

EFFECT OF DRYING TEMPERATURE ON LYCOPENE CONTENT OF PROCESSED TOMATOES

Andrea Mendelová, Lubomír Mendel, Martina Fikselová, Peter Czako

ABSTRACT

Recently it has been increasing interest worldwide in the production of dehydrated tomato products, which are used in food industry and in pharmacy. An important indicator of the quality of products, beside the microbiological stability is health safety and lycopene content. The aim of this work was to evaluate the effect of drying temperature on changes of the content of lycopene in selected varieties of tomato. Drying was performed at 45 °C, 70 °C and 90 °C. Varieties of Darina F1, Denár, Kecskeméty, Orange, Paulína F1, Šejk F1 were used. Tomatoes were processed into dried slices with the dry matter content of 80-85%. Content of lycopene was determined spectrophotometrically. The content of lycopene in fresh tomatoes ranged from 63.378 mg 100 g⁻¹ of dry matter (Orange) to 302.37 mg 100 g⁻¹ of dry matter (Šejk F1). After drying at all temperatures, content of lycopene decreased on average of 64.48 to 68.3%. The most significant changes were found at temperature of 90 °C. Based on the results the most appropriate temperature for drying among the monitored temperatures was at 70 °C, in this case the content of lycopene in the product ranged from 12.839 mg 100 g⁻¹ dry matter (Orange) to 115.9 mg 100 g⁻¹ of dry matter.

Keywords: tomato; lycopene; drying; processing; color of product

INTRODUCTION

As it is reported by several authors (**Dorais et al., 2008; Huang et al., 2010**) traditional tomato products are tomato puree, ketchup or tomato juice, etc. These products are characterized by high amount of carotenoids and their good bioavailability in humans. Recently, tomatoes have also been used for the production of dried products, which are further processed into various types of high quality vegetable oils or as a raw material in the production of instant foods or food supplements.

For drying are the most suitable tomato varieties for industrial processing. Desired are tomatoes in the form of plum fruit having higher content of dry matter (**Greensmith, 1998**). The basic objective of drying is to remove water from the material and the consequent limitation of microbial activity, longer shelflife and significant reducing of the volume of finished products (**Lewicki and Porzecka-Pawlak, 2005**). As state **Celma et al., (2009)** the most widely used for drying are conventional hot air dryers that transfer heat to the products using hot air. At drying currently used are techniques of osmotic dehydration and combination of osmotic dehydration and microwave drying.

Contreras et al., (2008) indicate that dried tomato products have main attributes of quality - nutritional value, acceptability, usability and safety of products. **Cernisev (2010)** states that the most important quality parameters that determine the acceptance of dried tomatoes by consumers are their color and flavor. Today's modern technologies aim is to minimize chemical degradation reactions, maximize the retention of nutrients and at the

same time to minimize energy consumption and to produce quality products. Dried tomato slices or powder could be characterized by an intensely sweet taste, delicious tomato flavor and dark red coloring (**Hui, 2008**). Coloring of tomatoes is determined especially by lycopene content. Lycopene belongs to the carotenoid natural colorants, tomatoes and products made from them have characteristic red color (**Acton, 2012**). Processing conditions such as high temperature, long duration of exposure and the presence of oxygen shown to contribute to increased degradation of lycopene (**Predy, 2012**). In the fresh tomatoes the lycopene is present in the form of all-trans isomers, which have lower bioavailability than its cis-configuration. During the heat treatment is transformed from all-trans-form to cis-form. Processing can therefore increase the bioavailability of lycopene (**Lockwood, 2007**). Short heat treatment of tomatoes leads to an increased yield of lycopene, as there is a cell disruption and release of extracellular matrix. High temperature combined with a long exposure time showed an opposite effect on carotenoids (**Dris and Jain, 2004; Dorais et al., 2008**).

The stability of colorants in dehydrated tomato products during storage is affected by temperature, presence of oxygen, water activity and texture of the product. By dehydration of the final moisture of 20%, with a water activity 0.69 and storage at 18 °C is possible to eliminate the loss of carotenoids (**Bidlack and Rodriguez, 2011**).

The aim of this work was to evaluate the content of lycopene in selected tomato varieties in the stage of technological maturity. To process tomatoes subsequently

by drying at three different temperatures into the dried tomato slices and to analyze the effect of temperature on the content of lycopene changes.

MATERIAL A METHODOLOGY

In this work we analyzed 6 varieties of tomato (*Lycopersicon esculentum* Mill.) as it follows: Darina F1, Denár, Kecskeméty, Orange, Paulína F1 and Šejk F1. Varieties Denár, Kecskeméty and Šejk F1 are primarily intended for industrial use. Paulína variety is recommended for processing or for direct consumption. Varieties Darina F1 and Orange are intended for direct consumption.

Samples of tomato were cultivated in the Botanical Garden of SUA in Nitra. Nitra area is characterised as very warm agro-climatic area and very dry sub-region. The average annual temperature of the area is 9-10 °C, average annual rainfall is 584.5 mm and the average rainfall for the growing season is 287.5 mm. In terms of soil characteristics, it is a glue fluvisol, formed on alluvial to calcareous sediments. Tomato fruits were harvested at the stage of technological maturity. The fruits were fully colored with a characteristic taste and aroma. Samples were processed by drying at 45 °C, 70 °C and 90 °C. Drying was performed after cutting the fruit to a thickness of 3 mm at air oven Concept SO 1020. The dryer is equipped with thermostat and temperature was continuously checked during drying by laboratory thermometer as well. Samples were dried to a residual moisture content of 15-20%. Time of drying was depending on the temperature: at 90 °C 10 hours, 16 hours at 70 °C and 24 hours at 45 °C. Fresh fruits were homogenized before analyzing by kitchen hand blender Bosh MSM 67 PF at least three minutes, dried slices were processed by the mill Bravo B-4090.

Lycopene content was determined spectrophotometrically by the device Jenway UV-VIS according to the methodology given by the Slovak Technical Standard 12136 - "Determination of total carotenoids and individual carotenoid fractions". Homogenized samples of fruit were extracted in acetone and then carotenoids were collected in petroleum solution. Lycopene content was determined by measuring absorbance at a wavelength of 470 nm.

The results were processed by the statistical program Statistica. Effect of variety and drying temperature on lycopene content was tested by one- and two-factor analysis of variance and Fisher's LSD test.

RESULTS AND DISCUSSION

Lycopene content of fresh tomato fruit was determined in the amounts of 1.68 -10.53 mg 100 g⁻¹ of fresh matter. The lowest content of lycopene was observed at variety of orange color Orange, in whose in large quantities β-carotene is synthesized at the expense of lycopene. Lycopene content in fresh matter of tomato fruits decreased in the order: Kecskeméty > Šejk F1 (8.99 mg 100 g⁻¹) > Denár (7.92 mg 100 g⁻¹) > Darina F1 (7.39 mg 100 g⁻¹) > Paulína F1 (6.14 mg 100 g⁻¹) > Orange.

Lycopene content in tomato is observed by number of studies and authors. **Sharma and Le Maguer (1996)** determined in fresh tomato fruits originating from Canada lycopene content in the amount of 5.4 mg 100 g⁻¹. **Martínez-Valverde et al., (2002)** found in various

commercial varieties of Spanish tomato lycopene content at 1.8-6.5 mg 100 g⁻¹. **Toor et al., (2006)** indicate that lycopene in three commercial varieties (Excell, Tradiro, Flavourine) of tomato reaches the amount of 2.7 to 4.7 mg 100 g⁻¹ in fresh matter. **Mendelová et al., (2012)** monitored the content of lycopene in tomato varieties for industrial processing and their found lycopene content from 4.11 to 6.11 mg 100 g⁻¹.

Rajoria et al., (2010) indicate lycopene as an important nutrient compound which is represented by 80% of all pigments contained in tomatoes. In our samples lycopene was represented by percentage of 28.95 to 96.64% of total carotenoids. In the variety of Kecskeméty lycopene had the largest portion of total carotenoids.

The dry matter content among monitored varieties ranged from 2.65% in Orange variety to 4.55% in Denar variety. Lycopene content after a dry matter conversion ranged from 63.38 to 302.37 mg 100 g⁻¹ of dry matter. We found statistically significant effect of variety on the lycopene content. By the Fisher's LSD test were observed relative differences in the content of lycopene among monitored varieties. Varieties created 5 homogeneous groups, which differed in the content of lycopene (Table 1).

Kuti and Konuru (2005); García-Valverde et al., (2013) observed the total content of carotenoids, lycopene and β-carotene and state that content of these components is statistically significantly affected not only by degree of maturity, but also by variety and locality of cultivation.

Vadivambal and Jayson (2007) state, that drying by hot air causes decomposition of a lot of components due to long process of drying and high temperatures used. Based on our analyses of lycopene content we can confirm these findings.

Although the content of lycopene in fresh matter of dried tomatoes was higher than that of the fresh fruits, lycopene content after conversion to 100% dry matter decreased. At dried tomatoes under the actual moisture, content of lycopene was the highest at drying temperatures of 45 °C and 90 °C detected in the dried slices of variety Paulína (79.455 mg 100 g⁻¹ of fresh matter 87.718 mg 100 g⁻¹ of fresh matter). At drying temperature of 70 °C lycopene content was the highest at variety Kecskeméty (90.4 mg 100 g⁻¹). The lowest lycopene content was found in Orange variety at all drying temperatures.

Abano et al., (2011) observed lycopene content in tomato fruits and dried tomatoes at 50, 60, 70 and 80 °C. In the fresh fruit content was found to be only 2.96 mg 100 g⁻¹, which is lower than the value we found in our work. The dried samples showed lycopene content from 59.10 mg 100 g⁻¹ of fresh matter to 65.28 mg 100 g⁻¹ of fresh matter. These values are comparable with our results for samples of Šejk F1 a Darina F1. **Takeoka et al., (2001)** in his work found lycopene content at dried tomatoes in the amount of 82.90 mg 100 g⁻¹, which is comparable with our findings at sample of Kecskeméty dried at 70 °C.

To assess changes in lycopene content after drying, we compared the content of lycopene converted per 100% dry matter (Figure 2). The highest content of lycopene in tomato fruits dried at 45 °C was at Paulína variety (99.194 mg 100 g⁻¹ dry matter) and the lowest in Orange variety (9.74 mg 100 g⁻¹ dry matter). The highest content of lycopene at drying temperature of 70 °C was found at variety Kecskeméty (115.898 mg 100 g⁻¹ dry matter) and

the lowest at Orange variety (12.829 mg 100 g⁻¹ dry matter). At 90 °C was the highest carotenoid content in

variety Paulína F1 (101.879 mg 100 g⁻¹ dry matter) and the lowest in Orange variety (8.517 mg 100 g⁻¹ dry matter).

Table 1 Mean content of lycopene (mg 100 g⁻¹ of dry matter) in fresh tomato fruits and homogeneous groups by the Fisher's LSD test

Variety	Mean	Homogeneous group
Orange	63.3778	a
Denár	173.756	b
Paulína F1	176.883	b
Darina F1	208.201	c
Kecskeméty	264.641	d
Šejk F1	302.365	e

Note: means indicated by the same letter are insignificantly different at p < 0.05

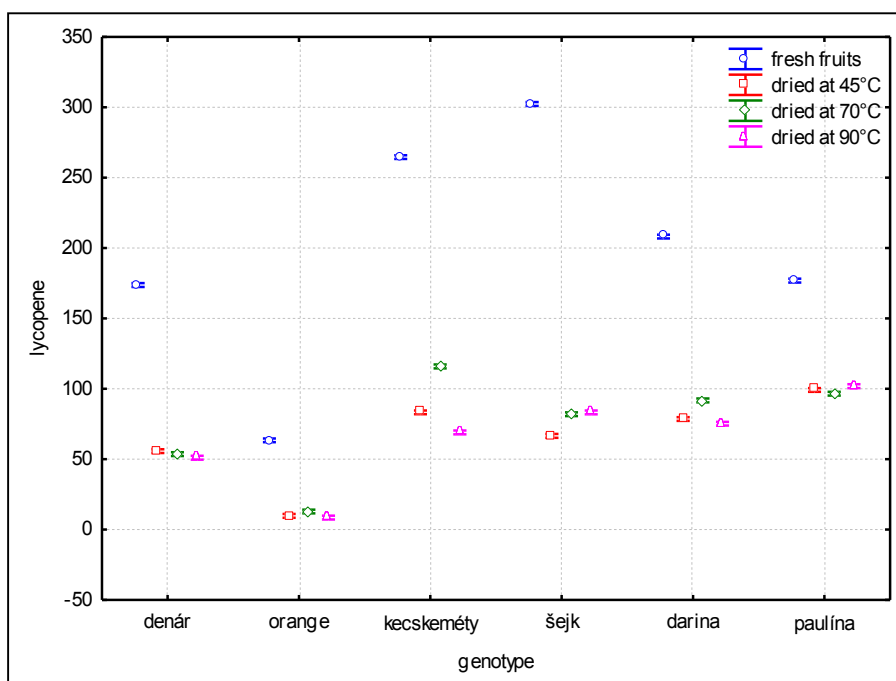


Fig. 1 Mean content of lycopene (mg 100 g⁻¹ of dry matter) in fresh tomato fruits and tomatoes dried at different temperatures

Table 2 Mean lycopene content (mg 100 g⁻¹ of dry matter) in dried tomatoes and homogeneous groups by the Fisher's LSD test

Variety	Mean at 45 °C	Variety	Mean at 70 °C	Variety	Mean at 90 °C
Orange	9.74627 a	Orange	12.8285 a	Orange	8.51704 a
Denár	55.7197 b	Denár	53.6053 b	Denár	51.0525 b
Šejk F1	66.5526 c	Šejk F1	81.9546 c	Kecskeméty	69.0464 c
Darina F1	78.5503 d	Darina F1	91.7592 d	Darina F1	75.2438 d
Kecskeméty	83.2921 e	Paulína F1	96.5348 e	Šejk F1	83.2331 e
Paulína F1	99.1944 f	Kecskeméty	115.898 f	Paulína F1	101.879 f

Note: means indicated by the same letter are insignificantly different at p < 0.05

At all regimes of drying statistically significantly the lowest lycopene content was determined at variety Orange. At drying temperatures of 45 °C and 90 °C was significantly the highest lycopene content at sample Paulina F1 and at 70 °C in the sample Kecskemeti (Table 2).

Based on the measured contents of lycopene as the most suitable temperature for drying in terms of retention of lycopene, as in the case of carotenoids appeared temperature of 70 °C, that was confirmed by the Fisher's LSD test.

It (Table 4) was confirmed statistically significantly that the most appropriate in terms of retention lycopene is drying at temperature 70 °C. At a given temperature, the average content of carotenoids in fruits was 75.43 mg 100 g⁻¹ dry matter, and was significantly higher than the content of lycopene at drying temperatures of 45 °C and 90 °C. Differences in the content of lycopene at

drying temperature of 45 °C and 90 °C were minimal and statistically insignificant. Clearly the highest lycopene content was at fresh tomatoes. Decrease of lycopene content at drying observed Zaroni et al., (1998); Shi et al., (1999); Laveli et al., (1999), who performed experiments with drying of tomatoes at temperatures of 55 °C to 110 °C. Davoodi et al., (2007) indicate that the percentage of lycopene retention is increased when the fruits before drying tomatoes are treated with potassium disulphite and calcium chloride. As reported Zaroni et al., (1998) at heat treatment of tomatoes by drying at 60-110 °C, a drying process takes 10 hours or more. The whole technology is performed in the presence of oxygen, which is reflected not only in the degradation colors of fruit, but also decreases the nutritional quality.

Table 4 Mean lycopene content (mg 100 g⁻¹ of dry matter) in fresh tomato fruits and dried tomatoes

Drying temperature	Mean	Homogeneous groups
90 °C	64.8287	a
45 °C	65.5092	a
70 °C	75.430	b
Fresh fruits	198.204	c

Note: means indicated by the same letter are insignificantly different at p<0.05

CONCLUSION

Production of dried tomato products such as finished products or as an intermediate in the production of dehydrated products, spice mixtures, or in the manufacture of dietary supplements based on lycopene have recently met with great interest of the food manufacturers, pharmacists and professionals and the general public. An important indicator of the quality of these products is their color, which is closely related to keeping the content of carotene pigment - lycopene. In this work, we investigated the effect of drying temperature on lycopene content in dried tomato slices. We tested six varieties of tomato and drying was performed in a hot air oven at 45 °C, 70 °C and 90 °C.

The highest content of lycopene was found to be at fresh fruits of variety Šejk F1 302.365 mg 100 g⁻¹ dry matter. After drying at all observed temperatures there was a decrease of lycopene content on average of 64.48% to 68.3%. The highest content of lycopene in dried slices (115.898 mg 100 g⁻¹ dry matter) was measured at variety of Kecskemeti dried at 70 °C. Crucial to the quality of the final products are variety and processing technology, in particular the temperature at which tomatoes are dried. Based on the results, temperature of 70 °C was determined as the most appropriate of the monitored temperatures for the production of dried tomatoes.

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Contact address:

Ing. Andrea Mendelová, PhD., Slovak University of Agriculture in Nitra, Faculty of Biotechnology and Food Sciences, Department of Plant Processing and Storage, A. Hlinku 2, 949 76 Nitra, Slovak Republic, E-mail: andrea.mendelova@uniag.sk

Ing. Lubomír Mendel, PhD., Plant Production Research Center Piešťany, Bratislavská 122, 921 68 Piešťany, Slovak Republic, E-mail: mendel@vurv.sk

doc. Ing. Martina Fikselová, PhD., Slovak University of Agriculture in Nitra, Faculty of Biotechnology and Food Sciences, Department of Food Hygiene and Safety, A. Hlinku 2, 949 76 Nitra, Slovak Republic, E-mail: martina.fikselova@uniag.sk

Ing. Peter Czako, PhD., Slovak University of Agriculture in Nitra, Faculty of Biotechnology and Food Sciences, Department of Plant Processing and Storage, A. Hlinku 2, 949 76 Nitra, Slovak Republic, E-mail: peter.czako@uniag.sk