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Lycopene in Tomato and Tomato-Based Products: Levels and Their Contribution to Dietary Lycopene

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Abstract. Lycopene is a carotenoid that has antioxidant properties and imparts the red pigment in some fruits and vegetables. Tomato (*Lycopersicon esculentum* Mill.) is one of the predominant source of lycopene in a typical Nigerian diet. This study evaluates the lycopene contents of various commonly consumed tomatoes and tomato products and estimates its daily intake levels. A rapid and simple spectrophotometric method for analyzing lycopene content in tomatoes and tomato products was used. Lycopene content in various tomatoes and their products on a fresh weight basis ranged from 56 mg/kg to 371 mg/kg. Average daily dietary lycopene intake levels were assessed by means of food frequency questionnaire and were estimated to be 33.39 mg/day. Fresh tomatoes accounted for 54% of total lycopene intake. The lycopene/β-carotene ratio of tomato products is less than unity while that of fresh tomatoes is greater than unity.

Keywords: lycopene, antioxidant, tomato products, dietary intake, spectrophotometric technique

Introduction

Tomatoes constitute an important agricultural crop worldwide and an integral part of human diet. They are grown for their edible fruits which can be eaten raw in salad or cooked, peeled or made into purees ketchup, soup or powdered or juice in any canning industry. In West Africa, tomatoes are used as condiments for stew, which are regular features in African meals. Recent studies have indicated the potential health benefits of diet rich in tomatoes and tomato products (Agarwal and Rao, 1998; Rao and Agarwal 1998).

Lycopene (φ, φ -carotene, Fig. 1.) the predominant carotenoid in tomatoes, is among the major carotenoids in human serum (Khachik, 1995; Satahl *et al.*, 1992; Parker, 1989); liver (Schmitz *et al.*, 1991; Kaplan *et al.*, 1990); testes (Stahl *et al.*, 1992; Schmitz *et al.*, 1991), and the prostate (Clinton *et al.*, 1996;1994). It can most easily be seen in ripe tomato fruit, watermelon and pink grapefruite, giving them characteristic red pigmentation. The lycopene content in tomato as a fruit is low and can only be increased by processing tomato fruits either into paste, ketchup or juice.

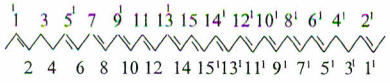

Fig. 1. Structure and numbering of lycopene.

The single oxygen-quenching properties of lycopene and there by its ability to trap peroxyl radicals (DiMascio *et al.*, 1989), result in reduction of the risk of developing arteriosclerosis and coronary heart disease (CHD), as it prevents oxidation of low density lipoprotein cholesterol (Agarwal and Rao, 1998). Moreover, there are a number of clinical evidences and epidemiological studies supporting the role of lycopene to provide protection against different types of cancer (Shi and Maageur 2000; Nguyen and Schwartz, 1999; Clinton, 1998; Ames and Gold, 1998; Plan *et al.*, 1996; Levy *et al.*, 1995).

Since humans are unable to synthesize carotenoids de novo, we depend upon the diet exclusively for the source of these micronutrients. At least 85% of our dietary lycopene comes from tomato fruits and tomato-based products, the remainder being obtained from watermelon, pink grapefruit, guava and papaya (Bramley, 2000). Inspite of the interest in the role of lycopene in the prevention of chronic diseases, information regarding the lycopene content of commonly consumed food products in Nigeria is lacking. As a result, estimates of daily intake of lycopene are not available. The aim of this study was to evaluate the lycopene content of tomatoes and different tomato based products commercially available in the market and supermarket and to estimates its daily intake levels.

Materials and Methods

Samples and materials. Tomatoes (Pear type) were purchased in commercial markets, Arada, Ogbomoso - Nigeria and maintained at 70 °C for no more than 48 h. The tomatoes (skin and pulp without seeds) were dried in a freeze-dryer and subsequently ground, and wrapped with aluminium foil and stored at

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-180 °C prior to extraction. Tomato-based products used were purchased from supermarkets and these include Tripak tomato ketchup (Tripak Sal Beirut, Lebanon); Heinz tomato ketchup (H.J. Heinz Co., Ltd; Hayes); Paone tomato paste and Pasta tomato paste (Packed in Italy) and Malee tomato juice (Malee Sampram Public Company Ltd, Thailand). All solvents used for the analysis were of analytical grade and the doubly distilled water (ddw) was used.

Extraction of lycopene. Lycopene from tomato and tomato-based products were extracted with hexane, methanol, acetone (2:1:1), containing 2.5% BHT. The extract was treated with doubly distilled water, methanol and 20% KOH/methanol (1:1:1) to saponify any triglyceride present. The extract is then washed with doubly distilled water and re-dissolved in hexane. Optical density of the hexane extract was scanned spectrophotometrically in the wavelength 400-750 nm against hexane as blank. Concentrations of lycopene and β-carotene were calculated at λ_{max} 505 and 487 nm respectively.

Estimation of dietary intake of lycopene. The average daily consumption of tomatoes and different tomato-based products was estimated using a tomato products consumption frequency questionnaire (CFQ), a modified from of Block Food Frequency Questionnaire (Block *et al.*, 1986). The amount of dietary lycopene was computed from CFQ and the lycopene contents of different products.

Results and Discussion

At present, little information is available regarding the lycopene content of commercial tomato products sold in southwestern, Nigeria. In an attempt to estimate the daily intake levels of lycopene, tomatoes and tomato products were purchased from local markets and supermarkets; and analyzed for their lycopene contents. Table 1 shows the lycopene contents of the commonly consumed commercial tomatoes and tomato products. The tomato samples has a lycopene concentration ranging, on a fresh weight basis, from 56 mg/kg in tomato juice to 37 mg/kg in tomato paste. The lycopene contents of those used in food preparation, like paste, has the highest lycopene levels from 266 to 371 mg/kg; condiments like ketchup ranged from 134 to 235 mg/kg and readily consumed product, like juice had low levels (56 mg/kg) of lycopene. Dried and fresh tomatoes had moderate levels (188 mg/kg and 211 mg/kg, respectively) of lycopene.

Table 2 shows the frequency of consumption of tomatoes and tomato products in Nigerian population and average daily intake of lycopene from various tomato products. Contribution of different tomatoes and their products to daily lyco-

Table 1. Lycopene and β-carotene content of commonly consumed commercial tomato fruits and tomato-based products.

Product	Lycopene, mg/kg mean ± SEM; (λ_{max} 505 nm)	β-carotene, mg/kg mean ± SEM; (λ_{max} 487 nm)
Heinz tomato ketching	235.4 ± 4.7	267.64 ± 3.08
Tripack tomato ketching	133.9 ± 2.0	156.61 ± 1.96
Malee tomato juice	55.87 ± 0.56	69.38 ± 0.62
Paone tomato paste	371.2 ± 4.1	448.8 ± 4.6
Pasta tomato paste	266.8 ± 2.8	344.7 ± 2.2
Dried tomato powder	188.1 ± 0.9	217.7 ± 1.1
Fresh tomato fruits	211.6 ± 2.1	119.8 ± 3.4

Table 2. Consumption frequency of tomatoes and tomato products and estimated daily intake of lycopene

Product	Serving size	Frequency of intake	% of population studied	Lycopene intake (mg/day/subject)	% of total daily lycopene intake
Tomatoes (fresh)	150 g	none	02	18.1	54.2
		<1/wk	08		
		1-4/wk	18		
		>4/wk	30		
Tomatoes (dried)	200 g	None	05	5.37	15.8
		<a/wk	24		
		1-4/wk	10		
		>4/wk	0		
Heinz (tomato ketchup)	15 g	None	16	1.51	4.52
		<1/wk	05		
		1-4/wk	35		
		>4/wk	14		
Paone (tomato paste)	60 g	None	05	3.18	9.52
		<1/wk	24		
		1-4/wk	14		
		>4/wk	03		
Tripak (tomato ketchup)	18.0 g	None	10	0.69	2.07
		<1/wk	26		
		1-4/wk	36		
		>4/wk	12		
Malee (tomato juice)	250 ml	None	15	2.25	6.74
		<1/wk	40		
		1-4/wk	18		
		>4/wk	0		
Pasta (tomato paste)	60 g	None	11	2.25	6.86
		<1/wk	30		
		1-4/wk	17		
		>4/wk	06		
Total				33.39	

pene intake was established on the basis of detailed dietary questionnaire, which contained information on the serving size and the frequency of intake. Amount of tomatoes and tomato products consumed on daily basis were then multiplied by their lycopene content to obtain daily intake values. Average Nigerian daily dietary intake of lycopene is about 33.39 mg. This is inagreement with dietary recommendations made by the study from Harvard School of Medicine where intake of 10 or more servings of tomato products per week were associated with decreased risk of prostate cancer (Giovannucci *et al.*, 1995). Ingestion of 23 mg of lycopene from tomato paste has also been reported to increase serum lycopene levels by 2.5 folds (Gartner *et al.*, 1997) as recommended as part of healthy eating, 52% of this dietary lycopene is being provided by fresh tomatoes. Gartner *et al.*, (1997) found that dietary lycopene when provided in the form of fresh tomatoes, failed to increase the lycopene. They concluded that lycopene from fresh tomatoes is not readily bioavailable. Although comparative bioavailability values for lycopene from processed tomato products appears to be more bioavailable than that from raw tomatoes (Gartner *et al.*, 1997; Stahl and Sies, 1992). The release of lycopene from the food matrix due to processing, the presence of dietary lipid and heat induced isomerization from an all *trans* to a *cis* conformation enhance lycopene bio-availability (Rao and Agarwal, 1999).

The bioavailability of lycopene is also affected by the dosage and the presence of other carotenoids such as β-carotene. The concentrations of β-carotene were also determined (Table 1). Jonson *et al* (1997) found that the bioavailability of lycopene was significantly higher when it was ingested along with β-carotene than when ingested alone. It is on this basis that we determined the concentration of β-carotene alongside that of lycopene Table 1, and from which the lycopene/β-carotene ratios of the tomatoes and tomato products were determined. The lycopene/β-carotene ratios of the tomato products are less than unity, showing that there is higher amount of β-carotene level than lycopene, which may further enhance the bioavailability of lycopene in these products, whereas, it is greater than unity in fresh tomato fruits. This is inagreement with the findings of Johnson *et al*, (1997) and this ratio may also be an aditional parameter for determining the bioavalability of lycopene in tomatoes and tomato based products.

Conclusion

It can be concluded from this study that inclusion of more processed tomato products in the diet is important in meeting the daily recommended level of lycopene and maintaining healthy eating habits. The lycopene/β-carotene ratio may also be a promising parameter for determining the bioavailability of lycopene in tomatoes and tomato-based products.

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