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# Morphological and Physico-Chemical Characteristics of *Saba comorensis*: A Highly Preferred Lake Victoria Basin Indigenous Fruit Tree in Busia District, Eastern Uganda

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*Saba comorensis*, an indigenous fruit tree (IFT) that is eaten when staple foods such as bananas, cassava, rice and maize are in short supply has not been investigated for its physico-chemical properties. The morphological characteristics and physico-chemical characteristics of mature ripe fruits of *S. comorensis* from Busia district (Uganda) were determined. The results showed that the fruit mean weight, fruit breath, fruit length and percentage pulp weight were;  $262.51 \pm 116.55$  g,  $7.36 \pm 1.18$  mm,  $7.43 \pm 1.35$  mm and 7.72%, respectively. The fruit pulp was acidic ( $\text{pH} = 3.10 \pm 0.04$ ) and rich in crude protein ( $4.83 \pm 0.01$  g/100 g), dietary fibre ( $7.97 \pm 0.85$  g/100 g),  $\beta$ -carotene ( $1.270 \pm 0.00$  mg/100 g), vitamins C ( $430.50 \pm 34.65$  mg/100 g) and minerals like potassium ( $1493.75 \pm 321.73$ ), magnesium ( $894.9 \pm 0.32$  mg/100 g) and calcium ( $209.0 \pm 0.51$  mg/100 g). *Saba comorensis* is nutritious fruit that can be consumed; particularly during times of food shortages. Therefore, there is need to promote on-farm domestication and consumption of *S. comorensis* for food and nutritional security.

**Keyword:** Morphological, physicochemical, *Saba comorensis*, Uganda.

### 1. Introduction

*Saba comorensis* (Bojer Pichon); commonly called rubber vine belongs to the family Apocynaceae and is a strong forest liana that grows up to 20 m long<sup>[1]</sup>. The stem is lenticillate and exudes white sticky latex when cut. The leaves are ovate or elliptic, base rounded or subcordate (large oval to oblong). The flowers produce white petals that are sweet scented about 3.5 cm long. The fruit is a large berry, rounded subglobose, 4-8 cm long and 3.5-6 cm wide with a thick greenish lemon-like skin when young, but turns orange-yellow after ripening. The edible fruits are cut into two pieces or pressed to break open when ripe<sup>[2]</sup> to expose sweet sour orange-yellow fruit pulp that has a taste similar to that of tamarind. The pulp has numerous brown-black seeds that are coated with pulp<sup>[3]</sup>. The fruit mainly ripen in the month of November and December.

*Saba comorensis* is native to tropical Africa particularly in the countries like the Comoros, Ghana, Kenya, Malawi, Sudan, Ethiopia, Mozambique, Tanzania and Uganda. It is very abundant in undisturbed forests, coastal areas and around the Great Lakes Region of Africa, but rare in open areas. This tree grows in sandy loam soils in an attitude of 1250 m, temperature of 20 °C and mean annual rainfall of 900-2000 mm. As an indigenous fruits tree, *S. comorensis* is called by different language dialects. It is called *mbungo* in Kiswahili in Kenya and Tanzania, *abukamira/mekek* in Arabic in Sudan<sup>[4]</sup> and *bishquor* among the Berta people of Ethiopia<sup>[5]</sup>. In Uganda, *S. comorensis* is called *amachawungo*, *mavongo*, *Ekumune* among the *Samia*, *Lusoga* and *Karamonjong* ethnic tribe dialects, respectively<sup>[6,7]</sup>. As forest resource, *S. comorensis* is enjoyed by both humans and wild animals like chimpanzees and monkeys as food and medicine<sup>[8]</sup>. The fruit pulp

produces a popular, edible, delicious and refreshing juice with a sour taste that is considered as a health drink and also for seasoning rice. In African traditional medicine, *S. comorensis* is used to treat several diseases including; venereal diseases, stomach ache, diarrhea [9], oral thrush, rheumatism and bark pain [7]. Other studies also report *S. comorensis* to be used for gynecological condition including labor induction [10], hypertension and infertility in women [3]. Among the communities where it grows, *S. comorensis* is regarded an ornamental tree, source of inferior rubber and for building, weaving granaries and lining fences.

As a result of food insecurity arising from changes in climate and weather variability, *S. comorensis* fruit is usually used as an alternative source of food for children and women, especially when staple food such as cassava, rice and maize are in short supply. Even chimpanzee animals rely on *S. comorensis* during dry season when food is scarce in the forests [11]. Consequently, *S. comorensis* fruits have gained commercial importance and are now sold along the roadsides in Busia district (Eastern- Uganda). In fact, *S. comorensis* has a potential for industrial agro-processing following a recent ranking of indigenous fruits trees within E. Africa which indicates that it is among the most preferred indigenous fruit trees in the Lake Victoria Basin [2]. According to ICRAF-ECA [12], indigenous fruits have great opportunities to be developed into products like juice, jam and wine that can improve not only the nutrition and health of people, but also livelihoods.

Despite, its potential role in food security, nutrition, health and novel product development, *S. comorensis* has remained one of the neglected tropical indigenous fruit trees. The nutritional composition has not been investigated, yet this information when available can be used to develop novel nutritional food products that can be processed and consumed during times of food scarcity. Therefore, the aim of this study was to evaluate the morphological and physicochemical composition of *S. comorensis* in Busia district, Eastern Uganda.

## 2. Materials and Methods

### 2.1 Sampling site

Fruit Sampling was carried out in Busia district located in the south -eastern part of the Republic of

Uganda, north of Lake Victoria. The district borders Tororo district in the north, Bugiri district in the west and adjacent to the border between Kenya and Uganda. Busia district covers a land area of 743km<sup>2</sup> and had a population of 297,600 people in 2012. The District lies approximately between longitudes 33<sup>0</sup>5' East and 34<sup>0</sup>1' East, and latitude 0<sup>0</sup>10' North and 0<sup>0</sup>35' North. The main indigenous tribe is the Basamia. The majority of the populations (over 80%) in the district are peasant farmers engaged in subsistence farming [14].

### 2.2 Fruit sampling

The mature ripe fruit of *S. comorensis* were harvested in November 2012 from 10 lianas in Bulimbi Sub County, Busia district. *S.comorensis* trees in fruits were identified and monitored for fruit ripening. Between 10 and 20 healthy orange-yellow fruits were harvested randomly each tree. (Plate 1).



**Plate 1:** Fruits of *Saba comorensis*.

### 2.3 Morphological analysis

In the laboratory, fruit morphological characteristics like weight, size and pulp weight percentage of 100 mature ripe fruits (selected randomly from the pool) were measured. The weight of each fruit (gm) was determined using an electrical analytical balance while the size (cm) was measured by taking the linear dimensions of length and breadth in the middle of each fruit using a Vernier Caliper [13]. After weighing, the fruit was divided into two portions by cutting it into half with stainless steel knife (Plate 2) and the combination of the pulp with seeds was removed with stainless spoon.



**Plate 2:** Fruit pulp of *Saba comorensis*.

The pulp together with the seeds were put into the stainless steel sieve and blended manually to separate the seeds from the pulp. The percentage fruit pulp weight was determined as weight of pulp divided by weight of the fruit. The seeds with residual pulp of each fruit were counted and later air dried in an oven at 40-50 °C for 36 hours. The seeds were then separated by peeling off any residual pulp from the seed. Similarly, the morphological characteristics for weight and size of the seeds were also determined. The weight of each seed was determined with an electrical analytical balance while dimensions were taken by measuring the length and breadth (cm) using a Vernier Caliper.

#### 2.4 Physico-chemical analysis

The freshly extracted pulp was used in the determination of the chemical and the nutritional characteristics such as moisture content, pH, total soluble solids, refractive index, titrable acidity, beta

carotene and sugars (glucose and fructose). The moisture content was determined using the oven method at 105°C for 4 hours [14]. Viscosity was measured using U-tube viscometer. The pH was determined at 20 °C using potable pH meter model, Hanner, RI02895, USA. Total soluble solids as brix and refractive index were determined using refractometer model, Bellingham + Stanley (Model No. A86006). Titrable acidity was estimated by mixing 10 gm of the pulp with 60 ml of de-ionized-distilled water with three drops of phenolphthalein indicator and then titrated using 0.1 N NaOH until the pH was 8.1 (by colour changing to pink). The volume of the sodium hydroxide added to the solution, was multiplied by a correction factor of 0.007 to estimate titrable acidity as percentage of citric acid.

The extracted fruit pulp was dried in an oven at 40-50 °C for 24 hours to form gum like dry pulp. The pulp was ground to powder using an electric grinder. The dry fruit pulp was used in the determination of crude protein, dietary fibre, crude fat and total ash [14]. The crude protein was determined as nitrogen content by the method of Kjeldhal and calculated using 6.2 as co-efficient factor. The carbohydrates value was determined by difference (100%-Crude protein content %-Total fat content %-Moisture content %). The caloric value was estimated by conversion factor of four for protein, nine for fat and four for carbohydrates [15]. Vitamin C (Ascorbic acid) was determined by using 2, 6- dichlorophenol indophenol and expressed as mg/100g [16,17].

#### 2.5 Mineral analysis of *Saba comorensis*

The mineral content (Na, K, Ca, Mg, Zn Cu and Fe) were determined using Atomic Absorption Spectrophotometer (AAS) shimadzu AA-63000 [17]. In this method, 2.0 g of the dry pulp was weighed and digested in a mixture of de ionized distilled water (5 ml) and concentrated nitric acid (20 ml) at a temperature of between 180 °C and 220 °C in a digester for 2 hours. The mixture was allowed to cool and 10 ml of concentrated perchloric acid was added and heated at the same temperature for 1 hour, cooled, filtered and 2 ml of concentrated hydrochloric acid added. The solution was made up to 100 ml with de ionized distilled water which was analysed with AAS.

## 2.6 Beta carotene and sugar analysis

The fresh fruit pulp sample was analyzed for beta carotene using HPLC (Shimadzu class VP 10) while glucose and fructose were analysed using UV-visible spectrophotometer [18].

**a. Beta carotene analysis:** The fruit pulp sample (2.5 g) was weighed into the extraction tube and homogenized with 50 ml of cold acetone for 1 minute. The extract solution was filtered with suction through a sintered glass funnel, concentrated in rotary evaporator at temperature (T)  $\leq$  35 °C and then dried under nitrogen. The dry sample was immediately re-dissolved in 1ml of HPLC grade acetone and then filtered through 0.22 mm PTFE syringe filter into sample vials. The filtered extract was added into 40 ml petroleum ether in 500 ml separately funnels and deionised distilled water (300 ml) was slowly added by letting it flow along the walls of the funnel. To avoid formation of an emulsion, the extract was not shaken. The two phases were allowed to separate and the lower aqueous phase was discarded.

The extract was further washed three times with water (about 200 ml each time) to remove residual acetone. In the final washing, lower phase was completely discarded, without discarding any portion of the upper phase. The petroleum ether phase was collected and the solution passed through a small funnel containing anhydrous sodium sulfate (15 g). The separating funnel was further washed with petroleum ether and the washing was combined with the petroleum ether solution of the carotenoids after passing through the funnel with anhydrous sodium sulfate. Further drying was also carried out by adding anhydrous sodium sulfate to the collected carotenoid petroleum ether solution until some crystals remained loose.

The standards of beta carotene were prepared at concentration of 1, 2, 4 and 8  $\mu\text{g/ml}$ . Twenty (20)  $\mu\text{ml}$  of the standard was injected into HPLC spectrophotometer and separated by a column C<sub>18</sub> (water spherisorb ODS2, 3  $\mu\text{m}$  4.6 x 150 mm) using isocratic elution with mobile phase, acetonitrile – methanol - ethyl acetate (0.05% triethylamine) (80:10:10) at flow rate of 2.0 ml/min and pressure of 95kg F/min. The retention time of beta carotene was observed after 15 minutes and its peak area was used to prepare the calibration curve ( $r^2 = 0.997$ ). The prepared fruit pulp samples (20  $\mu\text{ml}$ ) were also

injected in the HPLC spectrophotometer and concentration of beta carotene determine using the equation.

$$C_x (\mu\text{g/g}) = \frac{A_x \times C_s (\mu\text{g/ml}) \times \text{Total volume of extract (ml)}}{A_s \times \text{sample weight}}$$

Where  $C_x$  = Concentration of beta carotene;  $A_x$ =Peak area of beta carotene;  $C_s$ =concentration of the standard;  $A_s$ = Peak area of the standard.

**b. Sugar analysis:** Glucose and fructose were analyzed using UV-visible spectrophotometer [18].

**Glucose analysis:** The analysis of glucose started with the preparation of glucose oxidase peroxidase reagent and standard glucose solution. Glucose oxidase peroxidase reagent was prepared by dissolving O-dianisidine (25 mg) completely in methanol (1 ml) and 49 ml of 0.1M phosphate buffer (pH 6.5) was added into the solution. Thereafter, peroxidase (5mg) and glucose oxidase (5 mg) were added to obtain O-dianisidine solution- peroxidase reagent. Standard glucose stock solution was prepared by dissolving 100 mg glucose in 100 ml deionised distilled water. Ten ml of glucose stock solution was diluted to 100 ml with deionised distilled water to obtain the working standard. The fresh fruit pulp (0.5 ml) was mixed with deionised distilled water (0.5 ml) and O-dianisidine solution - peroxidase reagent (1 ml). The solution was added into a series of test tubes containing standard glucose solution 0(blank), 0.2, 0.4, 0.8 and 1.0 ml and made up to 1 ml volume with deionised distilled water. Each test tube in the series was mixed with glucose oxidase–peroxidase reagents (1 ml). The tubes were incubated at 35 °C for 40 minutes and the reaction was terminated by addition of 2 ml of 6N-HCl. The color intensity of the solution was measured using UV–Visible spectrophotometer at 540 nm. The glucose content was estimated using the calibration curve.

**Fructose analysis:** The analysis of fructose started with the preparation of resorcinol and standard fructose solution. Resorcinol reagent was prepared by dissolving resorcinol (1 g) and thiourea (0.25 g) in 100 ml glacial acetic acid. The solution was then stored in the dark. Five parts of concentrated hydrochloric acid was mixed with one part of distilled water to produce diluted hydrochloric acid. Standard

fructose solution was prepared by dissolving fructose (50 mg) in de ionised distilled water (50 ml). From the standard fructose solution, 5 ml was diluted to 50 ml with de ionized distilled water to make a working standard. The fresh extracted pulp (2.0 ml) was added to five test tubes in a series containing resorcinol reagents (1.0 ml) and diluted hydrochloric acid (7.0 ml). To a series of test tubes, working standard fructose, 0.2, 0.4, 0.6, 0.8 and 1.0 ml was pipetted and made up to 2 ml with de-ionized distilled water. The blank was set along with the working standard. The tubes were heated in a water bath at 80 °C for exactly 10 min and there after cooled by immersing in tap water for 5 minutes. The colours of the tubes were read at 520 nm within 39 minutes. Fructose was estimated from the calibration curve.

## 2.7 Statistical analysis

Physico-chemical characteristics tests were carried

out in triplicate. The means and standard deviations of both morphological and physicochemical were determined. The physico-chemical values of *S. comorensis* were compared with that of passion fruit, mango and oranges from literature.

## 3. Results

### 3.1 Morphological characteristics of *Saba comorensis* fruit

The morphological characteristics of *S. comorensis* fruit is presented in Table 1. The mean weight, fruit breath and length of *S. comorensis* fruit were 262.51±116.55 g, 7.36±1.18 cm and 7.43±1.35 cm, respectively. The mean pulp weight was 7.72±0.52% containing 33.67±0.85 pieces of seeds. The mean seed weight, length and breadth were; 0.82±0.12 g, 1.69±0.13 cm and 1.02±0.04 cm, respectively.

**Table 1:** Morphological characteristic of *Saba comorensis* fruit

Parameter	Mean	Minimum	Maximum
Fruit Weight (g)	262.51±116.55	73.09	432.00
Fruit Size (g)-Breath (cm)	7.36±1.18	5.15	9.23
Fruit size- Length (cm)	7.43±1.35	4.78	9.14
Pulp weight (%)	14.84± 8.43	37.86	8.44
Number of seeds per fruit	33.67±0.85	24.00	40.00
Seed weight (g)	0.82±0.12	0.61	0.93
Seeds size –Length (cm)	1.69±0.13	1.53	1.86
Seeds size –width (cm)	1.02±0.04	0.95	1.10

### 3.2 Physico-chemical composition

The physico-chemical composition of *S. comorensis* fruit pulp for titrable acidity (as citric acid), viscosity, refractive index, pH and total soluble solids were 5.30±0.98 mg/100 g, 53.69±7.68 m<sup>2</sup>/s, 1.364±0.000, 3.10±0.04 and 20.00±0.00 %, respectively (Table 2).

The moisture content, total ash, crude protein, dietary fibre, total fat, total carbohydrates and energy were; 74.08±0.85, 1.93±0.01, 4.83±0.01, 7.97±0.85, 0.00±0.00, 19.16±0.84 g/100 g and 97.78±1.61 Kcal, respectively.

Fructose and glucose contents were; 10.65±0.71 and 10.88±0.40 mg/100g, respectively while vitamin C

and beta-carotene were; 430.50± 34.65 and 1.270±00 mg/100g, respectively. The mineral composition of *S. comorensis* for sodium (Na), potassium (K), calcium (Ca), iron (Fe), copper (Cu), zinc (Zn) and magnesium (Mg) were in the ranges of; 79.0±0.35, 1493.75±321.73, 209.0±0.51, 3.40±0.32, 0.19±0.02, 1.80±0.01 and 894.9±0.32 mg/100 g, respectively.

## 4. Discussion

### 4.1 Morphological characteristics of *Saba comorensis*

The fruit size (length 4.78-9.14 cm and breath of 5.15-9.23 cm) and weight obtained for *S. comorensis* in this study is higher compared to size (4-8 cm length and breadth 3.5-6 cm) as previously reported

by Orwa *et al.*, [1]. These morphological characteristics indicate the high potential of *S. comorensis* to have a better market. This is so because it is a well-known fact that morphological characteristics of fruits like fruit weight and fruit size are not only important in marketing of fruits but also determine the market value of those particular fruits [22, 23]. Despite these, analysis of morphological

characteristics can also help in the proper design of processing equipment for handling, sorting, processing and packaging systems for particular fruits as a way of value addition [24]. The variation in morphological characteristics of *S. comorensis* fruits revealed in this study could have come about by changes in climate and variability in weather conditions.

**Table 2:** Physico chemical and mineral composition of *Saba comorensis* compared with mango, oranges and passion fruit

Parameter	<i>S. comorensis</i>	Passion <sup>a</sup>	Mango <sup>b</sup>	Orange <sup>c</sup>	<i>Sclerocarya birrea</i> <sup>d</sup>
<b>Physico-chemical</b>					
Titration acid (mg/100 g)	5.30±0.98	2.51	0.47		0.88
Viscosity (m <sup>2</sup> /s)	53.69±7.68				
Refractive index	1.364±0.000				
pH	3.10±0.04	2.77	3.90		3.9
Total soluble solids (%)	20.00±0.00	17.4	15.95		
TSS/Acid ratio	3.77				
Moisture content (g/100 g)	74.08±0.85	82.1	83.11	87.1	85.0
Total ash (g/100g)	1.93±0.01	0.5	8.58		0.90
Crude protein (g/100 g)	4.83±0.01	0.90	4.01	0.8	0.50
Dietary fibre (g/100 g)	7.97±0.85				1.2
Crude fat (g/100 g)	0.00±0.00	0.00	0.27	0.2	0.4
Total carbohydrates (g/100 g)	19.16±0.84	16.5		6.0	13.2
Glucose (mg/100 g)	10.65±0.71				
Fructose (mg/100 g)	10.88±0.44				
Energy (Kcal)	97.78±1.61				225
Vitamin C (mg/100 g)	430.50±34.65	128.3		62.0	194
Beta carotene (mg/100 g)	1.27±0.00			345	
<b>Mineral composition</b>					
Sodium (mg/100 g)	79.0±0.35	13.0	0.56	28.0	2.24
Potassium (mg/100 g)	1493.75±321.73	2183.0	0.67	99.4	317
Calcium (mg/100 g)	209.0±0.51	94.0	0.32	25.5	20.1
Iron (mg/100 g)	3.40±0.32	0.07		0.38	0.5
Copper (mg/100 g)	0.19±0.02			0.20	
Zinc (mg/100 g)	1.80±0.01	0.13		0.48	
Magnesium (mg/100 g)	894.9±0.32	158 <sup>a</sup>	0.62	16.2	25.3
Na/K ratio	0.05				

<sup>a</sup>Jiménez *et al.* [19], <sup>b</sup>Appiah *et al.* [20], <sup>c</sup>Paul and Shaha, [15], <sup>d</sup> Amarteifio and Mosase, [21]

The fact that mass of *S. comorensis* exceeds the mass of most indigenous fruits like *Trichilia dregeana*, *Annona senegalensis*, and *Xylothea kraussiana*, makes *S.comorensis* to be a potential fruit product for both local and international market. Nevertheless, the

low fruit juice content (14.84± 8.43%) reported for *S. comorensis* in this study is much lower than for most citrus fruits such as oranges, lemon, grape fruit, mandarins, clementines which have a fruit juice

content of 30-40%<sup>[25]</sup>. This low fruit juice content for *S. comorensis* could be due to high number of fruit seeds which are attached to the fruit pulp, thus making removal of the pulp difficult. In most cases people eat both the pulp and the seeds. Developing appropriate technology for extraction of the fruit pulp from *S. comorensis* is highly recommended if it is to be processed further into various desired fruit pulp products like juice.

#### 4.2 Physico-chemical characteristics of *Saba comorensis*

Analysis of the physico-chemical composition indicates that *S. comorensis* has high moisture content, just like other IFTs<sup>[26]</sup> and the pulp is highly acidic compared to *Sclerocarya birrea*, orange and mango. The high titrable acidity of the fruit pulp can be reflected by low pH value of the pulp. Basing on the minimum pH value of 4.0, *S. comorensis* can be regarded as highly acidic fruit. Similar fruits that are highly acidic like *S. comorensis* are *Myrciaria dubia* (pH= 2.56), *Platonia insignis* (pH= 2.68), *Spondias tuberosa* (pH= 2.62)<sup>[31]</sup>, but less acidic than passion fruit (pH=3.90). The pH value also helps to determine the state of deterioration of the fruit and is therefore associated with its quality and safety. The highly acidic nature of *S. comorensis* can be a reason it is used as food preservative.

Like titrable acidity, total soluble solids (TSS) measured as brix is also very important in determining the pulp fruit quality. The value of TSS of *S. comorensis* is higher than that of passion fruit and orange pulps. Determination of TSS and acid ratio is very crucial in assessing the maturity and sweetness of the fruit<sup>[31]</sup>. According to Muhtaseb<sup>[25]</sup>, TSS/Acid ratio for grape fruit is between 5.5 and 6.0 and this value is attributed to climatic differences while Rufino *et al.*<sup>[31]</sup> reported that fruits like *Copernicia prunifera*, *Mouriri elliptica* and *Anacardium occidentale* regarded as sweetest fruit had TSS/ Acid ratio of 7.5, 75.98, and 58.79, respectively. The reason for *S. comorensis* having low TSS/Acid ratio is due to its high titrable acidity.

Most fruit pulps often contain less protein. In this study, the protein content of *S. comorensis* is comparable to that of mango (4.1 mg/100 g), but higher than that of *Sclerocarya birrea*, passion fruit

and oranges. This value is moderately high considering that fruits may not be excellent source of protein. In contrast, Chan-Blanco *et al.*<sup>[27]</sup> reported the protein of 11.3 g/100 g in *Morinda citrifolia* juice on dry matter; Ayessou *et al.*,<sup>[28]</sup> reported *Maerua pseudopetalosa* (19.26–22.06%) while Okwu and Morah,<sup>[29]</sup> reported *Dennettia tripetala* fruit as having protein content of 15.3g/100g, much higher than that of *S. comorensis*. In addition, Wilson and down<sup>[26]</sup>, reported a mean protein content of 19 indigenous fruits of South Africa as 8.2 g/100 g.

Dietary fibres have health-promoting properties as they provide roughage that aid digestion<sup>[30]</sup>, lower plasma and liver cholesterol concentration, re-absorption of bile acids, diarrhea treatment and detoxification of poisonous metals<sup>[31]</sup>. The dietary fibre of *S. comorensis* reported in this study is comparable to fibre content of *Dennettia tripetala* fruit (9.8 g/100 g), but much lower than that obtain for *Vitellaria paradoxa* (36-49 g/100 g)<sup>[32]</sup>. Nevertheless, the fibre content value for *S. comorensis* in this study makes its very important fruits in diet of man.

In general, indigenous fruits have high level of fructose and glucose<sup>[26]</sup>. The value of fructose and glucose obtained in this study is comparable to fructose (7.0 mg/100 g) and glucose (6.67 mg/100 g) of *Annona squamosa*, a highly appreciated fruit in Brazil. The high level of glucose and fructose makes *S. comorensis* a good source of energy, especially at times of hunger<sup>[4]</sup>. Glucose is a sugar administered to patients unable to feed directly through the mouth as source of energy<sup>[30]</sup>.

A part from sugars, fat is also known to provide high level of energy and can be reservoir of fat soluble vitamins too. Food with low fat content is good for obese patients as they don't require high levels of carbohydrates<sup>[31]</sup>. In this study, fats have not been found to be available in the fruit pulp of *S. comorensis*, making it a good fruit for the obese patients. However, lack of fats in *S. comorensis* results in its low energy caloric value. Even then, the total carbohydrates in *S. comorensis* are higher than that in passion fruits and oranges. This indicates that *S. comorensis* a very good fruit for the obese and diabetic patients. Since low calorie intake can reduce the amount of low-density lipoprotein cholesterol in

the liver, *S. comorensis* fruits can be good in the management of cardiovascular diseases [33].

The pulp of *S. comorensis* is also rich in  $\beta$ -carotene and vitamin C. The  $\beta$ -carotene reported in this study is much higher than that of orange juice (345 mg/100 g), mango juice (150 mg/100 g), lemon juice (50 mg/100 g) as has been reported by Paul and Shaba [15] and even that of *Dialium guineense* (362 mg/100 g), an indigenous fruit from West Africa as reported by Oladejo [31]. Moreover the value reported for  $\beta$ -carotene of *S. comorensis* is currently almost the highest value so far reported for any fruit.  $\beta$ -carotene has enormous health benefits including prevention of cataracts, and age-related degeneration of the macula [34]. Thus, *S. comorensis* consumption of its fruits should be promoted for improving the health of patients.

Although vitamin C in *S. comorensis* is higher than that of an orange fruit (72 mg/100 g) and passion fruit (22-30 mg/100 g), consumption of *S. comorensis* fruits would still be highly recommended more especially in the drier season when there is serious food scarcity as vitamin C is known to help the body to use calcium, absorb iron and also act as a good anti-oxidant.

Among the minerals present in *S. comorensis*, potassium, magnesium and calcium are the most abundant. The values of potassium in *S. comorensis* is much higher than that of passion fruits [19], and mango [15]. It is important to note that potassium is important in protein synthesis, water balance, normal functioning nervous and muscles and absorption of glucose and glycogen and magnesium in the synthesis and breakdown of carbohydrates, fats, proteins and synthesis of DNA and RNA [17]. Calcium is essential in bone structure and function. Since mineral composition of *S. comorensis* is considerably high, the consumption of its fruits is very desirable as these dietary minerals play a significant role in maintaining good health of the population.

Sodium content in *S. comorensis* is also much higher than that in passion fruits (Jimenez *et al.*, 2010), and mango [15], but much lower than that in *Dialium guineense* (270mg/100g). Iron and copper usually needed for the production of hemoglobin and as biocatalysts required for body pigmentation, respectively were also present in *S. comorensis*. Although the iron content in *S. comorensis* is much

lower than that of *Dennettia tripetala* fruit (177.5 mg/100 g) [29], consumption of its fruit should be promoted widely within the LVB as iron deficiency is the most common cause of anemia.

Another important mineral needed for normal growth and development in human beings is Zinc, because it plays an important role in the normal functioning of the immune system [35] and also is an essential requirement for the production of insulin (a hormone) and carbonic anhydrase (an enzyme in the body), thus making it very useful in the management of diabetes. In general, production of *S. comorensis* should be promoted on-farms as it also provides the needed zinc whose content is higher than that in mango and even passion fruits for management of non-communicable diseases like diabetes.

## 5. Conclusion

*Saba comorensis* can be an alternative source of essential nutrients like  $\beta$ -carotene, vitamins C and minerals e.g. potassium, calcium and magnesium to supplement those obtained from usual staple food, particularly during times of food shortages. This also makes it an important tree whose on-farm domestication should be promoted as a way of enhancing communities, adaptation to climate change effects within the LVB as it provides important nutrients for nutrition and health.

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