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Comparative Assessment of Lycopene and Some Vitamins and Mineral Composition of Ripe and Unripe *Solanum lycopersicum* (Tomato) Sold in Kashere

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ABSTRACT

Solanum lycopersicum, or tomato, is a widely eaten vegetable because of its high levels of essential nutrients and antioxidant plant compounds. This study analysed the phytochemicals, vitamins, and mineral composition of ripe and unripe tomatoes available in Kashere using standard analytical methods. The analysis of ripe tomatoes revealed significantly (P<0.05) higher amounts of lycopene (153.550 ± 18.031 mg/100g), vitamin C (40.830 ± 0.948 mg/100g), vitamin E (0.4717 ± 0.009 mg/100g), Fe (0.0043 ± 0.00 mg/kg), Zn (0.087 ± 0.001 mg/kg), and Cu (0.001 ± 0.00 mg/kg) present. The lycopene (32 ± 0.001mg/kg) content of ripe tomatoes was higher compared to unripe tomatoes, which had lesser amounts of lycopene (85.655 ± 10.510 mg/100g), vitamin C (11.835 ± 0.248mg /100g), vitamin E (0.162 ± 0.000mg//100g), Fe (0.003 ± 0.000mg/kg), Zn (0.051 ± 0.001mg/kg), and Cu (0.018 ± 0.001mg/kg). However, there was a significant (p<0.05) difference in the vitamin A content of unripe tomatoes (0.082 ±0.000mg /100g), which was higher compared to ripe tomatoes (0.029 ± 0.009mg/100g). The findings indicate that the ripening process enhances the nutrient and phytochemical content of tomatoes, with a particular increase in phytochemicals, minerals, and vitamins. Consequently, the consumption of ripe tomatoes could be advantageous to human health, as they offer a higher concentration of minerals and nutrients.

Keywords: Lycopene, Vitamins, Tomato, Mineral composition , Kashere.

INTRODUCTION

Throughout history, fruits and vegetables have been an important part of animal and human diets (Salehi *et al.*, 2019). These foods provide essential nutrients, but may also have therapeutic or medicinal benefits. Tomato (*Solanum lycopersicum L.*) is especially noteworthy due to its established health benefits (Salehi *et al.*, 2019).They are often consumed as a vegetable and are a prominent part of the Mediterranean diet. They are commonly used in processed foods such as salads ,sauces, pastes, and soups (Lennuci *et al.*, 2006). Tomatoes contain a range of nutrients, including minerals ,vitamins, fiber, essential amino acids, monounsaturated fatty acids, phytosterol and carotenoids (Elbadrawy and Cello, 2016), which have multiple functions in the body, including the prevention of constipation, reduction of hypertension, stimulation of blood circulation, maintenance of lipid profiles and body fluids, detoxification of body toxins, and maintenance of bone structure and strength (Salehi *et al.*, 2019; Campestrini *et al.*, 2019).

Tomatoes contain bioactive compounds, including secondary metabolites, that are linked to averting chronic degenerative ailments like neurodegenerative diseases, cancer, and cardiovascular disease (CVD) (Li *et al.*, 2020). These compounds include carotenoids (beta-carotene and lycopene), ascorbic acid (vitamin C), tocopherol (vitamin E) and phenolic compounds (naringenin ,quercetin, lutein, caffeic acid, kaempferol ,ferulic acid and chlorogenic acid). ROS can be inhibited by scavenging free radicals, inhibiting cell proliferation and damage, chelating metals, preventing apoptosis, modulating cytokine expression, modulating enzymatic activities, and by blocking signal transduction pathways (Hossen *et al.*, 2017).

The main carotenoid present in tomatoes is lycopene, giving them their typical reddish colour. Lycopene and other phenolic compounds show multiple positive pharmacological effects, such as anti-cancer, anti-diabetic, anti-allergic, anti-inflammatory ,anti-atherogenic, antimicrobial, antioxidant, antithrombotic ,vasodilator, and cardioprotective effects, as explicitly documented in prior research (Zhu *et al.*, 2020). Tomatoes are an important part of a well-balanced diet as they contain vitamins, minerals, amino acids and fats. The antioxidant properties of tomato are largely attributed to various carotenoids, vitamin E, vitamin C and phenolic compounds, which can neutralise reactive oxygen species (ROS) and protect cell membranes from lipid peroxidation (Sofy *et al.*, 2020).

Despite its botanical classification as a berry, the tomato is a versatile fruit that can be used raw or cooked in a variety of dishes, salads, sauces, and beverages. Previous scientific studies have reported specific phytochemicals and antioxidant activities in the fruit of *Solanum lycopersicum*, despite its common use as a vegetable ingredient or side dish (Frusciante *et al.*, 2007). Tomato consumption is associated with reduced risk of chronic noncommunicable diseases (CNCDs), especially inflammation, cardiovascular diseases and cancer, including coronary heart disease, hypertension, obesity and diabetes (Canene *et al.*, 2005). Antioxidant metabolites, like phenolic acid, carotenoids, vitamins, and phenolic compounds, are found to have positive impacts on health in the human body (Canene *et al.*, 2005; Frusciante *et al.*, 2007). Tomatoes, alongside other plants in our diet, provide essential substances beneficial for our health, such as vitamins, minerals, and antioxidants (Frusciante *et al.*, 2007). Their efficacy in enhancing wellbeing has been well established.

Studies suggest that the antioxidant activity of tomatoes is mainly due to soluble phenolic compounds and vitamin C, which contribute 83% of the total antioxidant activity, while the remaining 17% is contributed by carotenoids, vitamin E and lipophilic phenolics (Kot'ıkov'a *et al.*, 2011). Tomatoes are widely consumed globally and are an essential component of the Mediterranean diet (Viuda *et al.*, 2014). Despite the significance of vegetables in providing essential nutrients to the human body, and preventing malnourishment, the nutritional value of some underutilised vegetables has been given insufficient attention. As a result, diets in many regions of the world continue to be deficient in critical vitamins and nutrients. However, there is a paucity of scientific literature on the mineral, vitamin and phytochemical composition of the different varieties of tomato. This study aims to objectively evaluate the mineral, vitamin, and phytochemical content of ripe and unripe *Solanum lycopersicum* grown in Kashere. The goal is to determine its suitability as a viable food source.

MATERIALS AND METHODS

Study Area

The study was conducted in Kashere, a town situated in the Akko Local Government Area in Gombe State. The coordinates for Kashere are 9° 46' 0" N latitude and 10° 57' 0" E longitude, at an elevation of 431m above sea level. Kumo serves as the administrative centre for the area, covering about 427km2 (158sqkm) with a population of 7,715 according to the 2006 census carried out by the Federal Republic of Nigeria. There has been an increase in population and economic activity in the area over the past five years, which may be a result of the establishment of the new federal university. Most residents are engaged in farming and trade.

Collection and Preparation of Samples

The collection and preparation of the samples involved the procurement of fresh tomatoes at different stages of ripeness from the market in Kashere. The samples selected were classified into two stages of ripeness: green, which is characterised by the fruit surface being completely green (immature), and red, where more than 80% of the surface has a red hue (ripe). For analysis, random samples of both ripe and immature tomatoes were selected, cleansed with cold tap water, dissected using a dissecting set, and left to air dry for four days. Dried samples were ground to a fine powder using a mortar and pestle before analysis. The research was conducted at the Department of Biological Science, Federal University of Kashere, Gombe State, Nigeria, and the Biochemistry Laboratory, Gombe State University.

Mineral Content Determination

The mineral content of the tomato samples was determined using the wet digestion method. 20 g of each ripe and unripe tomato sample was weighed into a 250 ml round bottom flask. An acid mixture of perchloric acid and nitric acid in a 1:1 ratio was utilized in the digestion process.The sample and the acid mixture were heated on a hot plate under a fume hood of perchloric acid. An atomic absorption spectrophotometer (AAS) was used to analyse the mineral content (iron, copper and zinc) of the digested solution, specifically the Model 3030 Perkin Elmer, in Norwalk, USA (Baranska *et al.*, 2006).

Phytochemical Content Determination

The samples were prepared using an extraction technique at the laboratory of the Department of Biological Science in Federal University of Kashere, Gombe State, Nigeria. The tomatoes were sliced, sorted, washed manually, and air-dried for four days, both ripe and unripe. A combination of 20 g of ripe and 20 g of unripe tomato samples were diluted with 100 ml of ethanol. After three days, the mixture was evaporated to dryness on a water bath, and the sample was extracted.

Determination of Lycopene

The tomato juice was thoroughly homogenised under vacuum to minimise the introduction of air bubbles and a 100 µL Drummond micropipette was used for sample collection. The pipette was inspected after wiping the glass bore Kim wipe to eradicate any potential bubble introduction. Thereafter, the sample was dispensed into a 20 screw-cap tube. A number of blanks were also prepared with 100 µL of water.

For the extraction, 0.96 g of each of the ripe and unripe tomato extracts were weighed and mixed with 0.8 mL of hexane:ethanol:acetone (2:1:1) using a pipette. Next, the test tube was capped, vortexed, and incubated in a shaded area for a total duration of ten minutes. Once the incubation was completed, 0.1 mL of water was introduced to each sample, and the mixture was vortexed once more. After a 10 minute interval, the sample was granted time for the separation of the phase and for the air bubbles to vanish. The cuvette was cleaned with the top layer of one of the blank samples and a new blank was used to calibrate the spectrophotometer at 503 nm. The top layer was used to measure the absorbance of lycopene at 503 nm. The lycopene concentration was calculated according to the method of Snell and Snell (1958).

The concentration of lycopene was calculated using the following formula:

lycopene (mg/kg fresh weight) = $(A503 \times 537 \times 0.55)/(0.10 \times 172) = A503 \times 137.4$

The molecular weight of lycopene is 573 g/mol, the volume of the mixed solvent is 0.8 mL, the volume ratio of the upper layer of the mixed solvent is 0.55, and the weight of the tomato added is 0.10 g. In addition, the extinction coefficient for lycopene in hexane is 172 m^-1.

Vitamin Analysis

The vitamin content of ripe and unripe tomatoes was analysed using the official method of the Association of Official Analytical Chemists (AOAC, 1990).

Determination of Vitamin E

One gram of both ripe and unripe tomatoes was weighed. It was then macerated in a test tube with 20 ml of n-hexane for 10 minutes. The solution obtained was centrifuged for 10 minutes and then filtered. From the filtrate, triplicate 3mL aliquots were transferred into separate dry test tubes which were then evaporated to dryness using a boiling bath. To the residue, 2 mL of 0.5N alcohol potassium hydroxide was added and the solution was then boiled in a water bath for 30 minutes. Next, 3 ml of n-hexane was added and the solution was shaken vigorously. Then, the n-hexane layer was transferred to a new set of test tubes and left to evaporate until dry. The remaining residue was mixed with 2 mL of ethanol, 1 mL of 0.2% ferric chloride in ethanol and 1 mL of 0.5% alpha1 alpha 1 -dipyridyl in ethanol. Finally, 1 mL of ethanol was added to give a total volume of 5 mL. The solution was mixed thoroughly. Absorbance was measured at 520 nm against the blank in accordance with the AOAC (1990) protocol.

Determination of Vitamin C

0.5g of both ripe and unripe samples were weighed and macerated in a test tube for 10 minutes with 10ml 0.4% oxalic acid. The solution was then centrifuged for 5 minutes and the filtrate was filtered. Then 1 ml of filtrate was transferred to a dry test tube (in triplicate). To each test tube, 9 ml of 2,6-dichlorophenol indophenol was added and the absorbance was measured at 520 nm after 15, 30 and 45 seconds according to the AOAC (1990) protocol.

Determination of Vitamin A

One gram of ripe tomato and one gram of unripe tomato were crushed and mixed with 20 ml of n-hexane for exactly 10 minutes. Subsequently, we transferred 3 ml of the upper hexane extracts into a new dry test tube, repeated the process thrice, and evaporated the contents until dryness. Then 0.2 ml acetic acid-chloroform reagent and 2 ml 5% trichloroacetic acid (TCA) in chloroform were added. Absorbance was measured at intervals of 15, 30 and 45 seconds at 620 nm using a spectrophotometer (AOAC, 1990).

Data Analysis

Data collected were evaluated using SPSS 20.0 software. Results are presented as mean ± S.D with $P < 0.05$ level of statistical significance.

RESULTS

Mineral Analysis of Ripe and Unripe Tomato grown in Kashere

The analysis of mineral composition presented in Table 1 indicates the concentration of Fe (0.0043± 0.00mg/kg), Zn (0.087± 0.001 mg/kg), and Cu (0.32 ± 0.001mg/kg) in ripe tomatoes and Fe (0.003 ± 0.000mg/kg), Zn (0.051 ± 0.001mg/kg), and Cu (0.018 ± 0.001mg/kg) in unripe tomatoes sold in Kashere.

Table 1: Mineral composition of ripe and unripe tomato

	Ripe Tomato	Unripe Tomato
	Mean ± SD	Mean ± SD
Fe (mg/Kg)	0.0043 ± 0.000a	0.003 ± 0.000b
Cu (mg/Kg)	0.032 ± 0.001a	0.018 ± 0.001b
Zn (mg/Kg)	0.087 ± 0.001a	0.051 ± 0.001b

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The ripe fruit of tomato (*Solanum lycopersicum*) had a lycopene(153.550 ± 18.031 mg/100g), vitamin A (0.029 ± 0.009mg/100g),vitamin C(40.830 ± 0.948mg/100g),vitamin E(0.4717 ± 0.009mg/100g), Fe(0.0043± 0.00mg/kg), Zn(0.087± 0.001 mg/kg) and Cu (0.32 ± 0.001mg/kg)content while the lycopene (85.655 ± 10.510 mg/100g),vitamin A (0.082 ±0.000mg /100g),vitamin C(11.835 ± 0.248mg /100g),vitamin E(0.162 ± 0.000mg//100g), Fe(0.003 ± 0.000mg/kg), Zn(0.051 ± 0.001mg/kg) and Cu (0.018 ± 0.001mg/kg) content in unripe tomatoes is shown in Table 2 below.

Table 2: Vitamin and lycopene composition of ripe and unripe tomato

	Ripe Tomato	Unripe Tomato
	Mean ± SD	**Mean ± SD**
Vitamin A (mg/100g)	0.029 ± 0.000[b]	0.082 ± 0.000[a]
Vitamin C (mg/100g)	40.830 ± 0.948[a]	11.835 ± 0.248[b]
Vitamin E (mg/100g)	0.4717 ± 0.009[a]	0.162 ± 0.000[b]
Lycopene (mg/100g)	153.550 ± 18.031[a]	85.655 ± 10.510[b]

Values are mean ± SD for triplicate analysis (n=3)
Mean values with different letters in the same row are significantly different ($P < 0.05$).

Evaluation of vitamin and lycopene Composition (mg/100g) of Ripe and Unripe tomato grown in Kashere

Table 2 shows the nutrient composition analysis of ripe and unripe tomatoes (*Solanum lycopersicum*). The ripe tomato contained lycopene (153.550 ± 18.031 mg/100g), vitamin A (0.029 ± 0.009mg/100g), vitamin C (40.830 ± 0.948mg/100g), vitamin E (0.4717 ± 0.009mg/100g), Fe (0.0043 ± 0.00mg/kg), Zn (0.087 ± 0.001 mg/kg) and Cu (0.32 ± 0.001mg/kg). On the other hand, the unripe tomato contained lycopene (85.655 ± 10.510 mg/100g), vitamin A (0.082 ± 0.000mg/100g), vitamin C (11.835 ± 0.248mg/100g), vitamin E (0.162 ± 0.000mg/100g), Fe (0.003 ± 0.000mg/kg), Zn (0.051 ± 0.001mg/kg) and Cu (0.018 ± 0.001mg/kg).

DISCUSSION

The concentrations of Zn, Fe, and Cu were significantly higher ($p<0.05$) in ripe tomatoes (Solanum lycopersicum) than in unripe tomatoes. The Fe content in ripe tomatoes was 0.0043 ± 0.00mg/kg, Zn was 0.087 ± 0.001 mg/kg, and Cu was 0.32 ± 0.001mg/kg, whereas the Fe content in unripe tomatoes was 0.003 ± 0.000mg/kg, Zn was 0.051 ± 0.001mg/kg, and Cu was 0.018 ± 0.001mg/kg. These results support previous studies by Farhana *et al.*(2020), Abdulahi *et al.* (2016), and Elbadrawy and Sello. (2016), which reported that both ripe and unripe *Solanum lycopersicum* fruits contain trace amounts of Zn, Fe, and Cu.

Minerals such as Fe, Zn and Cu are essential for various body functions, including regulating metabolic pathways and immune function. Fe plays a crucial role in oxygen transport via hemoglobin formation, while Zn and Cu are important for cellular growth regulation, building the immune system, and coenzyme functions for carbohydrates, proteins, and nucleic acids (Farhana *et al.*, 2020) .Ripe tomatoes had significantly higher concentrations of lycopene (153.550 ± 18.031 mg/100g) compared to unripe tomatoes (85.655 ± 10.510 mg/100g), which is consistent with the findings of Li *et al.* (2020). Lycopene, as a significant carotenoid constituent of tomatoes, possesses antioxidant attributes. It can avert prostate

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cancer by counteracting the generation of reactive oxygen species, eliminating free radicals, and shielding cell membranes and DNA from oxidative destruction (Li *et al.*,2020).

Ripe tomatoes also had significantly higher concentrations of vitamin C (40.830 ± 0.948mg/100g) and vitamin E (0.4717 ± 0.009mg/100g) than unripe tomatoes, except for vitamin A, which was higher in unripe tomatoes (0.082 ± 0.000mg/100g) than ripe ones (0.029 ± 0.009mg/100g). The study's results align with earlier findings by Ahmed *et al.* (2020) and Ramesh *et al.* (2020). For optimal bodily function, vitamins are integral, and the outcomes imply that vitamin levels rise as ripening ensues. Vitamin A improves immunity, supports clear vision, and impedes particular eye ailments. Similarly, vitamin E fortifies cell membranes, and red blood cell health while contributing to immune function. Vitamin C enhances wound healing, reinforces resistance to infections by enhancing the immune system, and enhances iron absorption (Ramesh *et al.*, 2020).

CONCLUSION

This study suggests that the nutrient and phytochemical composition of *Solanum lycopersicum* fruits improve as they ripen, resulting in higher concentrations of vitamins and minerals. The data revealed that the ripe fruits contained significantly higher levels of phytochemicals, vitamins (excluding vitamin A), and minerals than the unripe fruits. Therefore, Kashere residents may benefit from eating ripe *Solanum lycopersicum* fruits, which are rich sources of minerals, vitamins and antioxidants. Overall, the presence of phytonutrients and other important molecules in these fruits makes them a promising candidate for the treatment of malnutrition.

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