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THE INFLUENCE OF THERMAL PROCESSING ON ANTIOXIDANT CAPACITY OF TOMATOES BASED PRODUCTS

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ABSTRACT

We intend to study the influence of thermal processing on the antioxidant capacity of tomato products.

The products were analyzed for lycopene content and antioxidant activity. Lycopene was extracted using a mixture of hexane: ethyl alcohol: acetone, in ration of 1:25 (w: v). The antioxidant capacity was evaluated by the DPPH method. The obtained results show a higher quantity of lycopene in the processed products (8, 4800 ±0 ,48079 - 11,8217 ±0. 37010 mg/100g), compared to the fresh ones (2.9400±0.1510- 4.0933±0.16773 mg/ 100g) and the antioxidant activity registers higher values in the aqueous extracts (21-45%).

The thermal processing concentrates the content of lycopene and preserves the antioxidant activity, so that for the optimal nutritional intake of antioxidant phytonutrients, the consumption of processed tomatoes is indicated, to the detriment of the fresh tomatoes.

Keywords: lycopene, tomatoes, thermal processing, antioxidant activity

Introduction

The tomato fruits are valuable nutritionally natural sources whose dry matter is composed of sugar (40-60%), proteins and amino acids (15-20%), organic acids (4-10%), minerals (especially potassium), vitamins and pigments, insoluble matter (cellulose, hemicellulose and pectin). Lycopene is the carotenoid that gives color to tomatoes and plays an antioxidant role, along with carotene, phenolic compounds and vitamin C (1). The lycopene is a tetraterpene with eleven double conjugated and two non-conjugated bonds and has 72 geometric isomers.

Lycopene is mostly present in trans forms; however, in the presence of light, exposure to heat or during tomatoes' processing, the isomerization-cis takes place. Increased retention of cis isomers has generally been recorded in tomato processing compared to trans isomers (2, 3). The best stability is presented by the isomers: 5-cis ≥ all-trans ≥ 9-cis>> cis 13> 15-cis>> 7-cis> 11-cis. Lycopene has been found to be a more effective antioxidant than β-carotene, α-carotene and α-tocopherol; it is 2 times higher than $_{\beta}$-carotene and 10 times higher than Vitamin E (4).

Lycopene content varies widely in tomato varieties, as well as in other dietary sources, such as: apricots, guava, pink guava, watermelon,

papaya, pink grapefruit, strawberries. Given that thermal processing favors the formation of cis isomers, with a stronger antioxidant activity than trans isomers (which predominates in the natural form of tomatoes), it is explicable the recommendation to consume processed tomatoes in the form of pasta, tomato sauce and juice. (3). Also, it must be taken into account that the absorption is favored by the fats; olive oil substantially enhances absorption and makes it bioavailable (4).

Lycopene and other carotenoids are known for their antioxidant activities in inhibiting free radical reactions. Therefore, many researches have focused on the protective effect of lycopene on cardiovascular and tumor diseases (5, 6, 7). Toxic effects of carotenoids have not been reported. However, high consumption of lycopene-rich foods or supplements may result in orange skin coloration (lycopenoderma). The color disappears when the carotenoid consumption is reduced or stopped (4).

We focused in this study to study the lycopene content and antioxidant activity of tomatoes (Lycopersicum esculentum L., family Solanaceae), in their fresh and processed form.

Material and Methods

1. Samples analyzed

We chose one of the Romanian varieties obtained at Buzău Vegetable Research Station - Darsirius variety, with high dry matter, thin skin, few seeds in fruit and low acidity, in order not to create the fermentation phenomenon. It is well suited for industrial processing and does not require high energy consumption (8). At the same time with the Romanian variety, we also studied a similar variety from Italy suitable for processing - the Keren variety F1 (Italiare red pear), marketed in our country. The processed products were purchased from the supermarkets in Constanta (Romania), being produced by 2 producers from Romania and one from Italy. We chose from each category 3 different processed products: tomato juice, tomato sauce and tomato paste 28% dry substance.

2. Necessary reagents

Following reagents were used: Hexane of purity ≥ 96.0% (Merck, Germany); acetone of purity ≥ 99.8% (Merck, Germany); ethyl alcohol of purity ≥ 99.9% (Merck, Germany) and 2,2-diphenyl-1- (2,4,6-trinitrophenyl) -hydrazinyl radical (DPPH radical - Sigma Aldrich, Germany of purity ≥ 95%).

3. Extraction of lycopene

A mixture of hexanes solvents, acetone, ethyl alcohol (2: 1: 1) (v / v) was used. The lycopene extraction method consists of homogenization of one gram of sample and 25 mL of hexane: acetone: ethanol, using a funnel and mixing with rotary motion, after which it is left to rest and the homogenization is repeated several times for 30 minutes. At the end of this period, 10 mL of distilled water is added and stirring continues for 10 minutes. The solution was allowed to separate into distinct layers, polar and non-polar (1).

4. Determination of the lycopene content from freshly smashed tomatoes and heat processed tomato products was performed by UV-VIS spectrophotometric method at λ = 472 nm, relative to hexane. For the calculation, the value of the specific absorption coefficient (E1 cm1% = 3450) was used. Lycopene concentration was expressed in mg / 100g of product (1, 9).

5. The antioxidant capacity was evaluated by the DPPH method (c = 6x10-5M), using the 6800PC UV-VIS spectrophotometer, and the readings were made at 515 nm after 30 min, compared to the control sample (10).

$$\text{Radical scavenging activity (\%)} = 100 - \left(\frac{A_C - A_S}{A_C}\right) \times 100$$

here:

AC = Absorption of the control and AS = Absorption of the reaction mixture (in the presence of the sample).

6. Statistical calculation

All results were expressed as mean ± standard deviation (SD) of triplicate determinations. For statistically significant difference, the ANOVA method and the Student's test were used. Differences that have $p < 0.05$ are

Table 1 –Values obtained for lycopen from the analyzed samples (mg/100 g)

Descriptive Statistics				
Nr. sample	Sample	Mean		Std. Deviation
		Statistic	Std. Error	Statistic
P1	tomato juice prepared in the household	8.2533	0.03528	0.06110
P2	tomato paste prepared in the household	14.2733	0.08969	0.15535
P3	tomato juice prepared industrially by the Romanian producer X	8.9167	0.02728	0.04726
P4	sauce prepared industrially by the Romanian producer	11.2000	0.16073	0.27839
P5	28% tomato paste prepared industrially by the Romanian producer X	12.1433	0.08090	0.14012
P6-	tomato juice prepared industrially by the Romanian producer X	8.0433	0.03480	0.06028
P7	sauce prepared industrially by the Romanian producer X	9.2267	0.03844	0.06658
P8	28% tomato paste prepared industrially by the Romanian producer X	11.5000	0.06429	0.11136
P9	tomato juice prepared industrially by the Italian manufacturer T	8.4100	0.11590	0.20075
P10	sauce prepared industrially by Italian manufacturer T	15.0467	0.12979	0.22480
P11	28 % tomato paste prepared industrially by Italian manufacturer T	9.2933	0.01202	0.02082
P12	tomatoes (the Romanian variety Darsirius)	4.0933	0.09684	0.16773
P13	red (Italian variety Keren F1	2.9400	0.08718	0.15100

considered significant.

Results and Discussions

The lycopene content of the analyzed samples is shown in Table 1, respectively Figure 1, and the antioxidant capacity in Table 2 and respectively Figure 2. The way the products are prepared influences the lycopene content and the antioxidant activity.

The concentration of the products, although it involves a thermal processing, retains the large quantity of lycopene, so that the order of variation is: tomato paste> tomato sauce> tomato juice> fresh tomatoes. It is found that the values obtained in the concentrated samples that are industrially processed P3- P11 (8.0433 ± 0.06028 - 15.0467±22480) are lower than those that are homemade processed P2 (8.9167±04726 - 11.2000 ± 0.27839).

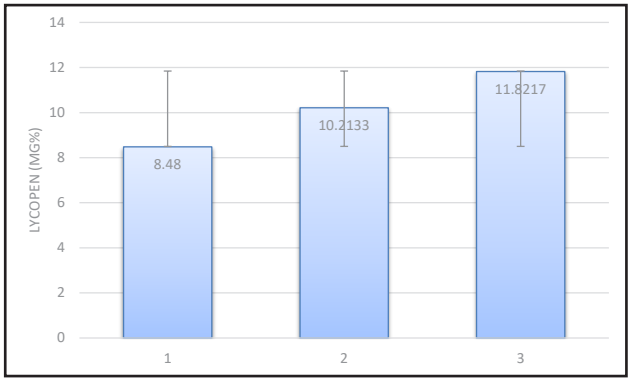

Figure 1 - The average variation of lycopene content in the analyzed samples

The results show a lycopene content in fresh Romanian tomatoes of approximately 4.0933 ± 0.16773 mg / 100g, and in the Italian ones' a smaller content 2.9400 ± 0.1510. Comparing the average values of lycopene to the Romanian samples processed industrially (P3 - P8), which come from 2 producers, we can see the correlation of the values with the degree of concentration Thus, the tomato paste contains

on average 11.8217± 0.37010; tomato sauce 10.2133± 1.0959; tomato juice 8.4800± 0, 48079 (Figure 2). Import products have lower values for juice P 9 (8.4100 ± 0.20075) and tomato paste 28% P 11 (9.2933 ± 0. 02082), except the sauce product P 10 which registers the most (15.0467 ± 0.22480).

This product contains spices with lycopene and olive oil, which facilitates availability. Comparing the average statistical values for each product assortment, presented in Table I, we find the following significant differences ($p < 0.05$): in the samples P1, P6, P5, P4 the difference is significantly higher than P3, P8 respectively P10.

The data obtained in this study are in accordance with the literature data, which shows a lycopene content in tomatoes ranging from 5.85 ± 2.46 mg/100g to 3.58 ± 1.70 mg/100g; in tomato juice - 7.32 mg/100g; tomato paste 12.24 ± 0.62 mg/100g (3).

Antioxidant capacity

Because the human body is unable to synthesize lycopene, the diet is the only source of this important component for blood and tissues. The lycopene content is preserved if in the processed products, part of the vitamins that have an antioxidant potential (C, E, A) are inactivated. The cis isomers that have much higher antioxidant activity than the trans isomers of fresh forms predominate (3, 4).

The DPPH test is largely used as a fast, reliable and reproducible method in vitro for quantifying the antioxidant activity of compounds isolated from natural sources as well as plant extracts. The reducing capacity of the compounds can serve as an indicator of the potential antioxidant property (9). In the present study, the results obtained underline a variation of the antioxidant activity between 21-45% (Table 2 and Figure 2).

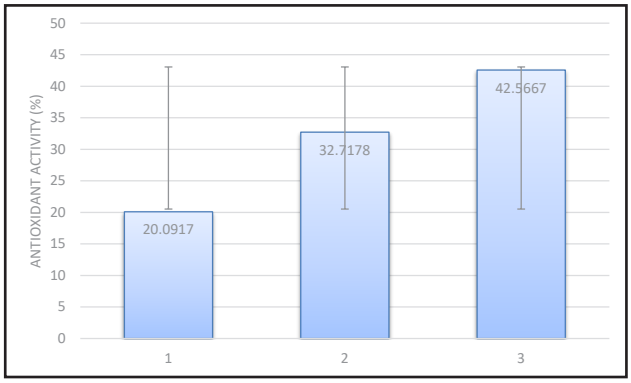

Figure 2 - The average variation of antioxidant avtivity in the analyzed samples

Table 2 Values obtained for antioxidant activity from the analyzed samples (antioxidant activity %)

Nr. sample	Mean		Standard Deviation
	Statistic	Standard Error	Statistic
P1	20.6333	0.84130	1.45717
P2	32.7667	1.13920	1.97315
P3	20.9000	0.20817	0.36056
P4	25.4000	0.34641	0.60000
P5	42.3000	0.28868	0.50000
P6	19.9000	0.23094	0.40000
P7	27.0533	0.07424	0.12858
P8	45.4000	0.23094	0.40000
P9	18.9333	0.08819	0.15275
P10	45.7000	0.17321	0.30000
P11	40.0000	0.70000	1.21244
P12	8.6167	0.15899	0.27538
P13	7.1500	0.13229	0.22913

Products processed in combination with other ingredients (vegetables + oil) have a higher antioxidant activity, which is confirmed for sample P10, with the highest value - 45%. This sample also has the highest lycopene content. Thermal processing retains the antioxidant activity; thus the values increase as the product concentration.

Antioxidant activity is higher in concentrated home made products - P1 and P2 (8,2533 ±0,06110 %; 14,2733 ± 0,15535 %), compared to those from the market P3-P11 (8,9167 ±0,04726 % - 9,2933± 0,02082%) (except for tomato paste samples 28% - P5, P8 and P10, where the content is highest, between 12.1433 ± 0.14012 % - 15,0467 ± 0,22480%), being the most concentrated forms. There are no significant differences for the same type of product, except for the imported product that contains different spices compared to the other food products.

Conclusions

Analyzing the data obtained, we observe that lycopene and antioxidant activity register the highest value in concentrated and thermal-processed products, due to the concentration of cis isomers: tomato paste, followed by tomato sauce and juice, compared to fresh tomatoes. The Romanian products on the market show higher concentrations of lycopene compared to the imported products, except for the imported product which has a mixed composition (tomatoes + vegetables + olive oil). Lycopene has high stability and bioavailability through heat treatment, which explains the antioxidant activity.

The conclusions of this study allow us to recommend for optimal food intake of lycopene, the consumption of processed products, associated with oil that makes it bioavailable in the body. Tomatoes remain valid sources as therapeutic agents in preventing or slowing the progress of reactive oxygen species and degenerative diseases associated with oxidative stress.

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