

EFFECT OF THERMAL PROCESSING ON BIOACTIVE COMPOUNDS OF TOMATO PASTE

Elena Corina Popescu*, Maria Iordan

Valahia University of Târgoviște, Faculty of Environmental Engineering and Food Science
Department of Foods Products Engineering, 18-24 Unirii Street, 130082, Târgoviște, Romania

*E-mail: corinapopescu2003@yahoo.com

Abstract

Tomato paste is used for color and taste of food preparations. Besides taste qualities, tomato paste has a high nutritional value due to its highly assimilable carbohydrate, vitamin C, carotenoids and minerals. This paper aims to determine the effects of thermal treatment on bioactive components (vitamin C, β -carotene and lycopene) of tomato paste. Vitamin C was dosed with 2-6 diclorphenolindophenol method, β -carotene by spectrophotometry and lycopene by spectrophotometric method too, using a water and alcohol solution in a 1:1 ratio. It was also followed, changing of the acidity, dry matter and the pH in tomato paste. In order to realize experiments, tomato paste with a 24% soluble dry matter containing, was maintained at 55°C, 70°C, 85°C and 95°C for 10 minutes. After heat treatment of tomato paste was brought to the initial weight so that evaporating water was completed. The results of experiments have shown that vitamin C decreased with increasing of the temperature, as well as β -carotene and lycopene amount increased with increasing temperature. Tomato acidity, expressed in citric acid decreases with increasing of the temperature and pH has varied little during the heat treatment. Loss not to register more than 50% of the total amount of provitamin A tomato should not be subjected to temperatures above 85°C Loss not to register more than 50% of the total amount of vitamin C I recommend that tomato paste is not subjected to temperatures above 70°C

Keywords: tomato paste, lycopene, β -carotene, vitamin C, heat treatment

Submitted: 15.11.2012

Reviewed: 05.12.2012

Accepted: 20.12.2012

1. INTRODUCTION

Tomato fruits (*Solanum lycopersicum*) have a great importance in food by their content in vitamins, minerals and organic acids. They have a variety of uses fresh or processed. Due base excess, tomatoes act as alkalizing. This is very important for human nutrition (Butnariu et al, 1993).

All products made by tomatoes (tomato sauce, paste, tomato juice) have antioxidant characteristics determined by the presence of bioactive compounds (lycopene, β -carotene, vitamin C, polyphenols and flavonoids), (Cernișev and Șleagun, 2007).

The level of these compounds in the body is an indicator of health, they functioning as biomarkers of food quality, (Costin și Segal, 1999).

Lycopene-bioactive compound is a carotenoid pigment predominantly in tomatoes, responsible for the intense red color of the fruit, which presents the highest antioxidant activity, (Gartner et al, 1997).

Processing tomatoes (by thermal process or mechanical) issues lycopene by its matrix and increase its bioavailability. Lycopene exists in the human body in cis form and in foods in trans-lycopene form.

Processed products contain more lycopene than fresh foods because cooking process leads to transformation of the trans isomers in cis – lycopene, (Boileau et al., 2002).

The same was sustained since 1997 by Gartner, which shows that lycopene by tomato paste is more bioavailable than lycopene by fresh tomatoes, because this is closed in fiber of the plant, (Gartner et al, 1997).

Besides lycopene, tomatoes contain significant amounts of β -carotene.

β -carotene is a bioactive compound with role in protecting the cellular membranes by the harmful action of the free radicals, (Costin și Segal, 1999).

Rock C.L. following the bioavailability of β -carotene by fresh products (carrots, spinach) comparatively of processed products reached the conclusion that β -carotene by fresh

products is present in blood in large amount than the processed products.

β -carotene isomerization of trans forms in cis forms is directly correlated with the intensity and duration of thermal processing, but cis forms have a lower bioavailability than trans forms [Rock et al 1998]. β -carotene is very sensitive to oxidation, oxidation that can be inhibited by the presence of ascorbic acid (vitamin C).

However the nutrients bioavailability increases during thermal processing due to structural changes that occur, (Adabi, 2011).

Vitamin C bioactive compound - has very important biological role, its field is very wide, so we can say that there are no essential metabolic or physiological process that can not participate. The majority reactions known to date, in which ascorbic acid participates, are oxidation-reduction reactions.

Vitamin C is more sensitive to oxygen than heat, so in the oxygen free environment is stable enough, [Segal, 2002].

2. MATERIALS AND METHODS

In order to realize experiments, tomato paste, type "Sultan" 24% soluble solids, procured from supermarkets in the area, is maintained at 55^oC, 70^oC, 85^oC and 95^oC for 10 minutes.

After heat treatment of tomato paste was brought to the initial weight so the evaporating water was added

Tomato paste was analyzed in terms of the content of bioactive compounds (vitamin C, β -carotene and lycopene), acidity (expressed as citric acid), dry matter and pH.

2.1. Determination of lycopene

Lycopene is determined by a spectrophotometric method, which consists in its extraction using a solution of water and alcohol in a 1:1 ratio. The amount of lycopene extracted is the difference between absorbance at wavelength $\lambda_1 = 570$ nm and absorbance at wavelength $\lambda_2 = 780$ nm, (Segal and Barbu, 1982).

Amount of lycopene in the sample is calculated using the formula:

$$\text{Lycopene} = \frac{A_{\lambda_1} - A_{\lambda_2}}{m} \cdot 100 \text{ [mg/100g]}$$

Where: A_{λ_1} - Sample absorbance at 570 nm;
 A_{λ_2} - Sample absorbance at 780 nm;
m - mass tomato paste, ,g.

2.2. Determination of β -carotene

β -carotene is determined by a spectrophotometric method. It is extracted from the product using petroleum ether. Sample absorbance was measured at 451 nm. β -carotene is calculated using the formula:

$$\beta\text{-carotene} = A_{451} \times 19.96 \text{ [mg / 100 g]}$$

Where: A_{451} - absorbance at 451 nm
19.96 - extinction coefficient

2.3. Determination of vitamin C

Vitamin C (ascorbic acid) is dosed with 2-6 diclorphenolindophenol, (STAS nr. 5950/71) Ascorbic acid content of the product is determined by:

$$\text{mg ascorbic acid 100 g} = [(V \times t) / m] \times d \times 100$$

Where: V—the volume of the 2-6- diclorphenolindophenol solution used for titration of the amount of ascorbic acid and dehydroascorbic acid, in cm³
t – the titer of the 2-6-diclorphenolindophenol solution, in mg/ cm³;
m– the quantity of analyzed product, g;
d – dilution factor.

2.4. Determination of acidity.

Acidity is determined by titration titrimetric method which consist in titration of sample with sodium hydroxide solution in the presence of phenolphthalein as indicator, (STAS 5952/79).

Titrate acidity (TA) is calculated by the formula:

$$\text{TA} = \frac{V_1 \times V_3 \times 0,1}{V_2 \times M} \times 100 [\text{cm}^3 \text{NaOHn} / 100 \text{g}]$$

Where: V_1 - the volume at which the amount of analyzed sample was diluted, cm^3 ;
 V_2 - the volume of solution that was taken for determination, cm^3 ;
 V_3 -the volume of the of sodium hydroxide solution 0,1 n used for titration, cm^3 ;
M- the quantity of analyzed product, g;

2.5. Determination of dry matter.

The sample is dried to constant weight by maintaining the oven at a temperature of $105 \pm 2^\circ \text{C}$, (STAS 5950/1985).

3. RESULTS AND DISCUSSIONS

Effect of thermal processing on lycopene is shown in Table . 1.

Table 1. Variation of lycopene from tomato paste with temperature

Temperature [°C]	21° C	55° C	70° C	85° C	95° C
Absorbance at 570 nm	0,04 3	0,04	0,04 1	0,04	0,03
Absorbance at 780 nm	0,04 0	0,03 6	0,03 7	0,03 6	0,02 6
Mass tomato paste [g]	0,13 2	0,13 5	0,12 8	0,11 5	0,11 1
Lycopene [mg/100g]	2,25	2,94	3,12	3,46	3,58

Analyzing the results presented in Table 1 is an increase in the amount of lycopene with temperature. The largest increase in the amount of lycopene is obtained after a thermostating for 10 minutes at 95°C , increase that has a value 37.15% comparatively to the amount of lycopene from tomato paste

Effect of thermal processing of β -carotene is shown in Table 2.

Analyzing the results presented in Table 2 we observe the the greatest loss of provitamin A (β -carotene) is obtained by maintaining at 95°C , tomato paste, a loss which has a value of 51.61%.

Table 2. Variation of β -carotene content of tomato paste, the temperature

Temperature [°C]	21° C	55° C	70° C	85° C	95° C
Dilution factor	10	11	10	5	0,5
Absorbance at 451 nm	0,31	0,25	0,17	0,355	0,3
β -carotene	61,87	54,89	47,90	35,42	29,94

β -carotene is unstable to heat. The results indicate a decreasing trend of β -carotene, with increasing temperature.

To avoid losses exceeding 50% of the total amount of provitamin A, tomato paste should not be maintained at temperatures above 85°C . Effect of thermal processing on vitamin C is presented in the Table 3.

Analyzing the results presented in Table. 3, we observe that the loss of vitamin C increase with temperature. The greatest loss of vitamin C is obtained by maintaining tomato paste at 95°C , a loss which has a value of 59.32%. To record loss not exceeding 50% of the total amount of vitamin C I recommend that tomato paste is not maintaining to temperatures above 70°C .

Effect of thermal processing on acidity, expressed in citric acid, is shown in Table 4. Analyzing the results presented in Table. 4 We observe a decrease of acidity with the increasing of temperature.

The largest decrease in acidity of tomato paste was obtained after a period of thermostating for 10 minutes at 55°C , which has the value of 17.89%, comparative with the initial amount. Lower acidity of tomato paste subjected to heat treatment, it may be due on the one hand decrease ascorbic acid (vitamin C), and on the other hand due to precipitation of salts existing in the paste.

Effect of thermal processing of dry matter is presented in Table. 5.

From the data presented it is observed that dry substance of tomato pasta varies very little during the heat treatment. The difference is probably the result of loss of the dry substance in water evaporated.

Table 3. Variation of vitamin C content of tomato paste, the temperature

Temperature [°C]	21° C	55° C	70° C	85° C	95° C
Weight [g]	5	5	1	1	1
Titer of the 2-6 diclorphenolindophenol solution, [mg/ml]	0,00088	0,00088	0,00088	0,00088	0,00088
Dilution factor.	10	10	10	10	10
Volume of the 2-6- diclorphenolindophenol [ml]	33,2	25	3,75	3,1	3
Vitamin C [mg/100g]	5,9	4,4	3,3	2,7	2,4

Table 4. Variation of acidity of tomato paste, the temperature

Temperature [°C]	21° C	55° C	70° C	85° C	95° C
V ₁ [cm ³]	250	250	250	250	250
V ₂ [cm ³]	50	50	50	50	50
V ₃ [NaOH cm ³]	3,9	3,2	2,8	2,6	2,4
M [g]	20	20	20	20	20
Acidity [cm ³ NaOHn/100cm ³]	9,75	8	7	6,5	6
Acidity (citric acid) [mg/100]	0,0682	0,056	0,049	0,044	0,042

V₁- the volume at which the amount of analyzed sample was diluted, cm³;
V₂- the volume of solution that was taken for determination, cm³;
V₃-the volume of the of sodium hydroxide solution 0,1 n used for titration, cm³;
M- the quantity of analyzed product, g;

Table 5. Variation of dry matter from tomato paste with temperature

Temperature [°C]	21° C	55° C	70° C	85° C	95° C
Dry matter [mg/100g]	28,7763	28,7517	28,6050	28,4666	28,4069

Table 6. Variation of pH-ului, of tomato paste, the temperature

Temperature [°C]	21° C	55° C	70° C	85° C	95° C
pH	4,42	4,469	4,505	4,525	4,55

Effect of thermal processing of pH is presented in Table 6.

The data presented in Table 6 we see that the pH of tomato paste has changed very little during the heat treatment, registering an increase of 4.42, as was initially tomato paste up to 4.55 at 95 ° C.

4. CONCLUSION

The analysis results can highlight the following conclusions:

⇒ loss not to register more than 50% of the total amount of provitamin A tomato should not be subjected to temperatures above 85⁰C;

- ⇒ loss not to register more than 50% of the total amount of vitamin C I recommend that tomato paste is not subjected to temperatures above 70°C;
- ⇒ acidity of tomato paste expressed in citric acid decreases with increasing temperature;
- ⇒ dry substance of tomato paste decreased very little during heat treatment;
- ⇒ pH of paste changed very little during the heat treatment.

5. REFERENCES

- [1] Butnariu H., Indrea D., Petrescu C., și alți. Legumicultură, Editura deidactică și pedagogică București 1993.
- [2] CERNIȘEV S. , ȘLEAGUN G. Influence of dehydration technologies on dried tomato biological quality and value. Cercetări agronomice în Moldova, anul XXXX, vol. 3 (131)/2007, pp. 63-68.
- [3] Costin G.M., Segal R. Alimente funcționale. Editura Academica Galați, 1999, pp 39-71.
- [4] C Gartner, W Stahl and H Sies. Lycopene is more bioavailable from tomato paste than from fresh tomatoes. American Journal of Clinical Nutrition, Vol 66, pp 116-122, 1997.
- [5] Thomas W.-M. Boileau, Amy C. Boileau and John W. Erdman Jr. Bioavailability of *all-trans* and *cis*-Isomers of Lycopene. Experimental Biology and Medicine, 227:pp 914-919, 2002.
- [6] Rock Cl., Loalvot J. L., Emenhiser Curt, et al.. Bioavailability of beta-carotene is lower in raw than in processed carrots and spinach in women. JN the journal of Nutrition. 1998 May;128(5):913-6.
- [7] Abadi Gebre Mezgebe. The relation between the *in vitro* bioaccessibility of β -carotene and structural characteristics of carrot pieces during thermal processing (sterilization and pasteurization) in a retort. African Journal of Food Science Vol. 5(16), pp. 845-850, 23 December, 2011.
- [8] Segal R. Principiile nutriției. Editura Academica, Galați, 2002.
- [9] Segal R., Barbu I. Analiza senzorială a produselor alimentare. Editura tehnică București, 1982.
- [10] Maguer M., Shi J. Lycopene in tomatoes (chemical and phzysical propertiesaffected by food processing), 4th Edition, Chapman and Hall, New York, pp 293-334, 2000.
- [11] Standards for Vegetable Products Collection