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Effect of Heat Treatment on the Lycopene Content of Tomato Puree.

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ABSTRACT

Lycopene is a powerful antioxidant. Epidemiological studies have associated its consumption with numerous health benefits. In this study the effects of heating on lycopene were investigated by exposing tomato (*lycopersicon esculentum*) puree to different temperature treatments (60, 90, 100, 120, and 150^{0}C) for 5, 10, 30, and 60 minutes respectively in the dark. The concentrations of total lycopene in the puree were 6.76, 12.97, 11.00, 12.07, and 11.41 mg/5g at 60^{0}C, 14.54, 16.11, 13.97, 13.60, and 13.72 mg/5g at 90^{0}C, 10.55, 11.73, 11.98, 11.35, and 10.85 mg/5g at 100^{0}C, 8.80, 9.82, 11.94, 12.68, and 10.21 mg/5g at 120^{0}C, and 17.30, 16.97, 16.66, 17.28, 17.53 mg/5g at 150^{0}C for 0, 5, 10, 30, and 60 minutes respectively. The result shows that lycopene was relatively stable during thermal treatment and however, the result suggested that thermal processes might break down cell walls and enhance the release of lycopene from the tomato matrix.

Keywords: Antioxidant, Lycopene, Thermal Treatment, Tomato.

INTRODUCTION

Tomatoes are an important agricultural commodity worldwide. The characteristics deep-red colour of ripe tomato fruits and tomato-based foods is mainly due to lycopene (Shi *et al*, 2002). Lycopene is a naturally occurring phytochemical that gives fruits and vegetables a red color. It's one of pigments called carotenoids (Shi and Le-Maguer, 2000). It is found in particularly high amounts in tomato products. Apart from tomato, lycopene is also responsible for the red color of watermelon, red grape fruit, apricots and Brazilian guava (Stahl and Sies, 1996). One cup (240 ml) of tomato juice provides about 23 mg of lycopene (Agarwal and Rao, 2000). Lycopene is a symmetrical, acyclic carotenoid ($C_{40}H_{56}$) with 13 double bonds of which 11 are conjugated arranged in a linear array (Fig. 1, Hwang, 2012). In tomato, it occurs as carotenoid-protein complexes or membrane bond semi-crystalline structures derived from plastids (Shi and Le-Maguer, 2000) and must be transferred into micelles before it is potentially absorbable (Faulks and Southon, 2005). It's known to exist in a variety of isomeric forms, including the all-Trans, mono–cis, and poly-cis forms. The all-trans isomer of lycopene is the predominant geometrical isomer in fresh tomatoes (Shi *et al*, 2002). Lycopene is proven antioxidants (Dimascio *et al*, 1989). Antioxidants neutralize free radicals, which may damage the body cells (singlet-oxygen-quenching ability) (Gerster, 1997). This singlet-oxygen-quenching ability of lycopene is twice as high as that of β-carotene and ten times higher than that of α-tocopherol (Vitamin E) (Weisburger, 2002). This singlet oxygen or in another word called reactive oxygen species (ROS) have been implicated in playing a major role in the causing and progression of several chronic diseases including cancer and cardiovascular diseases (Agarwal and Rao, 2000). These ROS are highly reactive molecules that combine with substances in the body cells, altering them in a harmful way, thus potentiating the disease (Rao and Agarwal, 1990). In the body, lycopene is deposited in the liver, lung, prostate gland, colon and skin. Its concentration in the body tissue tends to be higher than all other carotenoids (Zhang, and Tang, 1997). Due to that, lycopene has been shown in epidemiological and experimental studies to protect against prostate cancer, breast cancer, atherosclerosis, and associated coronary artery disease (Gartner *et al*, 1997; Nguyen and Schwartz, 1999; Stahl and Sies, 1992). It also reduces low-density lipoprotein (LDL) oxidation and helps reduce cholesterol levels in the body (Rao and Agarwal, 1990).

Research shows that, lycopene in tomatoes can absorbed more efficiently by the body if

processed into juice, sauce, paste and ketchup (Giovannicci, 1999).

This study therefore, quantify the lycopene content in the tomato puree after heating at different temperature treatment with varying time, so as to check whether processing raw tomatoes using heat in making of tomato juice, tomato paste or ketchup can actually affect/changes the lycopene concentration in the raw product into a form that is easier for the body to use.

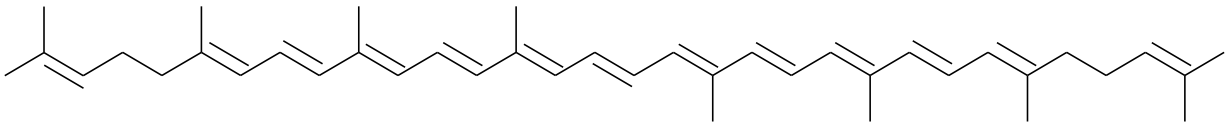

Fig.1. Molecular Structure of Lycopene

MATERIAL AND METHOD

SAMPLES COLLECTION

Matured tomatoes (*lycopersicon esculentum*) of almost same size were purchased from Yankaba market in Kano metropolis. They were free from insects and mechanical damage. They were transported to the laboratory within 30minutes of purchasing.

TOMATO PUREE PREPARATION

Damaged and over-matured fruits were discarded. Undamaged tomatoes were selected, washed with tapped 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 (Em-999, China) wrapped with aluminum foil. To minimized variation in total solid (TS), care was taken to consistently limit the lost of juice by covering well the blender during sample preparation and subsequent treatments (Shi *et al*, 2002).

THERMAL TREATMENT

Thermal treatment of freshly prepared tomato puree was carried out in an oven (Hot bone oven, Gallankamp, England) at atmospheric pressure. Approximately, thirty gram (30g) of tomato puree was weighted 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 150^0C for 5, 10, 30, and 60 minutes in oven. A sample at room temperature at zero (0) minute was used as the unheated sample (control). After heating treatment, the tomatoes purees were cooled at room temperature under dim light in order to limit photo-oxidation of the samples (Shi *et al*, 2002).

LYCOPENE EXTRACTION

Five gram (5g) of the tomato puree was precisely weighed in a 150 ml beaker. Fifty milliliter (50 ml) of hexane-acetone-ethanol solution (2:1:1 v/v/v) was added into the beaker containing the 5 g sample to solubilized the lycopene (Shi and Maguer, 2000). The mixture was allowed to stand for 5-10 minutes. It was then decanted in 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 1cm path length quartz cuvette cell at 503nm in a UV-Visible spectrophotometer (Spectrumlab. 752S, England) using Hexane as a blank. Readings were taken in triplet for each sample.

RESULT AND DISCUSSION

Lycopene has large absorbance at 503 nm. The molecular extinction coefficient of lycopene at 503 nm is $17.2x10^4$/M/cm (Zechmeister *et al*, 1943). Molecular weight of lycopene is 536.85 g/mol.

Lycopene content in a sample was estimated using the following relation (Fish *et al*, 2002):

$$\text{Lycopene (mg/kg tissue)} = \frac{A_{503}}{17.2\times10^4/\text{M/cm}} \times \frac{536.9\ \text{g}}{\text{Mole}} \times \frac{1\ \text{L}}{10^3\ \text{ml}} \times \frac{10^3\ \text{mg}}{1\ \text{g}} \times \frac{10.0\ \text{ml}}{\text{kg Tissue}}$$

$$= \frac{A_{503} \times 0.0312}{\text{kg tissue}}$$

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

(Fish *et al*, 2002)

Where the molar extinction coefficient of 17.2 x10^4 / cm is that 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 503nm was used in order to minimize interference from other carotenoids contents of red-fleshed watermelon, fresh red tomato, and pink grape fruit are utilized (Holden *et al*, 1999) together with molar extinction coefficients at 503nm 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 grape fruit. These levels of possible lycopene over estimation 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 of 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 exactly the same.

It's interesting that, our result shows that, heating at those temperatures at a longer time, lycopene began to increase dramatically except at 150^0C which recorded 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 2hours. 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.

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.

CONCLUSION

Conclusively, this research shows that lycopene in tomato 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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