Vol. 17(1), pp. 1-9, January-March, 2023
DOI: 10.5897/AJPAC2022.0896
Article Number: 0D7C63570364
ISSN: 1996-0840

http://www.academicjournals.org/AJPAC

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African Journal of Pure and Applied Chemistry

Full Length Research Paper

Physicochemical and nutritional properties of *Syzygium cumini* (L.) skeels fruits grown in varied microclimates in Kenya

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Received 22 September 2022; Accepted December 30 2022

Wild fruits contribute significantly to food security, thus becoming an important global discussion. This study evaluated the physicochemical and nutritional properties of *Syzygium cumini* (L.) Skeels fruits from two microclimates in Kenya as essential contributors to the human diet. Analysis was done using standard methodologies including the use of inductively coupled plasma - optical emission spectrometer for elemental analysis and high-pressure liquid chromatography for the determination of Vitamin C. The T-test showed significant differences in the fruit breadth, pH, total ash, sodium, calcium, manganese, copper, and zinc. The Pearson correlation matrix showed a small positive association between total soluble solids and titratable acidity with altitude, a medium positive correlation with rainfall, and a strong positive correlation between sunshine and skin colour intensity. Larger fruits contained substantial amounts of protein and crude fiber with a significant increase in energy values in fruits with high crude fat and carbohydrates, all correlating positively with the microclimate conditions; altitude, and rainfall. This study exemplifies the potential of *Syzygium cumini* as an alternative feed supplement to strengthen food security. It provides information on the variation of the physicochemical and nutritional composition of the fruits with climatic conditions, for the industries to employ the best strategies in obtaining marketable products.

Key words: Food security, fruit quality, microclimate, nutritional, physicochemical, *Syzygium cumini*

INTRODUCTİON

Kenya is endowed with several underutilized wild fruits, among them is *Syzygium cumini* fruits (Figure 1) which not only have medicinal value but also nutritive properties (Ayyanar and Subash–Babu, 2012). In Kenya, they mature twice a year, January to April and June to August, depending on the climatic conditions. These wild fruits are considered significant in food security and nourishment (Sunderland et al., 2013). They are widespread in India (Khan et al., 2019), Hawaii (Whistler and Elevitch, 2006), Australia (Lim, 2012), and the

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Figure 1. *Syzigium cuminii* fruits.
Source: Authors 2023

Philippines (Columna, 2019). *S.cumini* is oval-shaped, big, or small juicy fruits depending on the environment. They are dark purple when ripe (Ayyanar and Subash – Babu, 2012) and light pink when raw. They are rich in plant chemicals that can treat cancer and the heart (Neha et al., 2020). The fruit also has a characteristic taste (Kshirsagar et al., 2019; Srivastava, 2009). It is estimated that globally, 13.5 million tonnes of these fruits are produced annually with China leading in production and India contributing 15.4% (Madani et al., 2005). All the plant parts of these trees are used for medicinal purposes (Kshirsagar et al., 2019). These fruits are nutritionally rich containing carbohydrates, crude fiber (Gajera et al., 2018), crude fats (Raza et al., 2015), high energy (Shilpa et al., 2015) and vitamins (González-Cebrino et al., 2022). Syzigium fruits also contain proteins, with about 17 amino acids reported. Arginine and histidine were dominant (0.62 mg/100g each) in the study by Sibiya et al. (2021). With its high nutritional content, *S. cumini* fruit can be used in processing and value addition of jams, juices, jellies, and wine thus contributing to food security by prolonging the shelf life of the fruit products. This study provides data on the potential of *Syzygium cumini* fruits, as low-cost alternatives to supplement normal and emergency feeding programs to strengthen food security, reduce malnutrition and mitigate chronic diseases in Kenya. It also provides important information on the quality of fruits to the industries, for them to employ the best strategies and logistics in obtaining high-value marketable products. Fruit quality parameters such as colour (Ocholla et al., 2020) and vitamins for other indigenous fruits like Baobab (Stadlmayr et al., 2020; Muthai et al., 2017; Ibrahima et al., 2013) have been studied, but so far there is no documented work for similar parameters on Syzygium species *(Mzambarau* – Kiswahili) from Kenya.

MATERIALS AND METHODS

Study sites

Syzygium cumini fruits were sampled from two different microclimatic sites in Kenya; Bungoma County covering an area of 3,032 km^2, located at latitude 00 45’ 00” N and longitude 34 35’ 00” E (Ocholla et al., 2020). The altitude is 1385 to 1441 m above sea level. Kwale County on the other hand is located on the Kenyan south coast, at latitudes 4° 10′ 0″ S and longitudes 39° 27′ 0″ E an altitude of between 382 and 408 m above sea level.

Instruments

pH meter (Horiba Advanced Techno Co. Ltd, Japan), Oven (Memmert GmbH Co. Kg, Belgium), Muffle furnace (Yamato Scientific Co. Ltd., Japan), Digital refractometer (ATAGO Co. Ltd, Japan), HPLC (Shimadzu, Japan), Food processor (Von hot point, Whirlpool, USA), ICP – OES (Agilent technologies, USA), Bomb calorimeter (Parr Instrument Co., USA).

Chemicals

About 97.0% NaOH, Phenopthalein indicator, 30% H_20_2, 37% HCl, H_2SO_4 (95 to 97%), and Metaphosphoric acid (33.5 - 36%) were purchased from UNILAB (Nairobi, Kenya). All chemicals used in this study were of analytical grade.

Fruit sampling

Three fresh and ripe fruits were purposively sampled from tree canopies oriented towards the East, middle, and west of each tree. The three were classified as large, medium, and small in size giving a total of 120 fruits from the 40 trees that were sampled in each County. The positions of the trees were recorded using a Global positioning system (GPS) for future reference. The two sites (Counties) were selected due to their varied geographical location. The ripe fruits once picked were immediately transferred to the laboratory, washed, and de-pulped to separate the seeds from the

edible portions. The fresh samples were used for analysis except for moisture content where the samples were oven-dried.

Physicochemical properties

Fruit size and skin color

Fruit size was determined by measuring the lengths and breadth using digital veneer calipers, as described by Jahanbakhshi et al. (2019). The fruit's skin colour was measured using a handheld and portable Konica Minolta, CR 410 Colorimeter that was calibrated against a white background before taking measurement. The measurements for fruit skin colour were taken at three different points along the equatorial axis of each fruit. CIELab colour space was used to record the colour coordinates L^* (lightness to darkness), a^* (red to green), and b^* (yellow to blue) as described by Ly et al. (2020).

Determination of fruit juice pH

Determining the pH of fruit samples was done by separating fruit pulp from the seeds and juice extracted from 50 g of the edible portion using a food blender. The pH of the juice was determined using a LAQUA pH meter F-72, calibrated according to AOAC method 942.15 (AOAC, 2000).

Determination of moisture content

Moisture content was determined by weighing 3 g of fresh Syzygium fruits which were then placed in weighed crucibles and oven dried at 105°C for three hours. The crucibles were cooled and weighed. They were returned to the oven, heated, cooled, and reweighed, a process that was repeated until a constant weight was obtained. Equation 1 shows the calculation of moisture content of fresh fruit samples as described by Bahadi et al. (2016).

$$\% \text{ moisture} = \frac{\text{Weight of crucible + dried fruit sample} - \text{Weight empty crucible}}{\text{Weight of crucible + fresh fruit} - \text{weight of empty crucible}} \times 100 \quad (1)$$

Determination of ash content

About 3 g of the oven-dried *Syzygium* fruits were ashed in a Muffle furnace at 470°C for three hours followed by digestion in nitric acid and hydrochloric acid in the ratio of 2:1. The residue was evaporated and filtered using filter paper as reported by (Bukva et al., 2019). The ash content was calculated as shown in Equation 2.

$$\text{Ash content (\%)} = \frac{\text{Weight of crucible (g) + ash} - \text{Weight of empty crucible(g)}}{\text{Weight of crucible (g) + sample} - \text{weight of empty crucible (g)}} \times 100 \quad (2)$$

Determination of total soluble solids (°Brix)

Total soluble solids were determined by direct reading from fruit Juice using a digital refractometer ATAGO PR – 101α at 25° C. Two drops of fruit juice per fruit were analyzed according to AOAC method 932.12 (Scalisi, 2021).

Determination of % Titratable acidity (TA)

10 g of the fruit pulp was mixed with 200 mL of de-ionized water and boiled for one hour. On cooling, the mixture was filtered, transferred to a 250 mL volumetric flask, and made up to the mark. The fruit juice was titrated with NaOH (0.1M) and 1% phenolphthalein indicator then % TA was calculated considering tartaric acid which is the dominant acid in Syzygium fruits, as shown in Equation 3.

$$\% \text{ TA} = M_2 \times V_2 \times E^1 \times \text{d. f} \times 100/V_s \quad (3)$$

Where; M_2 = Molarity of NaOH, V_2 = volume of NaOH, E_1= milli-equivalent weight of tartaric acid (0.075), V_s = volume of Syzygium juice, d. f. = dilution factor.

Titratable Acidity was determined according to the method by Tsegay (2020). The results were expressed as % tartaric acid/100 g of fresh fruit.

Determination of mineral content

Fruit samples were prepared by first de-pulping and juicing using an HP2050W (China) domestic food processor. Analysis was done for heavy metals namely; cadmium, manganese, chromium, zinc, and copper. Other minerals are; sodium, iron, magnesium, and calcium. 0.8 mL of Syzigium fruit juice was mixed with an equal amount of nitric acid (ANALAR) in separate vials, and then the mixture was allowed to pre-react for 30 mins in a fume chamber. 0.6 ml 30% H_2O_2 was then added and samples were placed in closed Teflon receptacles for digestion using a microwave for 35 mins at a temperature of 180°C and maintained at the same temperature for 20 mins. Samples were cooled and further diluted tenfold. 1 mL of each sample was spiked by an internal standard to give 0.5 mg/L yttrium, and 1 mL of 1% triton was then diluted to 10 ml by 0.075% nitric acid. Blank samples were made using nitric acid to 500 µL and diluted as in the multi-elemental standards. Analysis was done using an Agilent 5110 Inductively Coupled Plasma - Optical Emission Spectrometer (ICP - OES) with a detection limit of between 0.01 to > 1 ppm, following the method described by Hong et al. (2019).

Nutritional properties

Determination of protein content

The crude protein was determined using the Kjeldahl method (AOAC, 2006), method 984-13. 2 g of fresh Syzygium fruit pulp was placed in a 100 mL Kjeldahl flask adding 1 g Kjeldahl catalyst mixture of sodium and copper sulphate, followed by 15 mL of concentrated sulphuric acid. The mixture was digested on a heater to clear color, cooled, and made up to 50 mL using distilled water. The resulting solution was ammonium sulphate which was then titrated with 10 mL of sodium hydroxide, 4% boric acid, and three drops of mixed indicator forming ammonium borate. The distillate was titrated with 0.1 M hydrochloric acid and then mixed with the indicator that was used to determine the endpoint (blue). Similarly, a sample without fruits was subjected to the same treatment. Nitrogen (N) content was calculated as seen in Equation 4.

$$\% \text{ N} = \frac{\text{HCl (M)} \times \text{blank titre} \times 0.014 \times \text{volume of blank}}{\text{Weight of fruit sample} \times \text{used volume of blank}} \quad (4)$$

Equation 5 shows how the crude protein was calculated using nitrogen content multiplied by a conversion factor of 6.25;

$$\% \text{ crude protein} = \% \text{ Nitrogen} \times 6.25 \quad (5)$$

Determination of crude fat

Crude fat was determined using the Soxhlet system. 3 g of fresh fruit pulp was weighed into a clean thimble and the weight of both was also noted. The top of the sample was covered using cotton wool and a thimble was placed in the Soxhlet flask which was placed in a heating mantle and connected to a reflux condenser. 0.15 L of petroleum ether was added to the thimble and extraction was undertaken for 16 hours. The sample was then placed in an oven at 100 ^{o}C, dried for one hour, cooled, and weighed. Determination was done in triplicates and the average was used to calculate crude fat content using Equation 6.

$$\text{Crude fat (\%)} = \frac{\text{Final weight of thimble and residue} - \text{Weight of empty thimble}}{\text{Weight of fresh fruit pulp}} \quad (6)$$

Crude fat was extracted following the (AOAC, 2006) procedure, method number 920-39.

Determination of crude fiber

The crude fiber was determined according to method No. 978-10 (AOAC, 2006) procedures.
2 g extract from crude fat was placed in a round-bottomed flask, then 0.2 L hot 0.1 M H_2SO_4 was added. This unit was attached to a reflux condenser for 30 minutes, with the addition of distilled water to maintain the volume. The extract was filtered using filter paper, washed with hot water, and tested for acidity until litmus paper does not turn pink. The washed extract was mixed with hot 0.3 M sodium hydroxide and refluxed for 40 mins., filtered using filter paper, washed with distilled water, and finally with 20 mL ethanol. The sample was then placed in an oven at 105°C until a constant weight was obtained. The resulting sample was ashed in a muffle furnace at 470°C for three hours. The loss in weight was recorded as the amount of crude fiber in the fruits following the procedure (Ranganna, 2001).

Determination of energy content

One gram of fruit sample was wrapped in an ash-less paper, fastened with a wire, and placed in a stainless steel sample holder which also contained a platinum wire dipping in the sample and held together by two electrodes. Excess oxygen was pumped into the vessel containing the cap to a pressure of 25 atm. The tightly closed container was immersed in an insulated water bath fitted with a stirrer and thermometer noting the initial temperature of the water. Incineration was done by completing the circuit allowing electricity to go through the platinum wire thus combusting the sample. The stirring of the water was continued, and the final temperature after combustion was noted. This procedure followed what was described by Núñez-Regueira et al. (2001).

Calculation of energy content/calorific value of *S. cumini* fruits was done as shown in Equations 7 and 8. Let:

'X (g) = weight of fruit sample
M (g) = weight of water in the calorimeter
ω (g) = Water equivalent
T_1 and T_2 (°C) = Initial and final water temperatures in the calorimeter respectively
L (Cal/g) = High calorific value of fruits
Heat dissipated on combustion of fruits = XL
Absorbed heat during the combustion process = $(M + \omega)(T_2 - T_1)$

Since the heat dissipated by the fruits is equal to what is absorbed by the water, Equation 8 shows the combination.

$$XL = (M + \omega)(T_2 - T_1) \quad (7)$$

$$\text{High Calorific Value, L(Cal/g)} = (M + \omega)(T_2 - T_1)/X \quad (8)$$

HCV is corrected due to errors introduced by fused wire that burns increasing heat (CF), and cooling time for the water (CT), the cotton thread used for fire is made of cellulose whose CV is 4140 Cal/g (CT). Due to high temperatures and pressure during the ignition, nitrogen, and sulphur present in the fruits reacted forming sulphuric and nitric acids, (CA).

L benzoic acid = 6335 Cal/g
The corrected equation is as shown in Equation 9.

$$L(Cal/g) = (M + \omega)(T_2 - T_1 + CT) - (CF - CcF - CA)/X\ \% \quad (9)$$

Determination of carbohydrates

The amount of carbohydrates in the fruits were obtained by subtracting the moisture content, crude proteins, ash, crude fat, and fiber from 100, and recorded as a percentage (Serrem et al., 2011).

Determination of Vitamin C content

Vitamin C was determined by dissolving 30 g per sample of the edible portions of fresh fruits in 80 mL of metaphosphoric acid and washed before filtration using a vacuum pump. Analysis was done using a Shimadzu LC20A HPLC system equipped with an SPD 20A Ultra Violet detector at 254 nm, column length of 2 m, and the concentration of vitamin C was determined according to the method by Zanini et al. (2018).

Statistical analyses

Results were obtained in triplicates and presented as mean ± standard error of the mean. All the data were analyzed by R 4.1.1 software and the Turkeys test was used to determine significant differences between the microclimate and *S. cumini* fruit parameters in the two counties at $\rho < .05$. Pearson's correlation matrix was used to present the relationship between any two variables.

RESULTS AND DISCUSSION

Climatic conditions

All the documented climatic parameters in this study except sunshine significantly varied between the two counties at $\rho < .05$ (Table 1). Table 2 shows variations in the physicochemical and nutritional content of *S. cumini* fruits at $\rho < .05$, within the two counties. Fruit sizes were slightly different between the sites with fruit breadth ranging between 15.62 ± 1.04 and 16.24 ± 0.67 mm. The widest fruits were collected from Kwale County. These values are higher than the 10.38 ±0.94 mm reported by Prasajith et al. (2019). The variation may be a result of the difference in climatic conditions (de Wit et al., 2010). There was no significant variation in Total Soluble Solids between the two counties, TSS which is the sugar content in fruits varies with their maturity, one of the

Table 1. Climatic conditions for Bungoma and Kwale counties, Kenya (2018 - 2021).

Site	Mean rainfall (mm)	Mean temperatures (°C)	Relative humidity (%)	Sunshine (%)
Bungoma	1700	21.89	59.82	63.47
Kwale	1032	25.72	72.57	66.29
R - score	0.8909	0.951	0.8638	0.6999
ρ - value	0.001	< 0.001	0.001	0.1127

Source: Authors 2023.

Table 2. Physicochemical and nutritional content of *S. cumini* fruits from Bungoma and Kwale Counties, Kenya.

Parameter	County		T value	ρ -value	Significance (ρ < .05)
	Bungoma	Kwale			
Fruit weight (g)	4.09 ± 0.8	4.56 ± 0.69	-1.61	0.05	n.s
Fruit length (mm)	23.38 ± 6.5	25.52 ± 1.27	-0.22	0.41	n.s
Fruit breadth (mm)	15.62 ± 1.04	16.24 ± 0.67	-1.70	0.04	*
Color					
L*	33.63 ± 0.01	32.84 ±0.09	0.90	0.18	n.s
a*	78.88 ± 0.04	79.43 ±0.06	-0.16	0.44	n.s
b*	-31.51 ± 0.37	-30.9 ±1.44	-0.19	0.42	n.s
C*	82.22 ± 0.01	87.4 ±0.02	-0.67	0.25	n.s
Moisture content (%)	86.12 ± 1.78	85.36 ± 0.35	1.52	0.06	n.s
Ash content (%)	1.61 ± 0.02	2.74 ± 0.01	-7.47	< 0.001	*
pH at 25°C	3.5 ± 0.0	3.16 ± 0.01	11.27	< 0.001	*
TSS (^{o}Brix at 25°C)	14.27 ± 0.1	15.05 ± 0.18	-1.07	0.14	n.s
Titratable acidity (%)	0.74 ± 0.01	0.78 ±0 .02	-1.14	0.13	n.s
Vitamin C (mg/100 g)	246.81 ± 0.1	353.61 ± 1.22	-1.57	-0.06	n.s
Crude fat (mg/100 g)	0.46 ± 0.14	0.49 ± 0.24	- 0.54	0.29	n.s
Crude fibre (mg/100 g)	0.96 ± 007	0.99 ± 0.09	- 0.19	0.43	n.s
CHO (mg/100 g)	19.46 ± 4.56	20.1 ± 1.82	- 0.47	0.32	n.s
Energy (Kcal/mol)	332.1 ± 0.0	334.24 ± 3.67	- 0.24	0.40	n.s
Protein (mg/100 g)	1.38 ± 0.12	1.53 ± 0.14	-0.94	0.17	n.s

n.s = no significant difference, * = significant difference, L^{*} = dark to bright scale, $^{+}$a = red and $^{-}$a = green, $^{+}$b = yellow and $^{-}$b = blue, C* = Fruit skin colour intensity.
Source: Authors 2023.

physiological factors, affecting the fruit flavour as reported by Ikegaya et al. (2019). The pH of fruits from Bungoma was significantly higher (3.5 ± 0.0) than that of fruits from Kwale (3.16 ± 0.01). In comparison, *S.cumini* pH values of 3.77 and 3.87±0.01 (Akhila and Umadevi, 2018; Ghosh et al., 2017), 3.60±1.9 for oranges, 2.34±1.8 for lemons, and 3.60 to 4.30 for red plums (Irkin et al., 2015) have been reported. Ozgen et al. (2008) attributed the variation in pH values of pomegranate fruits to genotypic and site factors. The correlation matrix shows positive correlations between fruit total soluble solids and titratable acidity with altitude (0.18, 0.25) and rainfall (0.33, 0.36) respectively in the fruit samples from both counties. Long exposure to sunshine also showed a positive correlation (0.94) with fruit skin colour intensity (C*) and vitamin C content (0.46). Larger fruits contained significant amounts of protein (0.98) and crude fiber (0.97), with a significant increase in energy values noted in fruits with high crude fat and carbohydrates as shown in Figure 2.

The ash content values varied significantly between the two counties as seen in Figure 3. High mean ash contents of 2.74 ± 0.01 % were reported from Kwale fruit samples, while 1.61 ± 0.02 % was reported from Bungoma fruit samples. Variation in total ash is an indication of varying mineral compounds and determines the fruit flavour, physical form, and rate of deterioration in the sample (Rehman et al., 2014). The values obtained

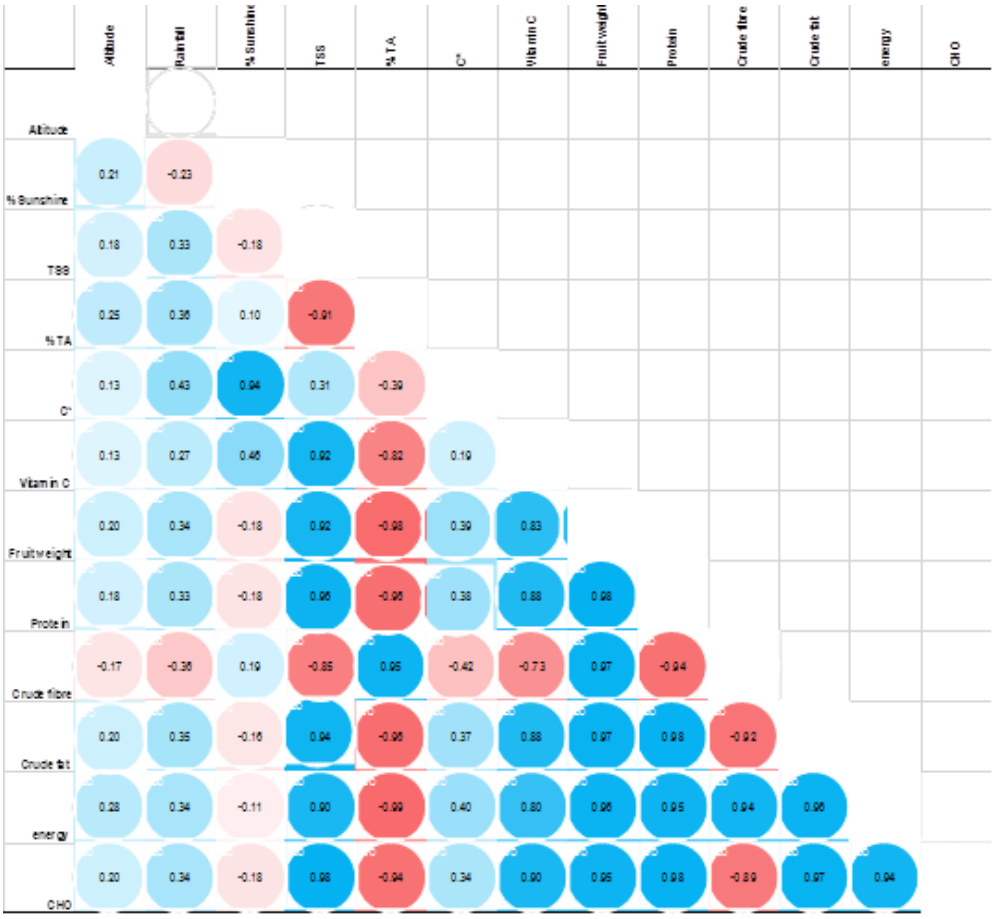

Figure 2. Correlation matrix for microclimatic conditions and *S.cuminii* quality. B= Bungoma, K= Kwale, TSS= Total soluble solids, TA = Titratable acidity, CHO = Carbohydrates, C* = Color intensity, = Strong positive correlation, = Strong negative correlation.
Source: Authors 2023.

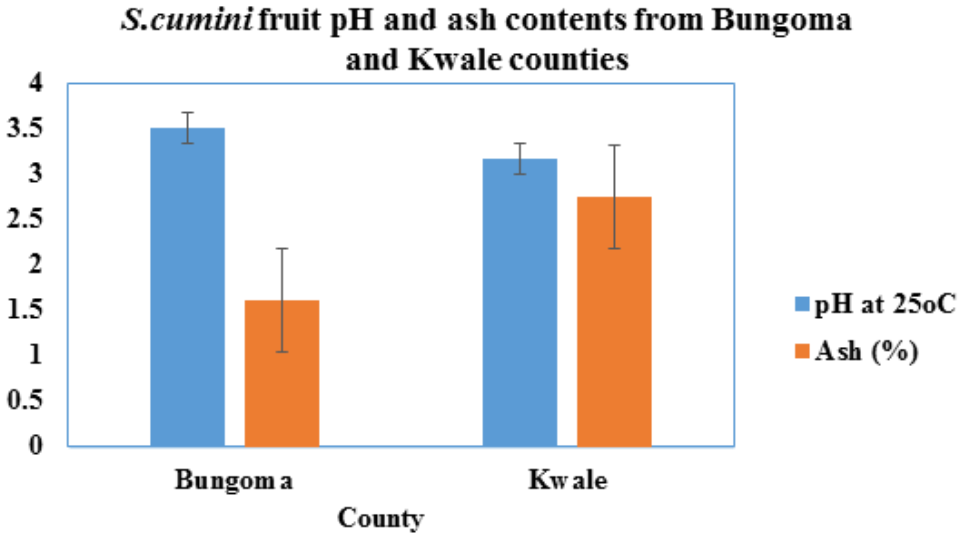

Figure 3. Variation of *S. cumini* fruit pH and ash contents from Bungoma and Kwale Counties.
Source: Authors 2023.

Table 3. Mineral composition of *S. cumini* fruits from Bungoma and Kwale Counties.

Parameter (mg/kg)	County		t - Value	ρ -Value	Significance (ρ < .05)
	Bungoma	Kwale			
Na	112.56 ± 0.07	348.63 ± 0.05	7.76	<0.001	*
Mg	243.67± 0.16	175.13 ± 0.15	2.71	0.001	*
Mn	55.57 ± 0.13	19.27 ± 0.17	5.29	<0.001	*
Fe	58.58 ± 0.06	26.33 ± 1.1	- 0.76	0.22	n.s
Cu	17.72 ± 0.08	7.76 ± 0.03	7.05	<0.001	*
Zn	6.95 ± 0.28	4.3 ± 0.37	2.79	0.001	*
Ca	15.51 ± 4.31	9.91 ± 0.39	-0.39	0.35	n.s
K	857.71 ± 4.8	841.67 ± 2.5	-0.44	0.33	n.s
P	21.22 ± 1.08	22.29 ± 1.02	-0.51	0.30	n.s

N = 40, results expressed as mean ± Standard error. n.s = no significant difference at p < .05, * = significant difference. Cr and Cd were not detected by the ICP OES, their limit of detection (LOD) were 0.003 and 0.001 ppm respectively.
Source: Authors 2023.

are higher than 0.365 % and 0.32 - 0.45 % reported by Akhila and Umadevi (2018) and Mayuri et al. (2019) respectively. The obtained ash values were confirmed by the average mineral content in the fruit samples as seen in Table 3. Na, Mg, Mn,Cu, and Zn contents from Bungoma and Kwale counties varied significantly (ρ < 0 .05). There was no significant difference in fruit colour between the sites. Fruit colour is one of the key external factors that determine fruit quality, as the appearance of the fruit greatly influences consumers' preferences (Agrawal et al., 2017). Vitamin C content also did not vary significantly between the study sites with 246.81 ± 0.1 and 353.61 ± 1.22 mg/100g fruit samples being reported from Bungoma and Kwale counties respectively. However, Akhila and Umadevi (2018) reported lower values of 194 mg/kg, while 55.6 ± 0.56 mg/kg was reported by Khandaker et al. (2015). The large variability is because vitamin C is labile and easily dissociates to hydro-ascorbic acid (Tu et al., 2017). The vitamin content of raw fruits was higher than that of ripe ones, and the levels vary depending on the length of exposure to sunlight and temperatures (Igwe, 2013). As an antioxidant, vitamin C improves the human immune system (Cerullo et al., 2020). Other parameters analyzed in this study but did not significantly vary between the sites include; Crude protein, carbohydrates, energy values, crude fat and fiber, titratable acidity, moisture content, fruit weights, and length.

The dominant mineral in fruit samples from both counties was Mg (macro element) with a mean of 243.67 ± 0.16 mg/kg reported from Bungoma and 175.13 ± 0.15 mg/kg from Kwale showing a large significant difference between the two sites. (Adeyemi and Oladiji, 2009) reported that Mg content is higher in immature fruits. As shown in Table 3, the least dominant mineral was Zn with *S. cumini* fruits from Bungoma varying greatly at (ρ < .003) with those from Kwale. Zinc values of 0.4 ± 0.00 (Mapunda and Mligo, 2019) and 13.6 ± 0.01mg/kg (Bhat et al., 2010) have been reported. Zinc is broadly involved in catalysis, cell structure formation, and regulation of body processes (Wang et al., 2021). Relative Dietary Allowance (RDA) for Zn is 8 mg/day for women and 11 mg/day for men. 1 kg of Syzigium fruits contains more than the required Zn per day. There was a significantly large variation in the copper content of the fruits between the counties (ρ<0.0001), with Kwale reporting a low of 7.76 ± 0.03 mg/kg. RDI for Cu is 3.9 µg/100 g hence Syzygium fruits meet this requirement. Cu is used by the body in the formation of red blood cells. Cadmium and chromium were below detectable limits in both Counties, indicating that the fruits are safe for human consumption. However, Khamis et al. (2021) reported Cd levels of 3.39 to 8 mg/kg and Cr levels of 10.3 to 16.25 mg/kg in clove spices from Zanzibar. Previous studies reported the following mineral concentrations in *S.cumini* fruits; Na: 117.3±1.70, Mg: 271.3±3.43, Cu: 18±0.41, Mn: 20±0.007 and Cr 10.6±0.13 (Madani et al., 2005). 2.4, 11.3, 627.2, 96, 321, and 1.8 mg/kg for Cr, Cu, Mg, Mn, Na, and Ni were reported by Ghosh et al. (2017). In this study, Syzygium fruits from Bungoma were reported to have higher Na and Mg content than exotic fruits namely; Apples, Na; Mg (1.08; 50. 42), Peach (9;125), oranges (0; 9.8), pears (120; 4.9), and pineapples (1.69;118 mg/kg respectively (Dehelean and Magdas, 2013). The variation in quality parameters reported in other studies may be a result of the difference in genetic, fruit maturity stage (Bertin, 2018), and environmental factors (Ansari and Ramjan, 2018).

Conclusion

The results from this study show that *S. cumini* like other indigenous fruits is a good source of fundamental

nutrients required for human health and wellness. There was significant variation in the physicochemical; fruit breadth, ash, pH, and essential minerals; Na, Mg, Mn, Cu, and Zn, with the varying microclimatic environment. There was also a positive correlation between microclimatic conditions and fruit quality parameters. The fruits have more than adequate minerals compared to apples, peaches, pears, oranges, and pineapples. The varying mineral compounds are an indication of the difference in fruit flavour, physical form, and the rate of deterioration among the samples in the two sites. The Fruit pulp can be value-added to make juices, Jam, and wine for small and medium enterprises and the fruit product industries to improve livelihoods and address food security.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

ACKNOWLEDGMENTS

The authors appreciate KEFRI – Karura technologists; Norman Wachira and Nathan Maitha for their assistance in the use of High-Performance Liquid Chromatography (HPLC) and the intern Maureen Wambui in the collection of fruits from the field. They are also grateful for the funding of this research by The Government of Kenya through Kenya Forestry Research Institute (KEFRI), 2019/2020 and 2020/2021 financial year Work plans.

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