The levels of mineral elements are high suggesting that the soursop fruits may be useful for the strengthening of bones in the body. Calcium and sodium, at 870 ± 29 mg/100 g-fw and 895 ± 56 mg/100 g-fw respectively, were the predominant mineral elements present in the fruit. The calcium level was much higher than the values of 14 mg/100 g [34] and 10.3 mg/100 g [30] reported for soursop fruits. Although the value of calcium in the Tanzanian soursop fruits is moderate it can still be used to contribute to the daily dietary calcium body requirement which is 2500 mg/day [24].

The average amount of potassium in soursop fruits was 367 ± 49 mg/100 g-fw (Table 6). This value is high when compared to the values of 45.8 mg/100 g-fw [25] and 270 mg/100 g-fw reported for soursop fruits elsewhere. The amount of potassium in the Tanzanian soursop fruits studied can be considered low since the level may not contribute significantly to the recommended daily allowance (RDA) for potassium which is 2000 mg/day for an adult [24].

The average sodium content of 895 mg/100 g-fw in the soursop fruits was higher than the value of 23 mg/100 g reported by Moos [25] for soursop fruits. The soursop fruits can contribute significantly to the daily amount of sodium needed by the body since the RDA value for sodium for adults is only 500 mg/day [24]. Soursop fruit is therefore recommended for this.

3.4.2. Heavy Metal Content

The heavy metal levels observed in the soursop fruits are summarized in Table 6. The iron content in soursop was 0.82 ± 0.06 mg/100 g-fw, a value less than the value of 47 mg/100 g-fw reported by [25] and higher than 0.64 mg/100 g-fw reported by [13]. The value was higher than the value of 0.11 mg/100 g-fw reported for Botswana fruits [31]. The contribution of iron by this fruits to the normal dietary requirement is poor as the range obtained in this study is very much less than the RDA range for iron which is 8.0 - 20 mg/day [24].

The copper content in the soursop fruits was 0.13 ± 0.04 mg/100 g-fw. This value is higher than 0.10 mg/100 g-fw reported for Turkish pomegranate fruits [35] but less than the value of 0.32 mg/100 g-fw reported for Indian fruits reported [33]. The level of copper obtained in this study compares very well to the level of copper reported for mangoes [5]. When these levels of copper are compared to the copper RDA level in foods of 1.2 - 3.2 mg/100 g-fw, these fruits can be considered as poor contributors to the Cu-RDA.

The level of zinc in soursop fruits was 0.32 ± 0.09 mg/100 g-fw which was lower than the value of 0.80 mg/100 g-fw reported for Indian pomegranate fruits [33]. However, the level of zinc in these Tanzanian soursop fruits is higher than the level in Tanzanian papaya [7] and oranges [8]. The zinc level found was well below the FAO and WHO permissible level of 6 mg/100 g-fw [24].

Cadmium content was below the detection limit of the measurement, an observation similar to that reported for

several fruits from Tanzania [5 – 8]. The very low amount of cadmium in this fruits shows that the fruits are not polluted and are farmed in unpolluted environments.

Lead in the soursop fruits had an average concentration of 0.11 ± 0.05 mg/100 g-fw, a level that is much lower than the maximum permissible limit of 3 mg/100 g-fw for lead in vegetables and thus falls within the safe limits for consumption as stated by FAO/WHO [36]. High lead levels have been reported in soils and vegetables grown close to the major roads of Dar es Salaam, Tanzania, [37] and Ethiopia [38]. This very low level of lead is generally very safe and cannot lead to any health hazard for consumers.

4. Conclusion

The physicochemical composition of soursop (*Annona muricata* L.) fruits from Coast Region, Tanzania, during ambient storage of the ripe fruits was determined. Changes in proximate composition (ash, titratable acidity, crude fat, crude fibre, moisture and sugars content), ascorbic acid level, macro-nutrients and heavy metals contents during the post harvest storage of soursop fruits were obtained. The soursop fruits had high moisture content (>73.1%), low acidity (<1.25% ca), low crude fat (0.42 mg/100 g-fw), moderate ash content (0.87 mg/100 g-fw) and crude fibre content (6.09 mg/100 g-fw), high ascorbic acid content (>19.7 mg/100 g-fw), high total sugar content (>34.3%), moderate reducing sugar content (18.9% - 39.2%) and sucrose content (15.5% - 30.0%). Of the macroelements (K, Ca and Na) determined, the high levels were of Ca and Na i.e. 870 and 895 mg/100 g-fw respectively. Heavy metals (Fe, Zn, Cu, Pb and Cd) content was very low in the soursop fruits signifying that these fruits were free from such pollution. The compositional information of this fruit provided by this study underscores the fact that soursop fruits can be a good source and supplement of nutrients to the human body. The results emphasize that these fruits are sweeter and juicier as they are stored up to six days after harvest and should be consumed fresh within this period. Comparison of our results and FAO/WHO standards reveals that this fruit from Coast Region, Tanzania, can play the valuable role of fulfilling daily human diet needs as well as be a healthy medical supplement for certain ailments.

More studies of similar and other properties on underutilized Tanzania fruits need to be undertaken as such studies serve as baseline information for nutrient composition of the fruits.

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