

## EFFECT OF SUNLIGHT ON FATTY ACID COMPOSITION OF TOMATO SEED OIL STORED IN DIFFERENT COLORED BOTTLES

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### ABSTRACT

Tomato (*Solanum lycopersicum* L.) seeds and skins, which are the wastes of the tomato processing industry, are often regarded as animal feed in everyday life. In this study, tomato seed oil was obtained by Soxhlet extractor. The oil yield of tomato seeds was approximately 20.8%. The oils in the transparent, amber and opaque glass bottles were exposed to sunlight from June to September. The sample intake was made every 20 days and this procedure was repeated 4 times. Each sample was analyzed for fatty acid composition in gas chromatography. The minimum and maximum rates of the major fatty acids in all of the oil samples were 54.12-55.72%, 21.68-22.35%, 11.92-12.55%, 6.18-6.63% and 2.39-2.62% for linoleic (C18:2n6), oleic (C18:1n9), palmitic (C16:0), stearic (C18:0) and  $\alpha$ -linolenic acids (C18:3n3), respectively. The results showed that there was no highly variation between the fatty acid rates in all samples.

**Keywords:** Fatty acids, tomato seed oil, sunlight, colored bottles, store

## FARKLI RENKLİ ŞİŞELERDE DEPOLANAN DOMATES ÇEKİRDEĞİ YAĞININ YAĞ ASİDİ KOMPOZİSYONU ÜZERİNE GÜN IŞIĞININ ETKİSİ

### ÖZ

Domates işleme endüstrisinin atıkları olan domates (*Solanum lycopersicum* L.) çekirdeği ve kabukları, günlük hayatta genellikle hayvan yemi olarak değerlendirilmektedir. Bu çalışmada, domates çekirdeği yağı Soxhlet ekstraktörü ile elde edilmiştir. Domates çekirdeğinin yağ verimi yaklaşık %20.8 olarak bulunmuştur. Şeffaf, kehribar ve opak cam şişelerdeki yağlar Haziran'dan Eylül'e kadar güneş ışığına maruz bırakılmıştır. 20 günde bir örnek alınmış ve bu işlem 4 kez tekrarlanmıştır. Her numune, gaz kromatografisinde yağ asidi kompozisyonu için analiz edilmiştir. Analiz edilen tüm yağ numunelerinin ana yağ asitlerinin minimum ve maksimum oranları, linoleik (C18: 2n6) için %54.12-55.72, oleik (C18: 1n9) için %21.68-22.35, palmitik (C16: 0) için %11.92-12.55, stearik (C18: 0) için %6.18-6.63 ve  $\alpha$ -linolenik asitler (C18: 3n3) için %2.39-2.62 olarak belirlenmiştir. Sonuçlar, tüm numunelerde yağ asidi oranları arasında önemli bir değişimin olmadığını göstermiştir.

**Anahtar kelimeler:** Yağ asitleri, domates çekirdeği yağı, güneşiği, renkli şişeler, depolama

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## INTRODUCTION

Tomatoes (*Solanum lycopersicum* L.) are the second most common vegetable with a production of about 171 million tonnes, while the first rank is potatoes in terms of production in the world (Turkey has a share of approximately 7% in world tomato production) (FAO, 2014). While most of the tomatoes are consumed fresh, a little more than one third of the production is processed for canning, tomato juice, tomato paste or puree, sauces and ketchup. Skins and seeds, which are by-products of the tomato processing, constitute about 4% of the vegetable (Del Valle et al., 2006). These products are often regarded as animal feed in everyday life (Barros et al., 2017). Tomato seed includes essential fatty acids, essential amino acids, minerals, antioxidants as ascorbic acid, phenolics, phytosterols, tocopherols and carotenoids (Al-Wandawi et al., 1985; Toor and Savage, 2005; Eller et al., 2010). The oil yield of tomato seeds is about %11-36 on a dry weight basis. Linoleic (C18:2), oleic (C18:1) and palmitic (C16:0) fatty acids compose of the majority of the composition which has 75.8% unsaturated fatty acids (El Amrani et al., 2007; Demirbaş, 2010). The higher the degree of unsaturation of fatty acids, the faster the lipid oxidation gets (Demirci, 2003).

Extrinsic (temperature, light) and intrinsic (fatty acid composition, presence of pro- or antioxidants) factors have an impact on the oxidation reactions (Cillard and Cillard, 2006; Fabien et al., 2014). Vegetable oils undergo photooxidation by the action of light, in which the photosensitive natural compounds in the oil react with triplet oxygen ( $^3\text{O}_2$ ) and form the excited state singlet oxygen ( $^1\text{O}_2$ ). Singlet oxygen having powerful reactivity attacks directly double bonds of unsaturated fatty acids and leads to form of hydroperoxides (Skibsted, 2000; Shao et al., 2015; Sun et al., 2015). Natural antioxidants with high  $^1\text{O}_2$  quencher properties are found in many foods and prevent oxidation reactions. Therefore, foods with high natural antioxidant content are more resistant to oxidation (Cillard and Cillard, 2006; Fabien et al., 2014). Natural antioxidants in tomato seed as ascorbic acid, phenolics, phytosterols, tocopherols and carotenoids can act

as  $^1\text{O}_2$  quencher. Lycopene is highly active on reactive singlet oxygen ( $^1\text{O}_2$ ) and is the most effective antioxidant among carotenoids (Woodall et al., 1997; Henry et al., 1998). The oxidation of lycopene causes loss of color (Xianquan et al., 2005).

The light transmission of packaging materials also influences the oxidation. The light barrier property of packaging materials has a great influence on the shelf life of food rich in fat (Zhang, 2004; Lu and Xu, 2009; Sun et al., 2015). Preservation of edible oils in coloured bottles affects oxidation reactions significantly. Amber colored glass provides better protection from light than transparent glass and photooxidation takes place more easily in the transparent case (Wang et al., 2014; Makni et al., 2015).

The purpose of this study was to determine the change in the fatty acid composition by the exposure of the tomato seed oil to the sunlight and the extent to which this change was affected by the transparent, amber and opaque glass bottles.

## MATERIALS AND METHODS

### Material

The seeds of the tomatoes taken from the market were manually removed and the seeds were dried for 2 days at room temperature. The oil of the seeds was extracted with Soxhlet extractor using petroleum ether. The solvent was evaporated at 40°C. The oil was divided into three different glass bottles (transparent, amber and opaque) and each bottle was exposed to sunlight from June until September (total 80 days). The sample intake was made every 20 days and this procedure was repeated 4 times. The samples were stored in dark at +4°C until analyzed.

## ANALYSIS METHODS

### Preparation of fatty acid methyl esters

The esterification of fatty acids was carried out according to the method described by Williams (1984) with some modifications. 0.4 g of sample was weighed in a screw-capped test tube. Then 4 mL of isooctane was added, and the tube was shaken vigorously. 0.2 mL of 2 N KOH in methanol was then added, and the tube was

shaken again. The tube was kept in the dark for 6 min. After dripping some methyl orange, 0.45 mL of 1 N HCl was added into tube. The tube was shaken and centrifuged (2000 rpm/5 min). The supernatant was removed and injected into the gas chromatography.

#### Chromatographic conditions for fatty acid analysis

Fatty acid profile analysis was performed on an Agilent 7890 A-FID gas chromatography system, equipped with a 100 m × 0.25 mm × 0.2 µm HP-88 capillary column. Split injector and flame ionization detectors (FID) were operated at 260 °C. Oven temperature was set at 140 °C, held for 5 min, and ramped at 4 °C/min to 240 °C for 15 min. The sample (1 µL) was injected into the system with a split ratio of 30:1. Hydrogen gas was used as the carrier gas at a flow rate of 30 ml/min, and air flow rate was set at and 300 ml/min (Destailats et al., 2010).

## RESULTS AND DISCUSSION

The oil yield of tomato seeds was found to be approximately 20.8%. El Amrani et al. (2007), Lazos et al. (1998) and Demirbaş (2010) determined oil contents as 11%, 21.8% and 36%,

respectively. Our result shows similarity with Lazos et al. (1998).

The fatty acid profiles of samples were presented in Table 1, 2, and 3. The majority of composition of tomato seed oil consist of linoleic (C18:2n6*c*), oleic (C18:1n9*c*), palmitic (C16:0), stearic (C18:0) and linolenic (C18:3n3) acids as 55.67%, 21.75%, 11.98%, 6.29% and 2.62%, respectively. Linoleic acid was found to be the dominant unsaturated fatty acid, followed by oleic acid, while palmitic acid was the dominant saturated fatty acid, followed by stearic acid. Similar results have been seen in the report of Lazos et al. (1998), their results were 53.6, 22.0, 14.0, 6.0 and 2.0 in percent, respectively. Demirbaş (2010) showed a little different results as 46.8, 24.6, 18.1, 4.0 and 0.4 in percent in the same order. The composition of tomatoes may vary depending on factors such as type, variety, applied cultural practices, growing environment (field, greenhouse), region, harvest time (Thakur et al., 1996; Cemeroglu et al., 2009). In our study the concentration of unsaturated fatty acids was composed of polyunsaturated fatty acids as 72.51% and monounsaturated fatty acids as 27.49%.

Table 1. Fatty acid compositions of tomato seed oil samples stored in transparent glass bottles

Fatty acid (%)		Transparent (days)				
		0	20	40	60	80
Myristic	C14:0	0.10	0.10	0.10	0.10	0.10
Pentadecanoic	C15:0	0.02	0.02	0.02	0.02	0.02
Palmitic	C16:0	11.98	12.05	12.18	12.24	12.55
Palmitoleic	C16:1	0.31	0.30	0.31	0.31	0.31
Heptadecanoic	C17:0	0.05	0.07	0.07	0.06	0.07
Stearic	C18:0	6.29	6.32	6.40	6.36	6.60
Elaidic	C18:1n9 <i>t</i>	0.06	0.13	0.12	0.10	0.12
Oleic	C18:1n9 <i>c</i>	21.75	21.72	21.82	22.05	22.35
Linoelaidic	C18:2n6 <i>t</i>	0.14	0.33	0.28	0.18	0.22
Linoleic	C18:2n6 <i>c</i>	55.67	55.33	55.10	54.98	54.12
Arachidic	C20:0	0.49	0.49	0.51	0.51	0.53
γ-Linolenic	C18:3n6	0.03	0.03	0.03	0.04	0.05
α-Linolenic	C18:3n3	2.62	2.58	2.53	2.50	2.39
Gadoleic	C20:1	0.09	0.10	0.09	0.10	0.10
Behenic	C22:0	0.10	0.12	0.12	0.12	0.13
Lignoceric	C24:0	0.19	0.21	0.22	0.23	0.23
Docosahexaenoic	C22:6n3	0.11	0.10	0.10	0.10	0.11

Analyses were performed at days 0, 20, 40, 60 and 80. The results are given in %.

Trace amounts (<0.6%) of C14:0, C15:0, C16:1, C17:0, C18:1n9*t*, C18:2n6*t*, C20:0, C18:3n6, C20:1, C22:0, C24:0 ve C22:6n3 were also found in tomato seed oil. Total of these fatty acids was 1.69% of the composition of the initial sample.

Table 2. Fatty acid compositions of tomato seed oil samples stored in amber glass bottles

Fatty acid (%)		Amber (days)				
		0	20	40	60	80
Myristic	C14:0	0.10	0.10	0.10	0.10	0.10
Pentadecanoic	C15:0	0.02	0.02	0.02	0.02	0.02
Palmitic	C16:0	11.98	11.96	12.04	12.11	12.33
Palmitoleic	C16:1	0.31	0.31	0.30	0.31	0.31
Heptadecanoic	C17:0	0.05	0.06	0.05	0.06	0.06
Stearic	C18:0	6.29	6.22	6.29	6.35	6.63
Elaidic	C18:1n9 <i>t</i>	0.06	0.10	0.07	0.07	-
Oleic	C18:1n9 <i>c</i>	21.75	21.68	21.80	21.81	21.98
Linoelaidic	C18:2n6 <i>t</i>	0.14	0.27	0.18	0.18	0.16
Linoleic	C18:2n6 <i>c</i>	55.67	55.65	55.53	55.36	54.81
Arachidic	C20:0	0.49	0.48	0.49	0.50	0.51
γ-Linolenic	C18:3n6	0.03	0.02	0.02	0.02	0.03
α-Linolenic	C18:3n3	2.62	2.61	2.60	2.58	2.53
Gadoleic	C20:1	0.09	0.10	0.09	0.09	0.09
Behenic	C22:0	0.10	0.12	0.11	0.12	0.12
Lignoceric	C24:0	0.19	0.21	0.21	0.22	0.22
Docosahexaenoic	C22:6n3	0.11	0.10	0.11	0.11	0.12

Analyses were performed at days 0, 20, 40, 60 and 80.

The results are given in %.

Table 3. Fatty acid compositions of tomato seed oil samples stored in opaque glass bottles

Fatty acid (%)		Opaque (days)				
		0	20	40	60	80
Myristic	C14:0	0.10	0.10	0.10	0.10	0.10
Pentadecanoic	C15:0	0.02	0.02	0.02	0.02	0.02
Palmitic	C16:0	11.98	11.97	12.00	12.01	11.92
Palmitoleic	C16:1	0.31	0.31	0.3	0.30	0.30
Heptadecanoic	C17:0	0.05	0.07	0.05	0.05	0.05
Stearic	C18:0	6.29	6.25	6.30	6.32	6.18
Elaidic	C18:1n9 <i>t</i>	0.06	0.09	0.10	0.07	0.10
Oleic	C18:1n9 <i>c</i>	21.75	21.70	21.75	21.76	21.74
Linoelaidic	C18:2n6 <i>t</i>	0.14	0.22	0.25	0.19	0.26
Linoleic	C18:2n6 <i>c</i>	55.67	55.64	55.49	55.53	55.72
Arachidic	C20:0	0.49	0.48	0.49	0.49	0.48
γ-Linolenic	C18:3n6	0.03	0.02	0.02	0.02	0.02
α-Linolenic	C18:3n3	2.62	2.61	2.61	2.61	2.61
Gadoleic	C20:1	0.09	0.10	0.09	0.09	0.09
Behenic	C22:0	0.10	0.12	0.12	0.12	0.11
Lignoceric	C24:0	0.19	0.21	0.21	0.21	0.20
Docosahexaenoic	C22:6n3	0.11	0.10	0.10	0.10	0.11

Analyses were performed at days 0, 20, 40, 60 and 80.

The results are given in %.

Limited number of studies have reported on the effect of light and packing materials on fatty acid composition of vegetable oils (Méndez and Falqué, 2007; Al Juhaimi et al., 2016). However, up to the moment, there are no works about tomato seed oil. In this study, it was investigated whether sunlight affects the fatty acid composition of tomato seed oil stored in different colored (transparent, amber and opaque) glass bottles. The results were evaluated as the alteration of each fatty acid that can be detected and the comparison of different colored glass bottles among each other during the storage time.

According to the results, storing in different colored glass bottles did not affect the fatty acid composition of the samples. All fatty acid values were close to each other in general. While there was no change in the proportion of myristic (C14:0) and pentadecanoic (C15:0) fatty acids detected in all three bottles during storage, the proportions of palmitoleic (C16:1), heptadecanoic (C17:0), gamma-linolenic (C18:3n6), arachidic (C20:0), gadoleic (C20:1), behenic (C22:0), docosahexaenoic (C22:6n3) and lignoceric (C24:0) acids were very similar within themselves.

During 80 days in transparent, amber and opaque glass bottles, the contents of linoleic, oleic and palmitic acids changed between 54.12-55.72%, 21.68-22.35% and 11.92-12.55%, respectively. Linoleic acid had slight decrease in transparent and amber bottles. In addition to this, the decline rate was higher in transparent bottle that transfers more daylight than amber one. Oleic acid increased smoothly for each bottles, the greatest amount of increase was seen in the transparent bottle. Palmitic acid showed a steady increase in transparent and amber bottles for 80 days. In opaque bottles, there was no great alteration of these fatty acids.

The ratios of stearic and linolenic acids are shown in Table 1, 2 and 3. There was an increase in stearic acid in the amber bottle and some fluctuations were observed in the increases in transparent and opaque bottles. Linolenic acid demonstrated a decrease in the same bottles as linoleic acid, and even the reduction in bottles

showed similarities. No change was in opaque bottle. The elaidic and linoelaidic acids exhibited a non-uniform increase over the initial values for all bottles. It should be noted that in the 80th day of the analysis, the elaidic acid in amber one was not detected.

The reason of decrease may be oxidation caused by light of double bonds in unsaturated fatty acids and isomerization of *cis*- forms to *trans*- forms. The reason of increase especially in *trans*- forms may be isomerization of *cis*- forms to *trans*-. The absence of change in the values may be the presence of natural antioxidants in the oil. In present study, we determined that sunlight did not dramatically alter fatty acid composition of tomato seed oil.

Al Juhaimi et al. (2016) investigated extra-virgin olive oil added rosemary essential oil and stored in red, green, yellow and transparent glass bottles for 90 days under sunlight. They analysed the samples every 30 days and concluded that fatty acid compositions of olive oils in four different glass bottles did not vary majorly during storage under sunlight. Méndez and Falqué (2007) used different packaging materials (clear PET bottle, aluminium foil covered PET bottle, glass bottle, tin and Tetra-brik®) for extra-virgin olive oil for 6 months exposing light and air. After 3 and 6 months of storage their results showed that the percentage of fatty acids analysed did not vary with respect to the initial composition.

In addition, the resultant colors of initially orange-red color tomato seed oil stored in transparent, amber and opaque glass bottles were evaluated visually. It was observed that the sample in the amber colored bottle was slightly whereas the sample in the transparent bottle was discolored markedly. The order of decolorisation of oil samples in glass bottles is like this: transparent > amber > opaque. In terms of color, opaque glass bottle seems to provide the best protection. The findings of Makni et al. (2015) are in agreement with the best preservation of vegetable oil colors by means of opaque bottles. Lycopene from carotenoids, which are thought to give tomato seed oil its redness, becomes isomerized and thus

loses overall color intensity when exposed to light (Shi et al., 2008; Shao et al., 2013; Shao et al., 2015). There is a need for further research to determine the effect of light on the lycopene degradation.

## CONCLUSION

The work was primarily aimed to see the change in fatty acid composition of tomato seed oil stored in different colored glass bottles under the sunlight. The oil yield of tomato seed was 20.8%. The results showed that the sunlight did not lead to major changes of fatty acid composition of samples, also valid for three bottles. As in other studies, the main fatty acids of tomato seed oil are linoleic, oleic, palmitic, stearic and  $\alpha$ -linolenic acids in this study. When the effect of the bottles on the composition was compared, it was observed that all values of the opaque bottle were stabilized and slight increases and/or decreases were observed in the transparent and amber bottle. At the end of storage, visually assessed oil color was found to be best preserved in the opaque bottle, a slight decolorisation in the amber bottle and a complete colorlessness in the transparent bottle. Lycopene is thought to give redness to tomato seed oil and it is known that lycopene is colorless by exposure to light. Future studies may be focused on evaluating the lycopene in terms of the stability and the effect on the other oxidation products when exposed to light.

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