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Stability of tomato lycopene under thermal- and light-irradiation treatments in an oil-based model system

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Abstract

The lycopene content in food may be increased by thermal and mechanical processing. Food processing is beneficial because it disrupts food matrices facilitating the release and solubilisation of lycopene resulting in increased carotenoid bioavailability for the formation of *cis*-isomers. A lycopene-rich and β-carotene oil-based system was used in this study. High-performance liquid chromatography (HPLC) and colour coordinates analyses were employed to analyse lycopene, its *cis*-isomers and β-carotene stability of the following sample set after 28 days of storage: fridge temperature at 1 ± 1°C in absence of light (FT dark), ambient temperature at 20 ± 1°C in natural light with different day and night illumination (AT light), ambient temperature at 20 ± 1°C in absence of light (AT dark), thermostatically controlled temperature at 37 ± 1°C in absence of light (TT dark) and thermostatically controlled temperature at 37 ± 1°C in UV irradiation (TT UV). The control sample in our study was lycopene enriched oil stored in the dark at 1 ± 1°C on day zero (0). The aim of this study was to create lycopene-enriched oil from tomato to investigate its stability and to prepare the recommendations to consumers for the storage conditions of this functional food. The results indicated that the *trans*-lycopene amount changed from 76.6% to 61.0% at ambient temperature (AT light and AT dark sample), and from 76.6% to 46.8% (TT dark) and 44.4% (TT UV) at 37 ± 1°C. According to our investigation, the highest percentage of 5-*cis*-lycopene isomer in all samples was found after 28 days of storage. The TT UV samples had the most colour changes. Vegetable oil enriched with lycopene from tomatoes is a high quality food product that can supplement daily diet and enhance absorption of lycopene from the intestine.

Key words: β-carotene, degradation rate constant, isomerisation, lycopene, *Lycopersicon esculentum*.

Introduction

Tomato and tomato-based products are important agricultural production worldwide. More than 80% of tomatoes grown worldwide are processed into the products such as tomato juice, paste, puree, catsup, sauce and salsa (Gould, 1992).

Nowadays the development of more attractive functional food is important for the consumers' health. The relationship between diet and health has become an important request for the consumer. The demand for information about functional food has increased (Kaur, Das, 2011). The concentration of the lycopene, a carotenoid, is particularly high in tomatoes. Lycopene is important mainly due to its beneficial properties for human health. Lycopene protects humans from attack by pathogenic agents responsible for a number of chronic diseases, such as cardiovascular diseases, different types of cancer (digestive tract, cervix, breast, skin, bladder and prostate), hypertension, osteoporosis, neurodegenerative diseases, male infertility and even transmission of acquired immunodeficiency syndrome from mothers to babies (Hof et al., 2000).

The availability of lycopene from food may depend on several factors: 1) lycopene content of food may be increased by mechanical processing (Hof et al., 2000); 2) the bioavailability of lycopene is greatly increased by thermal (cooking or by commercial) processing (Bates, 2005); 3) the addition of lipids, such as vegetable oils, increases lycopene absorption (Shi, Le Maguer, 2000); 4) it has been reported that lycopene is more efficiently absorbed when tomato juice is warmed with a supplemental lipid (Shi, Le Maguer, 2000); 5) β-carotene in the same dish as lycopene causes an increase in the absorption of lycopene (Bates, 2005). Moreover, during exposure to thermoenergy, oxygen light, lycopene can undergo isomerisation and degradation. Isomerisation converts all-*trans*-isomers to *cis*-isomers and results in a reduction in the biological properties of lycopene (Preedy, Watson, 2008). Red tomatoes normally contain

94−96% of all-*trans*-lycopene. All-*trans*-lycopene is thermodynamically the most stable form (Gupta et al., 2010). Some authors have reported that the formation of *cis*-isomers of lycopene may increase biological activity (Bartkiene et al., 2013). Determination of the degree of lycopene isomerisation during processing and storage would provide a measurement of the potential health benefits of tomato-based foods (Preedy, Watson, 2008).

It is important to develop more attractive ready-to-eat products to contribute to the increased consumption of fruit and vegetable products and their health benefits for the consumers, which should be attributed to food processing adaptation to enhance the bioavailability of nutrients (Martínez-Tomás et al., 2012). Additional information needs to be gathered on the thermal behaviour of lycopene before definitive answers conclusions can be drawn regarding its physical state and stability during processing and cooking. Little information is known about the stability of lycopene in supplemental form (Kopec et al., 2010).

The aim of this study was to create lycopene-enriched oil from tomato to investigate its stability and to prepare the recommendations to consumers for the storage conditions of this functional food.

Material and methods

Materials. The experiments were performed in 2013 at the Laboratory of Biochemistry and Technology of the Institute of Horticulture, Lithuanian Research Centre for Agriculture and Forestry. Fresh tomato (*Lycopersicon esculentum* L.) of the hybrid 'Admiro F_1' (grown in the greenhouses of the Institute of Horticulture) and rapeseeds oil (Lithuania) were used. The tomatoes were red ripe, uniform in size, firm and undamaged. The HPLC-grade solvents, including hexane, methanol, methyl-*tert*-butyl ether and ethyl acetate, were obtained from "Sigma-Aldrich" (Germany).

Sample preparation. Lycopene-rich tomato extract in oil was prepared. Whole washed tomatoes were chopped into pieces and mixed for 3 min in a homogenous mass using an electric blender MMB 2000 UC ("Bosch", Germany). The puree was then mixed by a laboratory stirrer ER-10 ("VEB MLW Prufgerate", Germany) with virgin rapeseed oil using a volumetric ratio of 1:1 (v/v). The temperature of the solution was stable during extraction (20 ± 1°C) (thermostat model 9100, "PolyScience", USA). After 2 hours, the oil phase was separated by a preparative centrifuge ЦРЛ-1 ("Texnokom", Russia). The extract was poured into 20 unit 2 ml vials, and the extract was divided into five groups. Stability of lycopene-rich oil extract was investigated during a 28-day storage period. Storage conditions were as follows: 1) fridge temperature at 1 ± 1°C in absence of light (FT dark), 2) ambient temperature at 20 ± 1°C in natural light with different day and night illumination (AT light), 3) ambient temperature at 20 ± 1°C in absence of light (AT dark), 4) thermostatically controlled temperature at 37 ± 1°C in absence of light (TT dark), 5) thermostatically controlled temperature at 37 ± 1°C in UV irradiation (TT UV). The control sample in our study was lycopene-enriched oil stored in the dark at 1 ± 1°C on day zero (0). The samples were stored in hermetically sealed containers. The control sample and all lycopene-enriched oil samples were prepared for HPLC analysis after storage. The oil extract was diluted with hexane using a volumetric ratio of 1:8 (v/v). HPLC analysis of the lycopene-enriched oil indicated the presence of β-carotene. The *trans*-lycopene (HPLC grade; all-*trans*-lycopene from tomato powder) and β-carotene (HPLC grade, synthetic, ≥93% purity, powder) standards were used ("Sigma-Aldrich", Germany).

High-performance liquid chromatography (HPLC) analysis of lycopene isomers and β-carotene. The stability of all-*trans*-lycopene and β-carotene in the extracts was analysed by the slightly modified reversed phase HPLC method of Ishida (Ishida et al., 2001; Urbonavičienė, Viškelis, 2013) connected to a detector Waters 2489 UV/Vis ("Water Corporation", USA). Detection of lycopene and β-carotene was at 473 nm. The mobile phase consisted of methanol, methyl-*tert*-butyl ether and ethyl acetate at a flow rate of 1.5 ml min^{-1}. The injection volume was 10 µl. The column temperature was 28°C. The samples were filtered through a 0.45 mm polyvinylidene fluoride (PVDF) syringe filter ("Millipore", USA) before injection. To quantify lycopene in the extract samples, a calibration curve was generated using an authentic all-*trans*-lycopene standard. Levels of *cis*-lycopene isomers are given in all-*trans*-lycopene equivalents.

Colour measurements. Colour change was measured by a spectrophotometer MiniScan XE Plus (Hunter Associates Laboratory Inc., USA) (Urbonaviciene et al., 2012). The apparatus (45/0 geometry, illuminant D65, 10 observer) was calibrated with a standard tile (X = 81.3, Y = 86.2 and Z = 92.7). A cylindrical glass cell filled with 3 ml of sample was placed on the top of the light source (2.5 cm opening) and covered with a white plate. Inclusion of air bubbles was prevented. The recorder X, Y and Z tristimulus values were converted to CIE L*, a* and b* colour values. Regarding light reflection, the L*, a* and b* parameters (lightness, redness and yellowness indices, respectively, according to CIE L*a*b* scale) were measured, and chroma (C) (1), hue angle (h°) (2) and the total colour difference (ΔE) (3) were calculated:

$$C = (a^{*2} + b^{*2})^{1/2} \quad (1),$$

$$h^{o} = \arctan\left(\frac{b^{*}}{a^{*}}\right) \quad (2),$$

$$\Delta E = \sqrt{(\Delta L^{*})^{2} + (\Delta a^{*})^{2} + (\Delta b^{*})^{2}} \quad (3).$$

The L*, C, a* and b* volumes were measured in NBS units, and hue angle was measured in degrees from 0 to 360°. A NBS unit is a unit of the USA National Standard Bureau, and it corresponds to one threshold of colour distinction power, i.e. the least distinction in colour that the trained human eye can notice (McGuire, 1992). The colour parameters were processed with the software *Universal V.4-10* program. Colour measurements were performed in triplicate.

Measurement and monitoring of environmental parameters. The temperature and illumination were recorded using a HOBO Pendant Temperature/Light Data

Logger 8K-UA-02-08 ("Onset", Finland) at 6-h intervals and were processed with software *HOBOware Pro*.

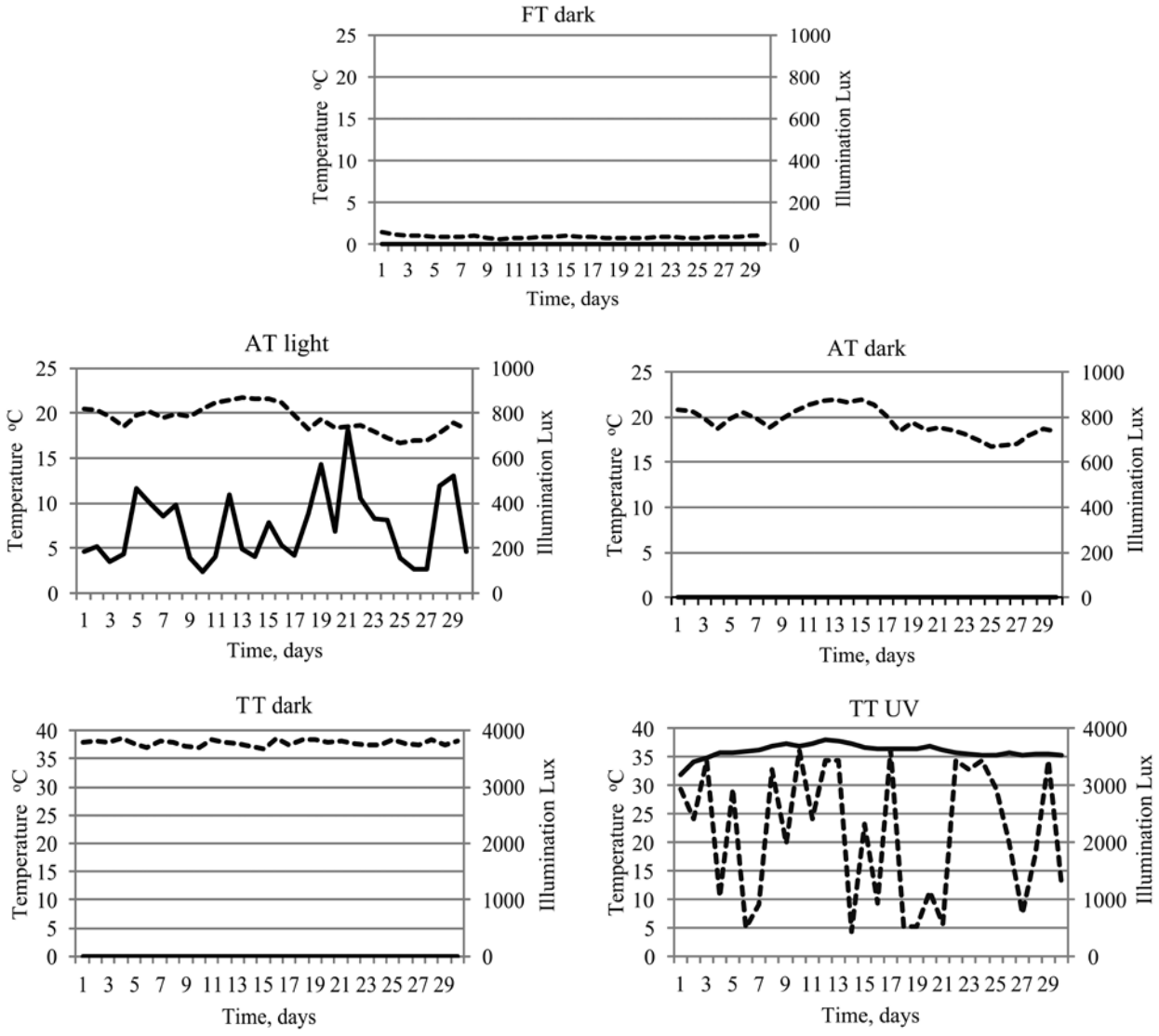
Statistical analysis. All experiments were replicated three times and the results were expressed as the means ± standard deviations. Statistical analysis was performed using software *SPSS*, version 16.0 (USA). Data were analysed using one-way ANOVA followed by Duncan's test. The confidence interval was 95% ($p < 0.05$).

Results and discussion

The development of suitable processing conditions and techniques can be used to stabilise lycopene and other carotenoids in the tomato products during the production and storage, and these are important issues for process optimisation (Chen et al., 2009). The effects of thermal- and light-irradiation processing on lycopene stability in an oil-based food model system have not yet been completely investigated.

The aim of our study was to investigate if the storage conditions lead to instability and change of the lycopene-enriched extract because it is important to provide consumers with advice on storage conditions for the lycopene-enriched oil and to know the main factors that affect lycopene isomerisation in an oil-based model system. The storage conditions of samples were selected advisedly. According to Rodriguez-Amaya (2001), exposure to light, especially direct sunlight or ultraviolet light induces *trans-cis* photoisomerisation and photodestruction of carotenoids.

Figure 1 shows the temperature and the illumination in the storage conditions of the samples during the test period. The illumination imitated the light effect from daylight (200–400 Lux) in addition to the aggressive UV radiation (2000–3000 Lux). It was important to clarify the temperature under which the extract was stable. Lycopene stability measurements were carried out in the temperature range from 1 ± 1°C to



FT dark − fridge temperature at 1 ± 1°C in absence of light; AT light – ambient temperature at 20 ± 1°C in natural light with different day and night illumination; AT dark – ambient temperature at 20 ± 1°C in absence of light; TT dark – thermostatically controlled temperature at 37 ± 1°C in absence of light; TT UV – thermostatically controlled temperature at 37 ± 1°C in UV irradiation

Figure 1. Storage conditions of the sample set

37 ± 1°C. The samples were stored in the dark at 1 ± 1°C in order to simulate storage conditions in the refrigerator. The samples were stored at ambient temperature (20 ± 1°C) in the dark or light in order to simulate storage conditions in the cupboard or on the kitchen counter. The samples were stored at 37 ± 1°C in the dark or light in order to simulate extreme storage conditions in the cupboard or on a counter next to working stove/oven.

Aiming to develop a technological process that yields a stable lycopene-enriched oil, we first investigated lycopene isomerisation during temperature and illumination changes in an oil-based model system. Lycopene is biosynthesised in plants mainly (above 90%) as an all-*trans*-isomer (Lambelet et al., 2009). In our study lycopene found in tomatoes consists of 92% of all-*trans*-isomers. Many researchers suggest that lycopene undergoes geometrical isomerisation during food processing, which increases the proportion of *cis*-isomers (Schierle et al., 1996; Shi et al., 2002). In our study, *cis*- and *trans*-isomers of lycopene were indentified, based on spectral characteristics and Q ratios as reported in a previous study (Lee, Chen, 2001). The comparison of all treatments, namely, FT dark, AT light, AT dark, TT dark and TT UV, showed that various *cis*- and *trans*-isomers of lycopene, including *5-cis*, were present. Our investigation showed that the *5-cis*-isomer changed distinctively during lycopene storage compared to the other lycopene isomers. Our results demonstrated that the *5-cis*-isomer of lycopene indicates the main isomerisation process because this isomer was dominant in all the samples during the 28 days of storage. In our study, the stability of lycopene isomers in an extract was investigated. Figures 2 and 3 show a decrease in the all-*trans*-lycopene-isomer of lycopene and a simultaneous increase in *5-cis*-isomers.

The lycopene *trans*- and *5-cis*-isoform in the FT dark treatment was stable during 28 days, it can be because the temperature was 1 ± 1°C and there was no

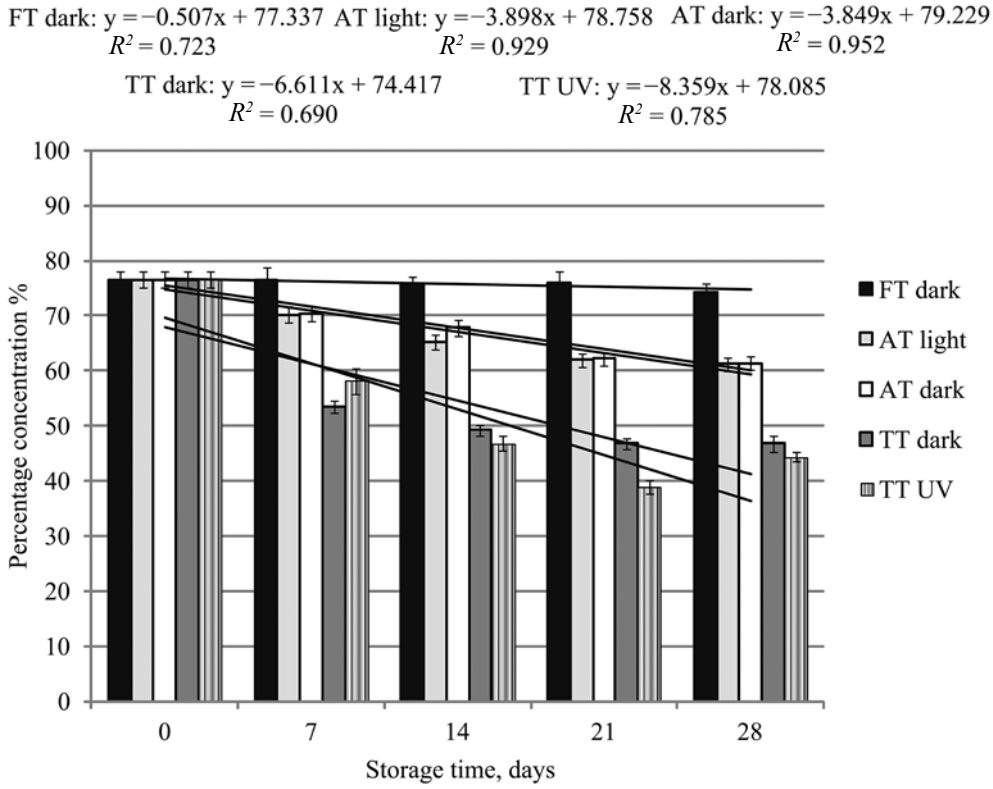


Figure 2. *Trans*-lycopene concentration as a percentage of total lycopene during illumination and temperature impact after 28 days in lycopene-enriched oil

illumination impact (0 Lux). When comparing the 20 ± 1°C temperature (AT light and AT dark samples) and the 37ºC temperature (TT dark and TT UV samples), the results showed that the temperature impact caused degradation of *trans*- and *cis*-lycopene isomerisation at the same time. The *trans*-lycopene content decreased significantly ($p < 0.05$) in the TT dark and TT UV samples with increasing temperature. The *trans*-lycopene amount changed from 76.6% to 61.0% at AT light and AT dark samples and from 76.6 to 46.8 and 44.4 % at TT dark and TT UV samples, respectively. Therefore, *trans*-lycopene degradation in the AT light and dark samples exhibited linear decline patterns with a correlation coefficient (R^2) greater than 0.92 for the plot of the concentration of *trans*-lycopene versus time. However, this linear characteristic did not fit well for the TT dark and TT UV samples with R^2 values ranging from 0.69 to 0.78. It is possible that *trans*-lycopene undergoes not only isomerisation, but also degradation, which may cause a misrepresentation of the results.

According to the results of this study, the *5-cis*-lycopene isomer amount increased in all samples after 28 days (Fig. 3). The *5-cis*-lycopene isomer amount indicated that the *trans*-lycopene isomer degradation (%) during the temperature and light impacts was 3.11, 10.98, 9.11, 19.10 and 20.68 for the FT dark, AT light, AT dark, TT dark and TT UV samples, respectively, after 28 days.

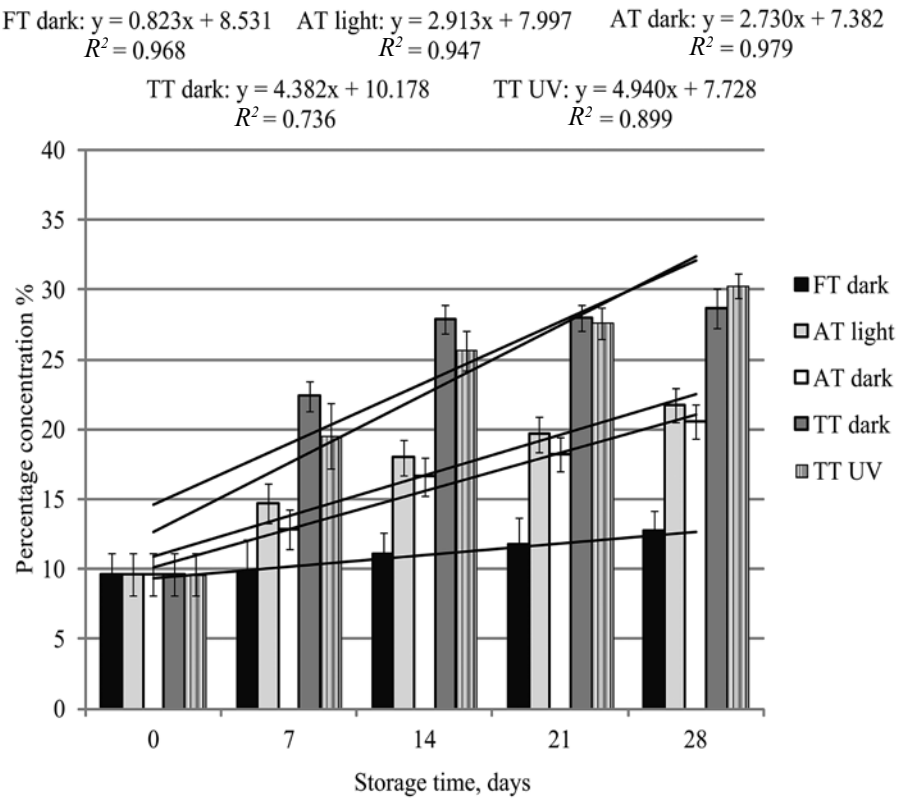


Figure 3. *5-cis*-lycopene concentration as a percentage of total lycopene during illumination and temperature impacts after 28 days in lycopene-enriched oil

The main change (more than 20%) of the *5-cis*-lycopene isomer in the oil was due to the influence of UV rays in the TT UV samples. The decreased of amount of *trans*-lycopene may have been due to isomerisation, resulting from additional energy (temperature and/or light) input, which led to unstable, energy-rich situations (Shi, Le Maguer, 2000). Our results indicated that formation of the stable *5-cis*-lycopene isomer in the supplement allowed bioavailability of lycopene. According to Roldán-Gutiérrez and de Castro (2007), *cis*-lycopene isomers are also less likely to crystallise or to aggregate and may therefore be more efficiently solubilised in lipophilic solutions and more readily transported within cells or between tissues.

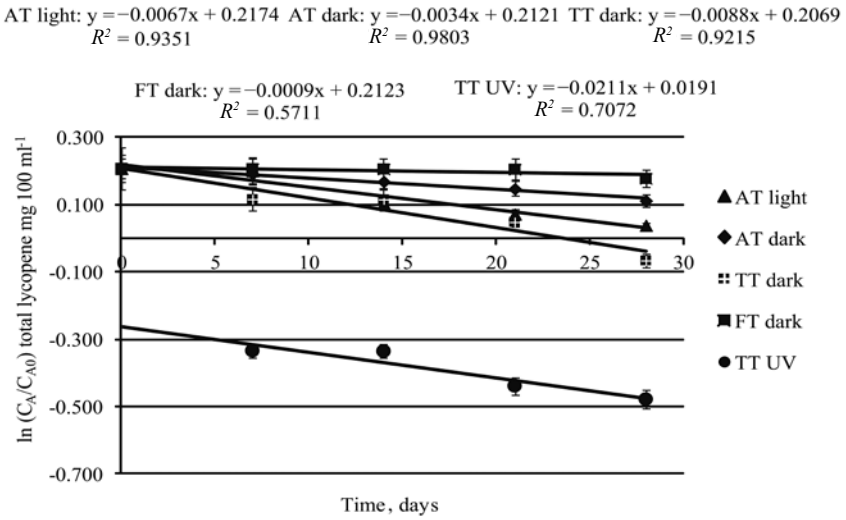
It is difficult to compare our results with those of recent investigations because little is known about the stability of lycopene in a supplemental form and the temperatures used in previous studies were either very high – from 80°C to 180°C (Shi et al., 2002; Chen et al., 2009) or low – ~24°C (Qiu et al., 2006).

In our study, in the TT dark sample stored at 37°C (the highest temperature used in our study) the percentage of *trans*-lycopene isomer decreased from 76.6% to 46.4% and the percentage of *5-cis*-lycopene isomer increased from 9.6% to 28.7%. The results show that higher temperature is directly correlated with decreasing amount of *trans*-lycopene isomer.

These data suggest that not only higher temperatures but also low temperatures, illumination and storage time are directly correlated with increasing lycopene losses and that thermal treatment leads to a significant decrease in the concentrations of all-*tran*-lycopene. In conclusion, storage time in soft temperatures (e.g., 20°C or 37°C) and natural light illumination can be used as an alternative process, which is clean and energy-efficient compared with many conventional processes.

Measurement of the degradation of total lycopene and the stability differences of the lycopene *trans*- and *cis*-isomers is useful to model the kinetics data. The stability of lycopene-enriched oil was investigated in our study. The degradation rate constant (k) of the total lycopene content in the oil-based model system under different treatment conditions was fitted to a first-order kinetic reaction model as shown in Figure 4. The kinetic degradation rate of total lycopene in the oil-based model samples showed a good-fit kinetic model with a linear correlation (R^2) range of 0.922–0.980 for the AT light, AT dark and TT dark samples, in contrast to the FT dark and TT UV samples with R^2 values of 0.571 and 0.707, respectively. The kinetic degradation rate constant (k in day^{-1}) resulted in total lycopene loss rates (in mg 100 g^{-1} in oil) of 0.0009, 0.0067, 0.0034, 0.0088 and 0.0211 during the temperature and light impact in the FT dark, AT light, AT dark, TT dark and TT UV samples, respectively, in the oil-based model. The largest kinetic constant (k = 0.0211) of the total lycopene degradation was for the TT UV sample.

According to results of this study, the reasons for the differences in kinetic constants are unclear. The main explanation could be related to the fact that there was only a slight but not significant change in the total lycopene content in the FT dark sample, so the linear relationship did not exist. In contrast, highly significant changes were found in the TT UV sample because UV irradiation could have led to the degradation of total lycopene content. Moreover, the degradation products (which were not investigated) may have influenced the kinetic constant.

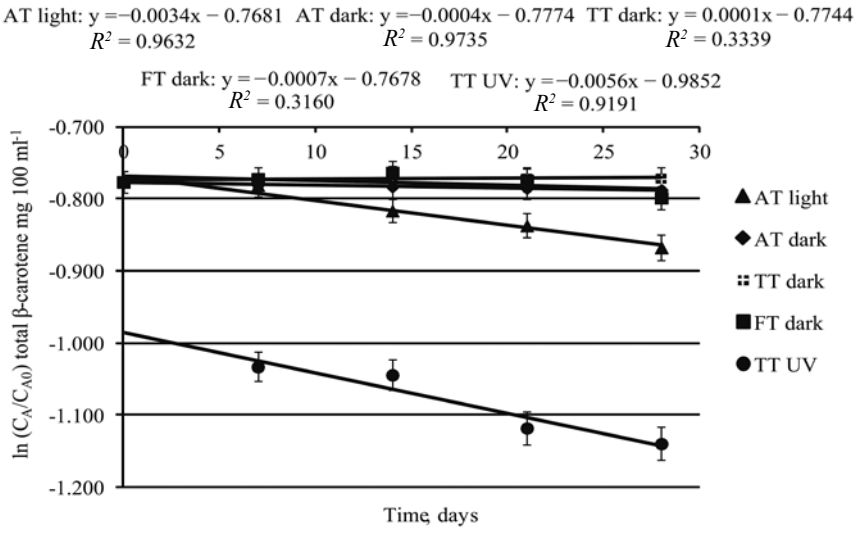


Note. The results are from the means of three HPLC analyses of three extracts; C_A – the total amount of lycopene after storage, C_{A0} – the initial amount of lycopene.

Figure 4. A plot of ln (concentration) *vs* time data for a first-order reaction of total lycopene

The kinetics of total lycopene degradation is complex, and the data depends on the other components in the oil-based system. Interactions with other carotenoids are complex and have only partly been studied. For example, β-carotene in the same dish increases the absorption of lycopene (Bates, 2005). Thus, in our studies using the oil model system and HPCL analyses, β-carotene was also found in the lycopene-enriched oil extract, which confirms that the lycopene-enriched oil-based model system has consumer health benefits. The high R^2 value (0.973) of total β-carotene in the AT dark samples indicated that the kinetics of the reaction followed as a first-order reaction (Fig. 5), and the slope provided the pseudo first-order rate constant. Because the concentration of the reactant is decreased, the slope was negative. Therefore, we used the absolute value to obtain the result for the rate constant. The R^2 value for a linear regression between the concentration and time data showed a poor correlation for the TT dark and FT dark samples with values of 0.316 and 0.334, respectively, indicating that the kinetics of this reaction was not pseudo first-order. Therefore, the natural logarithms of the concentration values were calculated, and the slope was determined. The kinetic degradation rate constant (k in day^{-1}) indicated that the rate of total β-carotene loss (in mg 100 g^{-1} in oil) during the temperature and light impact was 0.0007, 0.0034, 0.0004, 0.0001 and 0.0056 in the oil-based model for the FT dark, AT light, AT dark, TT dark and TT UV samples, respectively. The largest kinetic constant (k = 0.0056) for the total β-carotene degradation was found for the TT UV sample.

Consumers use the intensity of the red colour as an index of quality for tomato-based products (Kopec et al., 2010). The changes in colour values (a* and b* ratio; hue angle, h°; chroma C and colour difference (ΔE) of the control and samples over the course of 28 days



Note. The results are from the means of three HPLC analyses of three extracts; C_A – the total amount of β-carotene after storage, C_{A0} – the initial amount of β-carotene.

Figure 5. A plot of ln (concentration) *vs* time data for a first-order reaction of total β-carotene

of storage at 1, 20 and 37 ± 1 °C storage temperatures are shown in Table. In comparison to the control sample at day 0, the colour of all of the processed samples (AT light, AT dark, TT dark, FT dark and TT UV) changed as a function of storage temperature, illumination and time, but the differences were not significant. The a* and b* ratio indicated the colour changes of the tomato product from red to yellow. A slight difference of a* and b* ratio colour parameters in the sample set was found after 28 days. In comparison with other samples, the a* and b* ratio differences of the TT UV sample were significant (from control sample; 0.64 to 0.54 after 28 days). The hue angle indicated that the lycopene-rich nutritional supplement did not have a pure red colour. The hue angle varied from 56.2° (AT light) to 61.9° (TT UV) (90° would mean that the sample is yellow, and 0° indicates completely red) after 28 days. The results suggested that all samples had a reddish-yellow colour after 28 days compared to the colour at day 0. The chroma value indicates the degree of saturation of colour and is proportional to the strength of the colour. There were no differences in the chroma value between day 0 and after 28 days in the TT UV sample (35.13 and 36.3, respectively).

Table. The changes in colour values (a* and b* ratio; chroma, C; hue angle, h°; colour difference, ΔE) of the control and samples over the course of 28 days of storage at 1, 20 and 37 ± 1°C temperatures

Sample name	Colour parameters							
	a* and b* ratio		C		h°		ΔE	
Control sample	0.64	±0.025	35.13	±1.40	57.46	±2.18	0.00	
After 28 days								
AT light	0.65	±0.028 a	35.39	±1.42 a	56.23	±2.06 a	0.33	±0.013 a
AT dark	0.64	±0.020 a	35.02	±1.05 ab	57.15	±2.29 a	0.22	±0.011 b
TT dark	0.59	±0.026 ab	35.07	±1.58 a	59.10	±1.48 b	1.35	±0.054 c
FT dark	0.66	±0.030 a	34.86	±0.87 b	56.15	±2.17 a	0.82	±0.028 c
TT UV	0.54	±0.025 c	36.32	±1.09 ac	61.86	±1.85 bc	3.69	±0.148 d

Notes. The numbers are means followed by standard deviations (n = 3). Means within a column with different superscript letters are significantly different ($p \leq 0.05$). AT light – ambient temperature at 20 ± 1°C in natural light with different day and night illumination; AT dark – ambient temperature at 20 ± 1°C in absence of light; TT dark – thermostatically controlled temperature at 37 ± 1°C in absence of light; FT dark − fridge temperature at 1 ± 1°C in absence of light; TT UV – thermostatically controlled temperature at 37 ± 1°C in UV irradiation.

Our study indicated that the chroma value of the TT UV sample increased until day 21 and then decreased until the end of storage. The total colour difference (ΔE) was more than 3 in the TT UV sample after 28 days. According to Lee and Coates (2003), a value of $\Delta E \approx 2$ represents a noticeable colour difference, and $\Delta E > 3$ for many products is unacceptable according to consumers. Among the treatments, the FT dark, AT light, AT dark and TT dark samples had better colour retention, and the TT UV samples had the most colour changes. The FT dark, AT dark, AT light and TT dark samples had no colour loss.

Conclusions

1. Higher temperature has a greater influence on lycopene isomerisation (change from *trans*- to *cis*-isoforms) than light irradiation. The percentage of *trans*-lycopene changed from 76.6% (control) to 61% at 20°C (at AT light and AT dark) and to 46.8% and 44.4% at 37°C (at TT dark and TT UV).

2. The highest percentage of 5-*cis*-lycopene isomer in all samples was found after 28 days of storage. The percentage of 5-*cis*-lycopene changed from 9.6% (control) to 12.7, 21.7, 20.6, 28.7 and 30.3 % for the FT dark, AT light, AT dark, TT dark and TT UV samples, respectively. The highest increase in 5-*cis*-lycopene isomer was found in the oil that was stored in UV light at 37°C.

3. The ratio of a* and b* colour coordinates of all the investigated samples (AT light, AT dark, TT dark, FT dark and TT UV) changed as a function of storage temperature, illumination and time; however, the differences were not significant. The highest total colour difference (ΔE) was found between the control sample and TT UV samples, whereas FT dark, AT light, AT dark and TT dark samples had better colour retention.

4. The addition of tomato extracts to vegetable oil might increase the level of lycopene in a human diet and enhance its bioavailability. The optimum storage conditions for lycopene-enriched oil were at 20°C in the dark.

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Pomidorų likopeno stabilumas esant skirtingoms temperatūroms ir apšvitoms aliejinėje modelinėje sistemoje

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Santrauka

Likopeno įsisavinimas iš maisto produktų nėra pakankamas. Nustatyta, kad geriau įsisavinami ne natūraliai aptinkami *trans*-likopeno izomerai, o *cis*-izomerai. Maisto perdirbimas yra naudingas tuo, kad didėjant likopeno *cis*-izomerų kiekiui, gerėja jo įsisavinimas. Tirta likopenu ir β karotenu papildyta aliejinė modelinė sistema. Taikant efektyviąją skysčių chromatografiją ir spalvų koordinačių analizę, tirtas likopeno, likopeno *trans*- bei *cis*-izomerų ir β karoteno stabilumas bandiniuose skirtingomis laikymo 28 dienas sąlygomis: šaldytuve 1 ± 1 °C temperatūroje, tamsoje (FT tamsoje), kambario temperatūroje – 20 ± 1 °C, natūralioje šviesoje, kuri dienos ir nakties metu buvo skirtinga (AT šviesoje), kambario temperatūroje – 20 ± 1°C, tamsoje (KT tamsoje), termostatuojant 37 ± 1 °C temperatūroje, tamsoje (TT tamsoje) ir termostatuojant 37 ± 1 °C temperatūroje, šviesos šaltinis − ultravioletinė lempa (TT UV). Kontrolinis bandinys buvo likopenu papildytas aliejus, laikytas tamsoje 1 ± 1 °C temperatūroje eksperimento pradžioje (0 diena). Tyrimo tikslas – sukurti likopenu papildytą maisto papildą, ištirti jo stabilumą ir parengti rekomendacijas vartotojams, kokiomis optimaliomis sąlygomis laikytį šį maisto papildą. Tyrimo rezultatai parodė, kad *trans*-likopeno kiekis pakito nuo 76,6 iki 61,0 % kambario temperatūroje (AT šviesoje ir AT tamsoje) ir nuo 76,6 iki 46,8 % (TT tamsoje) ir iki 44,4 % (TT UV) esant 37 °C temperatūrai. Tyrimų duomenys rodo, kad, palyginus su kitais izomerais, 5-*cis*-izomero kiekis labiausiai kito likopeno laikymo metu. TT UV mėginiuose nustatyti didžiausi spalvų pokyčiai. Likopeno iš pomidorų turintis aliejus yra geros kokybės maisto papildas, kuris gali papildyti maisto racioną ir pagerinti likopeno įsisavinimą.

Reikšminiai žodžiai: β karotenas, izomerizacija, likopenas, *Lycopersicon esculentum*, reakcijos greičio konstanta.