

Assessment of Bio-Preservative Effects of Aqueous and Ethanolic Extracts of *Syzygium Guineense* Leaves on The Nutritional Composition of Tomato Fruit

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Abstract: The search for natural bioactive compounds that can serve as alternatives to synthetic preservatives has also double-paced. This study investigates the preservative efficacy of *Syzygium guineense* leaf extracts on the proximate and mineral composition of Tomato fruits. The proximate and mineral analyses of tomato fruits preserved by *S. guineense* leaf extracts were determined. A significant decrease in the Potassium, Magnesium and Sodium contents of the preserved tomatoes at 4°C were also observed, while the percentage of Calcium increased. Preserved tomato shows a lower considerable loss in the Moisture (from 90.99 to 87.86%), Crude fibre (from 0.39 to 0.32) and Carbohydrate contents (from 3.81 to 2.55). Preservative study revealed that ethanolic extract of *S. guineense* extends the shelf of tomato at 25°C and 4°C beyond 14 and 21 days respectively while the control samples showed a rapid deterioration in texture, colour and weight within 7 and 16 days respectively. There was significant difference in both the proximate and mineral composition of the treated and control tomato samples. Hence, the crude or fractionated components of *S. guineense* leaf extracts may serve as alternative preservative agents to synthetic preservatives in extending the shelf life of tomato fruits.

Key words: *Syzygium guineense* leaf, extracts, tomato fruits, preservative.

I. Introduction

Fruits play a vital role in human nutrition by supplying the necessary growth factors such as vitamins and essential minerals in human daily diet and that can help to keep a good and normal health (Al-Hindi *et al.*, 2011). One of the limiting factors that influence the fruits economic value is the relatively short shelf-life period caused by pathogens attacked. It is estimated that about 20-25% of the harvested fruits are decayed by pathogens during post-harvest handling even in developed countries (Droby, 2006; Zhu, 2006). Tomato (*Lycopersicon esculentum* Mill.) is the second most important vegetable worldwide, in terms of the amount of vitamins and minerals it contributes to the diet (Sozzi and Frascina, 1997). The primary cell wall of fruit is composed of approximately 10% proteins and 90% polysaccharides, which can be divided into three groups: cellulose, hemicellulose and pectin (Nathalie, 2006). Numerous cell wall degrading enzymes can be secreted by pathogens to breach the plant cell walls and use them as nutrient sources that reduced post-harvest life and finally lead to develop inedible, undesirable quality and soft rot spoilage (Raviyan *et al.*, 2005; Netsanet *et al.*, 2009; Al-Hindi *et al.*, 2011).

In developing countries, post-harvest losses are often more severe due to inadequate storage and transportation facilities. Fungal fruits infection may occur during the growing season, harvesting, handling, transport and post-harvest storage and marketing conditions, or after purchasing by the consumer. Fruits contain high levels of sugars and nutrients element and their low pH values make them particularly desirable to fungal decayed (Singh and Sharma, 2007). Studies by Li-Cohen and Bruhn (2002) had shown that fungi can survive and/or grow on fresh produce and that the nutrient content (carbohydrate, protein and fat) of fresh produce support pathogens.

Numerous microbial defects (signs and symptoms) of agricultural crops are characterized by the types of microorganism responsible for the deterioration; the process of infection in the case of fungal invasion follows the development of fungal penetrating structure (appressorium). Colonization of fungi is a critical phase in the microbial spoilage of post harvested fruits. The colonization process involves the ability of the microorganism (fungi) to establish itself within the produce (host). This is initiated when fungi (following adhesion and release of enzymes) depolymerises certain specific cell wall polymers (such as protopectin, the cementing substance) of the produce (Snowdon, 1991). Susceptibility of fruits and vegetables is largely due to differential chemical composition such as pH and moisture contents. The higher pH (near neutrality) and moisture contents are associated with their greater predisposition to fungal spoilage. The occurrence of fungal spoilage of fruits is also recognized as a source of potential health hazard to man and animals. This is due to their production of mycotoxins (naturally occurring toxic chemical often of aromatic structure) compounds which are capable of including mycotoxicoses in man following ingestion or inhalation. They differ in their degree and manner of toxicity (Effiuvwevwere, 2000). The contamination of fruits and vegetables by fungi could also be as a result of poor handling practices in food supply chain, storage conditions, distribution, marketing practices and transportation (Effiuvwevwere, 2000). Post-harvest fruit quality depends on textural durability during storage, nutritional and sensory attributes. The practice of harvesting many fruit prior to softening and full maturity, to improve resistance to damage during handling and shipping has resulted in crops that typically fail to accumulate the full complement of nutrients. Thus, if softening could be uncoupled from other ripening-related

processes, fruit could be harvested at a later stage, resulting in commodities with substantial resistance to over softening and a dramatically enhanced flavor and nutritional and commercial value (Lytoychenko *et al.*, 2009).

In developing countries, losses of fruits and vegetables during post-harvest fluctuate between 20 and 50% (Kader, 1992). Microbial Spoilage is manifested by a variety of sensory cues such as off-colours, off-odours, off-flavours, softening of vegetables and fruits, and slime. However, even before it becomes obvious, microbes have begun the process of breaking down food molecules for their own metabolic needs. Sugars and easily digested carbohydrates are used first, plant pectins are degraded. Then proteins are attacked, producing volatile compounds with characteristic smells such as ammonia, amines, and sulfides. This may be accompanied by the production of a wide range of metabolites which includes: alcohols, sulphur compounds, ketones, hydrocarbons, fluorescent pigments, organic acids, esters, carbonyls, diamines (Doyle, 2007).

Postharvest loss can be defined as a measurable quantitative and qualitative loss of a given product at any moment along the postharvest chain (Delucia and Assemato, 1994). Postharvest losses include the rotting of produce and damage during storage, packaging and transportation which leads to consumer rejection (Kader and Rolle, 2004). Most losses and wastes occur in the latter part of the food chain through excessive processing, packaging and marketing (FAO, 2008). Postharvest loss is much more painful and costlier than pre harvest loss both in terms of money and man-hours (Dasgupta and Mandal, 1989). Postharvest losses which decrease returns on fruits and vegetables occur mainly because of lack of infrastructure, poor handling and marketing knowhow (Prigojin, *et al.*, 2004). The magnitude of losses depends on the nature of the commodities, the condition of the produce at the time of collection, distance travelled and the nature of the road network. The principal causes of losses are physiological deterioration, mechanical damage and pathological damage (Kader and Rolle, 2004). According to Adeoye *et al.* (2009), pathological damage constituted the greater percentage (44%) of losses in a particular variety of tomatoes in Ibadan.

Syzygium guineense is a leafy forest tree of Myrtaceae family. It is found in many parts of Africa both wild and domesticated. *Syzygium guineense* (Water berry tree) is a dense, leafy forest tree around 30 meters high. It has flaky bark which is grayish-white in colour. Its leaves are broadly lanceolate, opposite and entire to the branch. Its fruit are ellipsoid drupe and purplish in colour (Bekele, 1993; Abebe *et al.*, 2003). Its fruit is used as a remedy for dysentery, while a decoction of the bark is used for treatment of diarrhea (Hamil *et al.*, 2000). The fruit can be made into a beverage, vinegar and added to spirits for flavouring. In Sudan, a meal is made from roasted and ground fruits. The bark is used for tanning and dyeing. Bark extracts are sometimes used to harden lateritic floors or to glaze pottery. The leaves and fruits are used as fodder for livestock, and the flowers are a source of nectar for honey bees.

Traditionally the decoction of the bark of the plant was used in treatment of diarrhea (Abebe *et al.*, 2003) and also the twigs and aerial roots are used for different stomach ailments (Kassu, 2002). *Syzygium guineense* was reported to have potent antibacterial effect against diarrhea causing bacteria (Tsakala *et al.*, 1996). Plants and plant extracts have been used since antiquity in folk medicine and food preservation, providing a range of compounds possessing pharmacological activities (Deans and Svoboda, 1990).

The search for natural bioactive compounds that can serve as alternatives to synthetic preservatives such as butylatedhydroxyanisole (BHA) and butylatedhydroxytoluene (BHT) had double paced. The reason for this is the restriction of the use of synthetic preservatives due to their carcinogenicity (Velioglu *et al.*, 1998). Antimicrobials from medicinal plants which are currently underutilized may be the answer to this. This is because plants with antimicrobials have been used by humans for ages and are known to be safe. There is therefore, need to investigate the preservative efficacy of *S. guineense* leaf extracts to replace the chemical preservative approach which had been implicated to have several side effects such as carcinogenesis, mental disorder and ageing among others.

II. Materials and Methods

Collection of Plant Materials

Fresh leaves of *Syzygium guineense* were collected from Federal University of Technology, Akure. The leaves were identified and authenticated at Department of Crop, Soil and Pest Management of the Federal University of Technology, Akure.

Collection of Tomato fruits

Tomato (*Lycopersicon esculentum* Mill.) fruits were purchased from Shasha market in Akure, Ondo state into a sterile plastic container and transported into the laboratory for analysis. At the laboratory, healthy fruits were sorted out to obtain homogeneous batches based on colour, size, texture, and absence of bruises. Fruits were selected to obtain samples ranging from 80g to 85g.

Preparation of Extracts of *Syzygium Guineense* Leaf

This was carried out as described by Alade and Irobi (1993) with minor modifications. The fresh leaves of *Syzygium guineense* were air dried at room temperature (25°C to 27°C). The leaves were grinded into coarse powder using a mortar and pestle and were further reduced to fine powder using an electric blender (MarlexElectrolyne IS: 250). The powder was transferred into grease free, airtight containers to avoid absorption of moisture. Leaf sample (400g) was weighed into different solvents (Ethanol and water). The mixtures were left covered in the laboratory for 72 hours and stirred every 24 hours using a sterile glass rod. Each mixture was then filtered using three-fold sterile muslin cloth and the filtrates were allowed to air dry in order to obtain crude extract. The crude

extracts were reconstituted and sterilized using membrane filter (0.2µm) before use. The recovery rate of extract was calculated using the formular below.

$$\% \text{ Recovery of Extract} = \frac{WA}{IW} \times 100$$

IW= Initial weight of extracts, WA= Weight of extracts recovered after extraction

Treatment of Tomato Samples

The method of Martinez-Romeo *et al.* (2003) was used with slight modification. Apparently healthy tomato samples were coated with the aqueous and ethanolic leaf extracts of *Syzygium guineense* while some were also immersed in distilled water and ethanol to serve as negative and positive controls respectively. Following treatment, all clusters were air dried for 10mins before storage at refrigerator temperature (4°C) and ambient temperature (28±2°C) for 28 days. Samples from both treated and control clusters were taken for proximate and mineral analyses at interval to determine the biopreservative efficacy of the extracts.

Proximate Analyses

Determination of moisture content

Clean, well labeled and dried petri dishes were oven dried at selected drying temperature, weighed and their respective weight recorded (W1). Two grams of each tomato samples were weighed into respective dishes (W2), spread as much as possible and then transferred into desiccators immediately to prevent absorption of moisture from the atmosphere. The dishes containing the samples were transferred from desiccators into the oven at 105°C and dried for 3 hours. After 3hours, they were cooled in the desiccators for 30 minutes and reweighed. The process of heating, cooling and weighing were continued until a constant weight (W3) was obtained (AOAC, 2019).

$$\% \text{ Moisture content} = \frac{W_1 - W_3}{W_2 - W_1} \times 100$$

Determination of ash content

Clean dried crucibles were weighed (W1). One gram of each sample was put into separate crucibles and weigh (W2). The crucibles were then heated in the muttle furnace set at 500°C. Heating was continued until a light grey or white ash was obtained. The crucibles were removed from the furnace, cooled in desiccator to room temperature and weigh (W3). Cooling and weighing were continued until a constant weight was obtained (AOAC, 2019). Percentage ash content was calculated as shown below.

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Determination of Crude fibre

Sample (1g) was put inside clean, dried and well labeled conical flask and weigh (W1). Two hundred milliliter of 1.25% H₂SO₄ was added to the samples in the conical flask and boiled for 30 minutes. The solution was filtered (to remove fat and sugar) and the residue was put back into the conical flask and distilled water was used to rinse it. Two hundred milliliter of 1.25% NaOH solution was added to each samples and heated to boil for 30 minutes. The boiled sample was filtered with ethanol and 10% HCl was thereafter added to rinse it. The residue of each samples were put in the oven for 3 hours at 105°C. The samples were removed and washed and weighed as W2. The samples were then ashes in the furnace for 3 hours at 500°C. The samples were removed, cooled in the desiccators and weighed as W3 (AOAC, 2019). The percentage crude fiber content was calculated as shown below.

$$\% \text{ Crude fibre content} = \frac{W_2 - W_3}{W_1} \times 100$$

Determination of Fat content

Filter paper were weighed (W1) and 1g of each sample was weighed into the filter paper, wrapped neatly with thread and weighed (W2). The filter paper with the sample was inserted into soxhlet apparatus and extracted under reflux which was carried out using petroleum ether (40-60% boiling range) for 6 hours. At the end of the extraction, the filter paper and their contents were dried in the oven for about 30 minutes at 100°C to evaporate the solvent and weigh (W3). The percentage fat content was calculated by the formular below (AOAC, 2019).

$$\% \text{ Fat content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Protein determination

Sample (0.5g) was weighed into a 50 ml kjehlda digestion flask. Concentrated H_2SO_4 (10ml) was added into the flask and a tablet of selenium catalyst was added. The mixture was heated at $105^{\circ}C$ in the block digester in a placed in a fume cupboard until a clear solution was formed. The flask was rotated at intervals until the digest was clear. The digest was allowed to cool and then transferred into 100ml standard flask making it up with distilled water and then transferred to the distillation unit. A 100ml volumetric flask containing 5ml of 2% boric acids and 5 drops of mixed indicator (0.016g methyl red + 0.083g bromocresol green in 100ml alcohol) was placed under the condenser. Four percent NaOH (1.5ml) was added to the digest in the reaction vessel via the funnel and ensuring it was alkaline by forming a cloudy solution. Steam from steam generator was passed into the reaction vessel with all outlets closed to prevent suck back. The tip of the condensing unit was dipped into receiving flask and distillation was allowed to continue until 50ml of distillate has been collected into receiving flask (AOAC, 2019). The distillate was then titrated against 0.010M HCl to a pink end point. The total nitrogen content was calculated as:

$$\% \text{ crude protein} = \% N \times 6.25 \text{ (protein factor)}$$

N = Nitrogen content end point

Carbohydrate content determination

The carbohydrate content of sample was determined using difference method viz:

$$\% \text{ Carbohydrate} = 100 - (\% \text{ ash} + \% \text{ protein} + \% \text{ fat} + \% \text{ crude fibre} + \% \text{ moisture}).$$

Determination of Mineral Content

Two grams of each sample was placed in a crucible and placed in muffle furnace at $550^{\circ}C$ for 5hours to ash and later transferred into a desiccator to cool. The cooled ash was dissolved in 10% HCl and filtered, then diluted to 50ml volume in standard flask with deionized water. The solution was aspirated into atomic absorption spectrophotometer to obtain the mineral content (AOAC, 2019). The minerals analyzed include; potassium, sodium, calcium and magnesium.

Statistical Analysis

All data were analyzed by one-way analysis of variance (ANOVA) at 95% confidence limit. Means were separated by Duncan's Multiple Range Test using SPSS window 17 version.

III. Result

Percentage recovery of the Extracts

The percentage recovery of the extract from *Syzygium guineense* is shown in Table 1. The percentage yield from ethanolic extract was 16.53% while aqueous extract yielded 7.72%.

Table 1: Percentage recovery of extracts from *S. guineense* leaf sample

Medium of Extraction	Original weight OW (g)	Extracted weight EW (g)	(%) EW/OW $\times$ 100	recovery=
Ethanol	400	66.12	16.53	
Aqueous	400	30.86	7.72	

Bio-preservative efficacy of *Syzygium guineense* leaf extracts on Tomato fruits

Figures 1a to 1d show the state of the treated and controlled tomato samples stored at ambient temperature ($28 \pm 2^{\circ}C$) on day 7. The tomatoes treated with ethanolic extract shows gradual deterioration on day 14, while rapid deterioration started on the 3rd day of storage for the tomato samples treated with aqueous extract. For the positive control sample (tomatoes treated with ethanol), spoilage started on the 5th day of storage but there was decline in colour which was more pronounced on the positive control than on tomatoes treated with ethanolic extract. While the negative control (tomatoes treated with distilled water) shows rapid deterioration on the 5th day of storage, although the colour was intact.

Figures 2a to 2d show the tomato samples stored at refrigerated temperature ($4^{\circ}C$). There was no decline in the appearance of all the samples on the 7th day, except for tomatoes treated with ethanolic extract and tomatoes treated with ethanol that experienced loss of colour. Under the refrigerated temperature, there was increase in the shelf-life of the tomato samples compared to those kept at ambient temperature. After the 14th day of preservation, the shelf-life of the controlled tomato samples kept at $4^{\circ}C$ witnessed a progressive decline till the last day of preservation (day 28). The aqueous extract treated tomato samples experienced deterioration on day 18, while the ethanolic extract treated tomato samples were intact in their appearance except for their colour till 21st day of preservation.

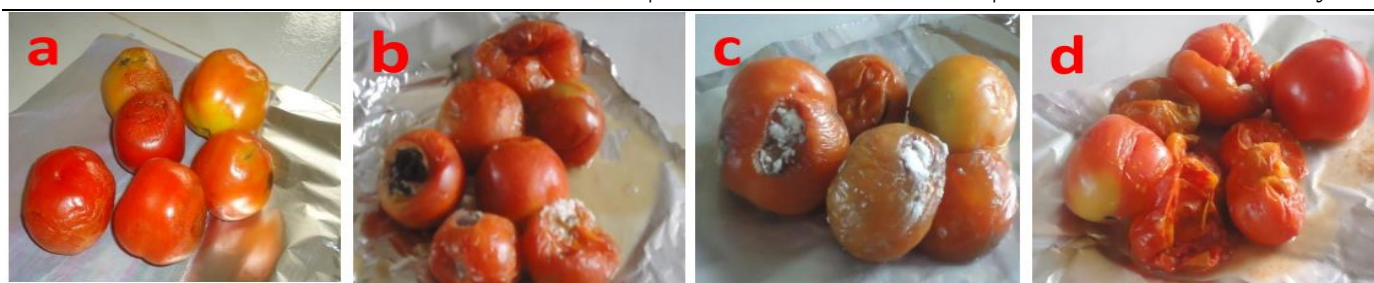


Figure 1: Tomato treated with ethanolic extract and stored at ambient temperature on day 7 (a), Plate 3b: Tomato treated with aqueous extract and stored at ambient temperature on day 7 (b), Plate 4a: Tomato treated with ethanol and stored at ambient temperature on day 7 (c), Plate 4b: Tomato treated with distilled water and stored at ambient temperature on day 7 (d)



Figure 2: Tomato treated with distilled water and stored at refrigerated temperature on day 7 (a), Tomato treated with ethanol and stored at refrigerated temperature on day 7 (b), Tomato treated with aqueous extract and stored at refrigerated temperature on day 7 (C), Tomato treated with ethanolic extract and stored at refrigerated temperature on day 7 (d)

Proximate Composition

The outcome of the proximate analysis shown in tables 2 and 3 revealed that the treated tomato shows a lower considerable loss in the moisture, crude fibre and carbohydrate contents compared to the controlled samples under the two environmental conditions. At 28 day of storage, there was increase in the crude protein, fat and ash contents of both treated and controlled samples. The negative control showed significant increase in the ash, crude protein and fat contents when compared to the treated and positive control samples at ambient and refrigerator temperature.

TABLE 2: PROXIMATE COMPOSITION OF TREATED AND CONTROL TOMATO SAMPLES STORED AT REFRIGERATOR TEMPERATURE.

Parameters/Proximate value (% wet weight)							
Day	Sample	Moisture content	Fat content	Crude protein	Crude fibre	Ash content	Carbohydrate content
0	TD	90.51±0.00 ^d	0.86±0.01 ^b	3.23±0.16 ^a	0.49±0.10 ^{bc}	0.33±0.10 ^a	4.59±0.17 ^f
	TE	91.08±0.02 ^f	0.48±0.24 ^a	3.45±0.02 ^a	0.54±0.19 ^c	0.42±0.03 ^{ab}	4.04±0.45 ^e
	TAe	91.79±0.01 ^g	0.48±0.08 ^a	3.71±0.24 ^{ab}	0.32±0.07 ^a	0.35±0.04 ^a	3.36±0.12 ^d
	TEe	90.99±0.12 ^e	0.53±0.02 ^a	4.04±0.38 ^b	0.39±0.06 ^{abc}	0.38±0.13 ^a	3.81±0.34 ^{de}
28	TD	86.23±0.03 ^b	1.66±0.05 ^c	10.45±0.42 ^e	0.36±0.03 ^{ab}	0.51±0.01 ^b	0.80±0.42 ^a
	TE	86.10±0.02 ^a	0.71±0.01 ^b	9.78±0.31 ^d	0.32±0.01 ^a	0.42±0.03 ^{ab}	2.69±0.28 ^c
	TAe	86.09±0.01 ^a	0.83±0.12 ^b	10.93±0.41 ^e	0.34±0.02 ^a	0.38±0.03 ^a	1.44±0.33 ^b
	TEe	87.86±0.01 ^c	0.72±0.04 ^b	8.26±0.21 ^c	0.32±0.01 ^a	0.41±0.06 ^{ab}	2.55±0.01 ^c

Key: TD – Tomato washed in distilled water; TE – Tomato treated with ethanol
TAe– Tomato treated with aqueous extract; TEe – Tomato treated with ethanolic extract

Value of triplicate mean $\pm$ standard deviation determination with the significant different in ($p < 0.05$).

Samples with different superscripts within the same column were significantly ($p \leq 0.05$) different.

Table 3: Proximate composition of treated and control tomato samples stored at ambient temperature.

Parameters/Proximate value (% wet weight)							
Day	Sample	Moisture content	Fat content	Crude protein	Crude fibre	Ash content	Carbohydrate content
0	TD	90.51 $\pm$ 0.00 ^d	0.86 $\pm$ 0.01 ^d	3.23 $\pm$ 0.16 ^a	0.49 $\pm$ 0.10 ^{bc}	0.33 $\pm$ 0.10 ^a	4.59 $\pm$ 0.17 ^e
	TE	91.08 $\pm$ 0.02 ^e	0.48 $\pm$ 0.24 ^a	3.45 $\pm$ 0.02 ^{ab}	0.54 $\pm$ 0.19 ^c	0.42 $\pm$ 0.03 ^a	4.04 $\pm$ 0.45 ^d
	TAe	91.79 $\pm$ 0.01 ^f	0.48 $\pm$ 0.08 ^a	3.71 $\pm$ 0.24 ^{bc}	0.32 $\pm$ 0.07 ^{ab}	0.35 $\pm$ 0.04 ^a	3.36 $\pm$ 0.12 ^c
	TEe	90.99 $\pm$ 0.12 ^e	0.53 $\pm$ 0.20 ^{ab}	4.04 $\pm$ 0.38 ^c	0.39 $\pm$ 0.06 ^{abc}	0.38 $\pm$ 0.13 ^a	3.81 $\pm$ 0.34 ^{cd}
28	TD	82.94 $\pm$ 0.16 ^a	1.64 $\pm$ 0.04 ^e	14.00 $\pm$ 0.01 ^f	0.35 $\pm$ 0.08 ^{ab}	0.64 $\pm$ 0.07 ^b	0.42 $\pm$ 0.19 ^a
	TE	85.50 $\pm$ 0.01 ^b	0.72 $\pm$ 0.04 ^{cd}	12.57 $\pm$ 0.01 ^e	0.36 $\pm$ 0.11 ^{abc}	0.42 $\pm$ 0.05 ^a	0.43 $\pm$ 0.13 ^a
	TAe	86.14 $\pm$ 0.01 ^c	0.67 $\pm$ 0.01 ^{bc}	11.86 $\pm$ 0.44 ^d	0.27 $\pm$ 0.02 ^a	0.44 $\pm$ 0.01 ^a	0.63 $\pm$ 0.45 ^a
	TEe	85.45 $\pm$ 0.01 ^b	0.72 $\pm$ 0.05 ^{cd}	12.03 $\pm$ 0.01 ^d	0.29 $\pm$ 0.02 ^a	0.36 $\pm$ 0.01 ^a	1.14 $\pm$ 0.04 ^b

**Key: TD – Tomato washed in distilled water; TE – Tomato treated with ethanol
TAe– Tomato treated with aqueous extract; TEe – Tomato treated with ethanolic extract**

Mineral analysis

The results of the mineral analysis of treated and controlled tomato samples were presented in Tables 4 and 5. At refrigerator temperature (4°C), only the negative control showed increase in Potassium from 0.63 on day 0 to 1.40 on the 28th day of preservation when compared to other samples. There was significant decrease in the Sodium, Calcium and Magnesium contents of the preserved tomatoes at 4°C, but there was increase in percentage of Calcium in the treated samples. Only tomato samples treated with aqueous extract showed increase in Magnesium from 0.17 to 0.23 on the 28th day of preservation.

At ambient temperature (28 $\pm$ 2°C), there was significant decrease in Sodium, Potassium and Magnesium of the preserved tomatoes, but only the negative control had an increase in the Potassium and Magnesium from 0.63 to 1.65 and 0.15 to 0.18 respectively. The results also revealed that there was increase in Calcium of the preserved tomatoes, except for the positive control which had a reduction from 1.21 to 0.54 on the 28th day of preservation.

Table 4: Mineral composition of treated and control tomato samples stored at refrigerator temperature

Day	Sample	Potassium	Sodium	Calcium	Magnesium
0	TD	0.63±0.03 ^a	0.88±0.01 ^e	0.63±0.01 ^e	0.15±0.01 ^{bc}
	TE	1.92±0.02 ^e	2.24±0.01 ^g	1.21±0.01 ^g	0.34±0.01 ^e
	TAe	2.00±0.20 ^e	1.23±0.01 ^f	0.56±0.02 ^d	0.17±0.02 ^c
	TEe	1.88±0.08 ^e	0.86±0.01 ^d	0.13±0.02 ^a	0.43±0.03 ^f
28	TD	1.40±0.01 ^d	0.63±0.01 ^a	0.38±0.01 ^c	0.14±0.01 ^b
	TE	1.02±0.01 ^b	0.62±0.01 ^a	0.37±0.01 ^c	0.11±0.01 ^a
	TAe	1.24±0.01 ^c	0.77±0.0 ^c	0.86±0.01 ^f	0.23±0.01 ^d
	Tee	0.98±0.01 ^b	0.71±0.01 ^b	0.31±0.01 ^b	0.10±0.00 ^a

Key:

TD – Tomato washed in distilled water

TE – Tomato treated with ethanol

TAe– Tomato treated with aqueous extract

TEe – Tomato treated with ethanolic extract

TABLE 5: MINERAL COMPOSITION OF TREATED AND CONTROL TOMATO SAMPLES STORED AT AMBIENT TEMPERATURE

Day	Sample	Potassium	Sodium	Calcium	Magnesium
0	TD	0.63±0.03 ^a	0.88±0.01 ^e	0.63±0.01 ^e	0.15±0.01 ^{bc}
	TE	1.92±0.02 ^e	2.24±0.01 ^g	1.21±0.01 ^g	0.34±0.01 ^e
	TAe	2.00±0.20 ^e	1.23±0.01 ^f	0.56±0.02 ^d	0.17±0.02 ^c
	TEe	1.88±0.08 ^e	0.86±0.01 ^d	0.13±0.02 ^a	0.43±0.03 ^f
28	TD	1.65±0.02 ^c	0.62±0.02 ^a	0.69±0.02 ^c	0.18±0.01 ^d
	TE	1.49±0.04 ^b	0.73±0.13 ^{abc}	0.54±0.11 ^{bc}	0.15±0.01 ^{bc}
	TAe	1.40±0.10 ^b	0.68±0.08 ^{ab}	0.68±0.03 ^c	0.14±0.01 ^{ab}
	TEe	1.55±0.05 ^{bc}	0.85±0.25 ^{bc}	0.42±0.23 ^b	0.12±0.01 ^a

Key:

TD – Tomato washed in distilled water

TE – Tomato treated with ethanol

TAe– Tomato treated with aqueous extract

TEe – Tomato treated with ethanolic extract

IV. DISCUSSION

The percentage recovery of *S. guineense* extracts varied in the two solvents used. Comparatively, ethanol gave higher yield than water and this observation is in accordance with Kordali *et al.* (2003) and Campos *et al.* (2002) who respectively worked on the leaves of three *Pistacia* species and *Croton cajucana* and reported that the recovery level of plant extracts is dependent and vary with the different extracting solvent. Also the low percentage recovery obtained in water compared to ethanol might be due to the organic nature of ethanol as well as being polar which allow them to actively dissolve the chemical components of the leaves. The observation is also supported by Cowan (1999) who reported that the most active components are generally insoluble, hence it is expected that low polarity organic solvents would yield more percentage recovery.

The result obtained in the proximate analysis revealed that there was significant decrease ($p \leq 0.05$) in the moisture, crude fibre and carbohydrate contents of the tomato samples. The reduction was more pronounced in the control when compared with the treated tomato samples. This could be as a result of the antimicrobial activity of *S. guineense* on the microorganisms that would have utilized the carbohydrate content in the treated tomato samples. At 28 day of storage, there was increase in the crude protein, fat and ash contents of both treated and controlled samples. Sopade (1995) attributed the changes to the fact that increase in the rate

of water removal increases the chemical nutrient. The nutrient composition on dry matter base became concentrated as a result of reduction in moisture content of the tomato samples. The negative control showed significant increase in the ash, crude protein and fat contents when compared to the treated and positive control samples at ambient and refrigerator temperature (Tables 4 and 5). This increase could be attributed to increase in microbial biomass. Post-harvest fruit quality depends on textural durability during storage, nutritional and sensory attributes.

There was significant decrease in the Sodium, Calcium and Magnesium contents of the preserved tomatoes at 4°C, but there was increase in percentage of Calcium in the treated samples. Only tomato samples treated with aqueous extract showed increase in Magnesium from 0.17 - 0.23% on the 28th day of preservation. While at ambient temperature (28 ± 2°C), there was significant decrease in Sodium, Potassium and Magnesium of the preserved tomatoes, but only the negative control had an increase in the Potassium and Magnesium from 0.63 to 1.65 and 0.15 to 0.18 respectively. The results also revealed that there was increase in Calcium of the preserved tomatoes, except for the positive control which had a reduction from 1.21 to 0.54 on the 28th day of preservation. The difference in mineral content could probably be due to the fact that these minerals are important components of the biomolecules of the spoilage organisms (Ibrahim, *et al.*, 2011). Keeping the right potassium balance in the body depends on the amount of sodium and magnesium in the blood (Oshodi, 2003). Calcium, magnesium, sodium and potassium are essential minerals for life, they are important in the formation of bones and teeth as a cofactor for enzymes and a component of ATP, DNA, RNA and cell membranes.

Calcium helps in the regulation of muscle contraction required by young animals and fetuses for bones and teeth development. Calcium is useful in sustaining strong bones, muscular contraction and relaxation, blood clotting Manganese is a co-factor for antioxidant enzymes like mitochondrial superoxide dismutase, oxygen-handling enzymes, and also helps in brain functioning, bone structure, and regulation of blood sugar. It acts as a cofactor for numerous vital enzymes e.g. Manganese peroxide dismutase is an antioxidant enzyme that prevents or reduces the oxidative stress, controls the chronic diseases such as diabetes mellitus (Murray *et al.*, 2000).

Magnesium is essential in skeletal tissue metabolism and neuromuscular transmission. Magnesium is necessary as an activator of many enzyme systems, particularly those concerned with carbohydrate metabolism (Anhwange *et al.*, 2004). It is believed to be essential in the structural stability of nucleic acids. It plays a significant role in the intestinal absorption of electrolyte in the body.

V. Conclusion and Recommendation

The investigation of the effect of *S. guineense* leaf extracts on the proximate and mineral composition of tomato fruits revealed that these extracts have promising natural antimicrobial agents with potential applications in the food or pharmaceutical industries. The aqueous and ethanolic extracts of *S. guineense* leaves showed significant preservative efficacy under refrigerated temperature. However, only ethanolic extract showed preservative efficacy at ambient temperature. This study confirms that the crude extracts of *S. guineense* leaves could serve as alternative bio-preservatives to chemical preservatives.

This study therefore recommends the use of *S. guineense* leaf extracts for the preservation of tomato fruits.

Also, further studies could be intensifying to ascertain the biosafety of the treated tomato fruits.

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