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Comparative Study of the Effect of Preservation Methods on Lycopene and Mineral Contents in Tomatoes Sold Within Kaduna Metropolis.

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Abstract

This study aimed to compare the effects of various preservation methods on the lycopene and mineral element content of tomatoes sold in the Kaduna metropolis. Lycopene analysis was performed using a UV/Visible spectrophotometer at 503 nm, with extracts prepared in hexane: acetone: ethanol mixture. Lycopene and mineral element concentrations were measured in mg/100 g and mg/kg, respectively. Tomato samples (Derika VF) were sourced from Kawo, Central, and Barnawa markets. The preservation methods tested included boiling in a glass container (BIG), boiling in a plastic container (BIP), air drying, and the use of chemical preservatives. Results indicated that the average lycopene concentration in fresh tomatoes was 5.89 mg/100 g, while the concentrations of mineral elements were as follows' K, Na, Ca, Mg, Zn, and Fe were 247.99 mg/kg, 426.87 mg/kg, 30.65 mg/kg, 109.50 mg/kg, 1.670 mg/kg and 2.9 mg/kg respectively. In the preserved samples, the concentrations of lycopene ranged from 5.70 mg/ 100 g - 7.401 mg/100 g in BIP, 5.767 mg/ 100 g - 7.434 mg/100 g in BIG, 5.67 mg/100 g - 7.897 mg/100 g in dried tomato and 5.718 mg/100 g - 7.561 mg/100 g in chemically preserved tomatoes from day 1 - day 28 respectively. This indicates that dried tomato has the highest lycopene content. For mineral elements, the concentration of potassium (288.16 mg/kg) and sodium (812 mg/kg) were higher in the chemically preserved sample and BIP had the highest concentration of zinc (63.50 mg/kg). Concentrations of iron (626 mg/kg) and calcium (728.12 mg/kg) were higher in BIG, while the concentration of magnesium in BIP and dried tomatoes where the same (118.38 mg/kg). However, there was a good distribution of minerals in each method of preservation. This indicates that all the methods of preservation are suitable for lycopene and mineral elements.

Keywords: Antioxidant, Minerals, Lycopene, preservation, Tomato.

Introduction

Regular intake of fruits and vegetables has been recognized as a strategic approach to enhancing livelihoods and reducing malnutrition (South Pacific Foods, 1995). Fruits and vegetables are the primary sources of minerals, vitamins, antioxidants, and dietary fiber. Vitamins, lycopene, and minerals play a crucial role in regulating human metabolism (Martinez et al., 2002). Tomato (*Lycopersicon esculentum* Mill.) is one of the most significant agricultural commodities among fresh vegetables globally and has gained considerable popularity in recent decades. As a member of the Solanaceae family, it is a short-duration crop with high yield potential. Its economic appeal has led to a continuous expansion in the area under cultivation (Guil-Guerrero et al., 2009). The red color of certain fruits such as tomatoes, red grapes, watermelon and red guava is due to the presence of lycopene (Stah and Sies, 1996). Lycopene is the primary carotenoid found in tomatoes and possesses the strongest antioxidant activity and singlet oxygen-quenching ability among all dietary carotenoids. It is an unsaturated, acyclic carotenoid with eleven linear conjugated double bonds and two non-conjugated double bonds (Shi et al., 2002).

Lycopene naturally occurs in the trans-form and features a chain structure with an extensive conjugated polyene system, which is crucial for its biological properties, including its susceptibility to oxidative degradation (Shi et al., 2002). It is a symmetrical, acyclic carotenoid ($C_{40}H_{56}$) with 13 double bonds, 11 of which are conjugated and arranged in a linear sequence, while 2 are non-conjugated (Shi and Le-Maguer, 2000). Research indicates that lycopene in tomatoes is better preserved in certain processed forms than in fresh tomatoes. Therefore, this study aims to compare the lycopene and mineral content in various preserved tomato samples with that of fresh tomatoes.

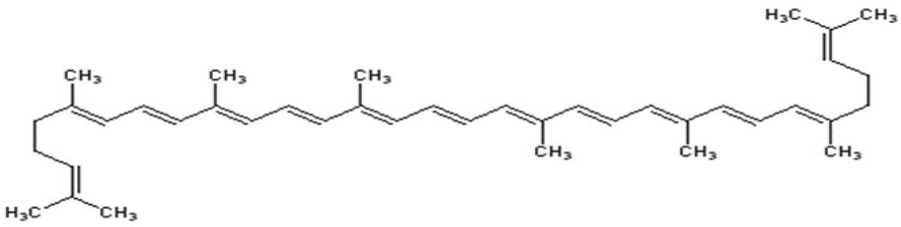

Fig.1. Molecular Structure of Lycopene

Minerals are chemical constituents and inorganic substances found in all body tissues and fluids, essential for maintaining various physiological processes vital to life (Soetan et al., 2010). Although they do not provide energy, they play crucial roles in many bodily functions (Eruvbe, 2003). Minerals can be broadly categorized as either macro (major) or micro (trace) elements. Macro minerals include calcium, phosphorus, potassium, sodium, and chloride, while micro-elements consist of iron, copper, cobalt, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium, and sulfur (Eruvbe, 2003).

Food preservation involves the treatment and handling of food to prevent or slow down spoilage, which includes the loss of quantity, edibility, or nutritional value, thereby extending its storage life (Ananou et al., 2007). Traditional preservation methods include drying, refrigeration, and fermentation, while modern techniques encompass canning (both industrial and home-based), pasteurization, freezing, irradiation, and the use of chemicals. Advances in packaging materials have also significantly contributed to modern food preservation (Alzamora et al., 2000). Today, various forms of preserved tomatoes are available on the market, including dried, chemically preserved, and more recently, boiled tomatoes packaged in glass or plastic containers. These methods ensure a continuous supply of tomatoes throughout the year and help prevent spoilage. However, it has been noted that some preservation techniques may result in the loss of certain nutritional contents in tomatoes (Hossain et al., 2010). Numerous studies have highlighted the use of chemical preservatives, such as sodium benzoate and potassium metabisulfite, in the preparation of tomato juice and paste. Research has shown that sodium benzoate is a more effective preservative for tomatoes and tomato products compared to potassium metabisulfite and sorbic acid (Hossain et al., 2010).

Material and Method

Samples Collection

Matured tomatoes (*Lycopersicon esculentum*) of almost the same size were purchased from the

market in the Kaduna metropolis. It was wanted to be free from insects and mechanical damage. They were transported to the laboratory within 30 mins of purchasing.

Tomato Puree Preparation

Undamaged tomatoes were selected, washed with tap water, and rinsed with deionized water. Cores were removed along with any blemished or discolored parts. The unpeeled fruits were then chopped into pieces and pureed using an Emel blender wrapped with aluminum foil.

Thermal Treatment

Thermal treatment of freshly prepared tomato puree was carried out in an oven at atmospheric pressure. Approximately, (30 g) of tomato puree was weighed into a 200ml beaker covered with aluminum foil, and the beaker was placed into an oven set at the treatment temperature. The heating treatment temperatures are 60, 90, 100, 120, and 1500C for 5, 10, 30, and 60 minutes in an oven. A sample at room temperature at zero (0) minutes was used as the unheated sample (control). After heating treatment, the tomatoes were cooled at room temperature under dim light to limit photo-oxidation of the samples (Shi et al, 2002).

Extraction of Lycopene

5 g of the tomato puree was precisely weighed in a 150 ml beaker. 50 ml of hexane-acetone-ethanol solution (2:1 sample to solubilize the lycopene (Shi and Maguer, 2000).

The mixture was allowed to stand for 5-10 minutes. It was then decanted in a 250 ml separatory funnel to separate the two layers. The layers were separated, and the upper hexane layer was collected into amber screw vials to avoid light oxidation for spectrophotometric analysis.

Spectrophotometric Analysis

An aliquot of the hexane extract was then poured into a 1cm path-length quartz cuvette cell at 503 nm in a UV-visible spectrophotometer (Spectrumlab. 752S, England) using Hexane as a blank. Readings were taken in triplets for each sample.

Result And Discussion

Lycopene has a large absorbance at 503 nm. The molecular extinction coefficient of lycopene at 503 nm is $17.2x10^4$/M/cm (Zechmeister et al, 1943). The molecular weight of lycopene is 536.85 g/mol. Lycopene content in a sample was estimated using the following relation (Fish et al, 2002).

$$\text{Lycopene(mg/g tis)} = \frac{A_{503} \times 31.2}{\text{Tissue(g)}}$$

Where the molar extinction coefficient of 17.2 $x10^4$ / cm is reported by Zechmeister et al, (1943) for lycopene in hexane. Most extinction coefficients that have been reported subsequently are within 1-2 % of this value (De Ritter and Purcell, 1981). Although not the absorbance peak at 503 nm was used to minimize interference from other carotenoids contents of red-fleshed watermelon, fresh red tomato, and pink grapefruit utilized (Holden et al, 1999) together with molar extinction coefficients at 503 nm in hexane for these carotenoids (Zechmeister et al, 1943; Zechmeister and Polgar, 1943). The potential error can be estimated if absorbance contributions by other carotenoids are ignored. Such a calculation suggests that constituent carotenoids other than lycopene will contribute to the absorbance at 503 nm <2 %, for red-fleshed watermelon, <4 % for fresh red tomatoes, and <6 % for pink grapefruit. These levels of possible lycopene overestimation are at or near the levels of uncertainty in the parameters used in the calculation and other parameters of the method. Thus, this or any extraction/spectrophotometric assay for lycopene should provide reasonable results for those foods in which lycopene constitutes at least 70 % of the constituent carotenoids (Fish *et al*, 2002). We chose to work with values of lycopene

content expressed in terms of mg/g since that (or the equivalent, µg/g) makes data handling easier and a unit of concentration commonly used in the literature (Beerh and Siddappa, 1959; Perkins-Veazie et al, 2001). The changes in total lycopene contents during heating treatments are shown in Table 1. Because the puree samples for different heating treatments were obtained from different batches the initial concentrations of lycopene were not the same.

Table 1: The changes in lycopene levels (mg/5g puree) during heating treatment*

Time (min.) /Temperature	60^0C	90^0C	100^0C	120^0C	150^0C
0	6.76±0.0	14.54±0.03	10.55±0.0	8.80±0.04	17.30±0.03
5	12.97±0.0	16.11±0.03	11.73±0.0	9.82±0.04	16.97±0.0
10	11.00±0.07	13.97±0.0	11.98±0.0	11.94±0.0	16.66±0.0
30	12.07±0.0	13.60±0.0	11.35±0.0	12.68±0.0	17.28±0.0
60	11.41±0.08	13.72±0.0	10.85±0.0	10.21±0.06	17.53±0.0

**Values are the average of three replicates on each treatment ±SD.*

Interestingly, our result shows that heating at those temperatures at a longer time, lycopene began to increase dramatically except at 150^0C which recorded an insignificant increase compared to other temperatures. This reveals that heat is facilitating the release of lycopene from the tomato matrix. This result, however, is consistence with other studies on the effect of processing on lycopene content. Graziani et al. (2003) showed that extractable lycopene content significantly increased when tomatoes were heated in an oil bath at 100^0C for 2 hours. Re et al. (2002) also reported that processing tomato pulp under different temperatures for paste production resulted in apparently higher lycopene content and a higher antioxidant activity. Dewanto et al. (2002) and Chang et al. (2006) suggested that thermal processes might break down cell walls and weaken the bonding forces between lycopene and the tissue matrix. Such disruptions in the cell wall fraction may enhance the release of phytochemicals from the matrix.

Conclusion

Conclusively, this research shows that lycopene in tomatoes appears to be relatively stable at those treated temperatures and duration of treatment. The result also reveals that longer time treatment caused greater extractability of lycopene. And, the ease of chemical extractability could also translate to greater bioavailability.

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