

**Effects of Storage Conditions and PET Packaging on Quality of Edible Oils in Iran**<sup>1</sup>Mousavi Khaneghah, <sup>2</sup>Sh. Shoeibi, and <sup>3</sup>M. Ameri<sup>1</sup>*Department of Food Science and Technology, Islamic Azad University, Science and Research Branch, Tehran, Iran.*<sup>2</sup>*Food and Drug Control Laboratories (FDCLs), Deputy for Food & Drug, MOH, Tehran, Iran.*<sup>3</sup>*Head of R&D Lab. Savola Behshahr Ind. Co., Tehran, Iran.*

Mousavi Khaneghah, Sh. Shoeibi and M. Ameri: Effects of Storage Conditions and PET Packaging on Quality of Edible Oils in Iran

**ABSTRACT**

The Effects of polyethylene terephthalate (PET) pieces and different storage conditions on fatty acids profile and some quality factors in three types of commercial oils, namely sunflower oil, canola oil, and blended oil containing sunflower oil, soy bean oil, and cottonseed oil were studied. Fatty acid profile and quality factors such as peroxide value, free fatty acids, and iodine value and induction period before and after storage of samples at 25 and 45°C for 20 and 60 days in the presence or absence of PET pieces were investigated. Results showed that the amount of polyunsaturated fatty acids like linoleic acid was decreased slightly and the amount of monounsaturated and saturated fatty acids like oleic acid and palmitic acid, respectively, was marginally increased. Thus, it was concluded that the stability of vegetable oils is dependent on the type of oil and its initial physical and chemical properties, time and temperature of storage and the type of employed packaging material (PET and glass). This study showed that storing oils at low temperatures ( $T < 25$  °C) may be recommended in order to extend the shelf life and maintenance quality of commercial oils which are packaged in PET containers.

**Key words:** canola oil, fatty acid profile, blended oil, PET pieces, sunflower oil, quality factors**Introduction**

Oils play a crucial role in the human diet. More than 90% of the world oil production from vegetable, animal and marine sources is used in foods or as part of it [32]. Different kinds of oil have various uses in the food industry, among them canola and sunflower oils are used extensively for cooking. The blended oil (which contains sunflower oil, soy bean oil, and cottonseed oil) is considered as one of the current oils in Iran's market. The materials which are used for packaging have a large variety. Glass, metal and different kinds of plastics are used in oil packaging [34,32]. The kinds of packaging have significant affect on shelf life of the oils as the carefully processed oil may be damaged by inelegant selection of packaging materials [26]. PET is one of the most commonly used plastics in food packaging covering a wide range of packaging material. PET satisfies many important requirements such as good aesthetic aspect (brilliance and transparency); suitability for coloring; good mechanical, thermal, and chemical resistance; low production cost; suitability for short storage, easy recyclability, and low weight with respect to glass bottles [34]. The trend toward incorporating modifier compounds into PET

packaging resins has grown in order to produce containers with a high degree of clarity, in a wide variety of custom shapes, and free from residual acetaldehyde. In addition, incorporation of antioxidant stabilizers in PET increases its application in the food area, particularly for vegetable oil storage [27,34]. Important characteristics such as barrier properties of packaging materials against moisture, oxygen and the interaction between foodstuff and packaging materials have an important effect on the quality and shelf life of oils in foodstuff [29]. Hence, the major function of packaging is to minimize the reaction which has direct effect on stability of the contained product [13,12]. One of the crucial reactions which leads to the quality deterioration is rancidity of food products. Rancidity is the development of off-flavor that is generated by oxidation and hydrolysis which make the food unusable [8]. Storage stability and shelf life of fats and oils are attracting the attention of nutritionist, food processor, government regulator and consumers. The studies published about the effect of packaging on oil quality have concluded that stability can be enhanced by suitable selection of packaging material [22,19,21,26,5,34,33].

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The maximum limits for migrated substances from various plastic containers for food are important and this depends on the speeds of migration and the amount of migrated compounds affect the quality and stability of foods. One of the additives, fat soluble phenolic antioxidants, present in the compounded polymer may migrate at an appreciable rate into the oil during storage which then effect its stability [23,6,4]. Numerous studies have shown the release of antioxidants from the packaging materials into oil-containing foodstuff [3,25]. The extension of shelf life of some products due to the presence of such compounds has been reported [24]. The shelf life and oxidative stability of olive oil stored in glass and polyethylene (PE) bottles were examined [20]. Due to this research, glass bottles which prevent oxygen from entering the oil were more protective against oxidation in comparison with plastic bottles (PE). Sharma *et al.* [29] studied the effect of thin plastic film contact, including PE, polypropylene (PP) and butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) which incorporated with polyethylene on the shelf life refined sunflower oil and groundnut oil at 37°C. The results indicated that changes in peroxide value and thiobarbituric acid (TBA) in the presence of plastic films were significantly lower than the blank samples [12]. Kaya *et al.* [19] studied the effect of permeability and transparency of the packaging materials (glass and PET bottles) on the shelf life and also stability of sunflower and olive oils. In this research, oxidative stability of the oil was studied by measuring the peroxide values. The results demonstrated that storage stability of oil increased in the order which depended on packaging material, colored glass > transparent glass > PET [6]. Oil quality can be controlled by measuring peroxide value, acid number and thiobarbituric acid value [30]. Satue *et al.* [28] reported that the extent of oil oxidation is often specified by measuring the peroxide value (PV). Since this index is related to the hydroperoxides, the primary oxidation products which cause rancid flavor because of their instability and hence conversion to secondary oxidation products [19,28]. Kucuk and Caner [21] studied the effect of PET packaging materials and the various keeping conditions on storage stability of sunflower oil. The results showed that PET packaging, presence of oxygen, light and storage period increased the peroxide value, free fatty acids and iodine value in addition to soap content compared with glass packing in the above mentioned conditions [21], in this case they leave a great impression on decreasing the oil storage stability.

The effect of different type of plastics (polyethylene terephthalate (PET), polyvinylchloride (PVC), polypropylene (PP) and polystyrene (PS) on the stability of olive, sunflower and palm oil were studied [32]. The authors have concluded that the period and temperature of storage as well as

packaging materials have significant effects on the stability of the above mentioned oils [32]. Tawfik [33] studied the oil absorption and the global migration of different types of plastic material (PET, PVC, PP and PS) into different vegetable oils (olive, sunflower and palm oil). The findings showed that the amount of overall migration from plastic packaging into a vegetable oil is determined by the type of plastic packaging and the kind of oil considered. Tawfik concluded that the chain length of the fatty acids and the degree of saturation clearly influence the oil absorption by polymers whereas the migration of components from plastic was not influenced that much [33].

The present study examined the effects of PET plastic pieces and various storage conditions on fatty acid profile and some quality factors. Hence, Fatty acid profile and quality factors such as peroxide value, free fatty acids and iodine value and induction period before and after storage of samples at 25 and 45°C for 20 and 60 days in presence or absence of PET pieces in three types of common oils from Iran's market were investigated.

## Materials And Methods

**Oils and PET bottles:** Commercial sunflower, canola and blended oils (contains sunflower, soy and cotton seed oils) (amount of added B.H.T as antioxidant 100 mg/kg in all of the oils) and PET bottles were obtained from Savola Behshahr Co., Tehran. Iran. Chemicals solvents were purchased from Merck Co., Germany.

### Sample Preparation:

After measuring a specific surface on the bottles, they were cut to 14 pieces with the same size (surface of them are 6 cm<sup>2</sup>). Pieces were placed in 250ml Glass vessels, the glass vessels were poured with oil up to 150ml volume of container, so that the test pieces were always remained well apart from one to another and immersed completely in each type of oil. The glass vessels that contain tests pieces were stored at 25 and 45°C for 20 and 60 days [33]. Since all of the samples have been stored in a dark place and in sealed container (in glass vessels 250 ml) the effect of light and oxygen parameters in all specimens were similar. The temperature were controlled and the data recorded by data logger (LASCAR, England). Glass vessels containing oils only were placed in the same conditions and served as blank samples. Every treatment was performed in four replicates.

### Chemical Tests:

For determination the profile of fatty acid, a transmethylation technique followed by GC-FID determination [2] was used as practice method. The

gas chromatograph system (Agilent Technologies model 6890N, Germany) equipped with flame ionization detector (FID) and HP88 column with the specifications of 100m\*250mm\*0.2m [1,2] was used as practice method. Temperature of the column has raised from 170 to 190°C in 5 minutes and 0.5°C per minute and remained in this temperature for 20 minutes, the detector temperature was at 250°C, the carrier gas was helium at 0.7ml/min, the pressure was 10 PSI and the amount of sample injection was 1 micro liter [1,7].

By using rancimat system (Metrohm model 734, Switzerland) and AOCS (Cd 12b-92) the induction period test was done at 110 °C [7].

The iodine value was calculated based on mathematical formula which presented in AOCS (Cd 1c-85), which directly calculated from the oil fatty acid profile (Firestone, 1994). In oxidative rancidity oxygen is taken by the oil with the formation of peroxide. The degree of peroxide formation (Peroxide Value) was calculated according to the AOCS (Cd 8-63) [7]. Determination of free fatty acids was done by AOCS (Cd 3d-63) [7].

#### Statistical Analysis:

Experiments on each of samples were performed at four times. Two analyses were taken from the test samples at each specific time interval. Statistical analysis (Mean values and standard division were calculated at each time interval, so were analyzed by SPSS ver. 17 (SPSS Inc. Michigan Avenue., Chicago, USA) and Minitab ver. 11.12 (Minitab Inc., USA).

#### Results And Discussions

Tables 1, 2 and 3 shows the fatty acids composition of sunflower oil, blended oil (sunflower, soybean and cotton seeds oils) and canola oil before and after storage for 20 and 60 days at 25 and 45°C. As it is shown in results, some small changes in the amounts of saturated and unsaturated fatty acids in above mentioned oils were observed.

Main fatty acids in the sunflower oil include palmitic acid 7.74(%), oleic acid 23.37(%), linoleic acid 61.76(%) and linolenic acid 1.63(%) that slightly alterations were detected in the amount of mentioned fatty acids after storage. As an example the profile of the sunflower oil was altered to palmitic acid 8.7(%), oleic acid 25.15(%), and linoleic acid 57.83(%) after 60 days storage at 45°C. As result the amount of poly unsaturated fatty acids like linoleic acid was decreased and the amount of mono unsaturated and saturated fatty acids like oleic acid, and palmitic acid, respectively, were increased.

Most notable fatty acids in the blended oil include palmitic acid 9.43(%), oleic acid 23.80(%), linoleic acid 58.00(%) and linolenic acid 2.42(%) that some slight changes were observed, similar to

sunflower oil, after storage. The composition of indicated fatty acids was changed to palmitic acid 9.63(%), oleic acid 24.79(%), and linoleic acid 55.56(%) after 60 days storage for at 45°C.

In canola oil with this initial fatty acid profile: palmitic acid 5.07(%), oleic acid 56.01(%), linoleic acid 20.94(%), linolenic acid 9.15(%) small changes in fatty acid profile was observed after storage at the same conditions.

Effects of time passing and raising of temperature caused breaking 2 cis double bonds and converting them to single double bond and without double bonds, Also, the conversations between different shape of geometrical isomerization such as Cis or Trans and local isomerization such Iso caused above mentioned alteration [31].

Since all of the samples have been stored in a dark place and in sealed container (in glass vessels 250 ml) the effect of light and oxygen parameters in all specimens were similar. Presence or absence of plastic pieces has no significant effect on fatty acids profile

According the results which is shown in Fig. 1, significant decrease ( $P \leq 0.05$ ) was observed at induction period (IP) in the mentioned oils after storage for 20 and 60 days at 25 and 45°C. Among the oils, canola has maximum induction period because this oil contain a large amount of oleic fatty acid (mono unsaturated) and the blended oil has the minimum induction period because the oil contains different types of fatty acids such as poly unsaturated fatty acids. A significant difference ( $P \leq 0.05$ ) at induction period was observed in the presence or absence of plastic pieces. These differences indicate the effect of plastic pieces on decreasing induction period and correlates with previous investigations [14,21]. In the case of the blended oil, the significant decreasing in induction period after 60 days at 45 °C has made the oil useless, with consider to blended oil standard (maximum authorized of induction period is 8 hours) [16,15,17]. The result shows that the canola oil has the maximum induction period in comparison with other oils.

As shown in Fig. 2, sunflower and blended oils have increased significantly ( $P \leq 0.05$ ) in peroxide value (PV) after 20 and 60 days at 25 and 45°C and in the presence or absence of PET pieces but in canola oil only period and temperature has affected significantly ( $P \leq 0.05$ ) in peroxide value. In blended oil that contains different types of fatty acids; peroxide value was formed quickly because of the large amount of poly unsaturated fatty acids. Peroxides in sunflower and canola oil was formed slower than blended oil due to the presence of high amount of natural antioxidants and mono unsaturated fatty acids like oleic acid, respectively [21,18,4] but during storing and after decreasing efficiency of natural antioxidants and decreasing amount of mono unsaturated fatty acids the amount of peroxide value has increased in sunflower and canola oil in

comparison with the initial oils. In presence and absence of plastic pieces, the sunflower and canola oil has increased significantly ( $p \leq 0.05$ ) in peroxide value after 20 and 60 days at 45°C. Relatively, the PVs have been altered at the end of storage period, and have been increased as a result of releasing pro oxidant compounds such as aldehydes from plastic pieces. Moreover, it has been stimulated by increasing temperature. This result was confirmed by previous investigations [14,9,21,11]. Maximum authorized value of peroxide in National standard of Iran for sunflower, canola and blended oils are 2.5, 2.0 and 5.0 meq/kg, respectively, so based on these values, sunflower oil which stored at 45°C in both of storage periods, canola oil which stored at 45°C for 60 days and blended oil that stored at 45°C for 20 days with plastic pieces, 60 days with and also without plastic pieces became useless [16,1517]. Results show that canola oil has the minimum PV in comparison with other oils at the end of storage period.

The Iodine value (IV) is decreased during the storage period as shown in Fig. 3. The amount of unsaturated fatty acid has a direct effect on IVs. As the result existence of poly unsaturated fatty acids in the blended and sunflower oil, The IVs in sunflower and blended oil significantly declined ( $P \leq 0.05$ ) after 60 days at 45°C and in presence or absence of PET pieces. Slight changes after decreasing of iodine

value in canola oil were observed. The Results correlates with the previous investigations [32].

Amounts of free fatty acids (FFA%) during different conditions of storage were shown in Fig. 4. It is well accepted that during storage period, partial hydrolysis of oils has taken place, thus free fatty acid content were increased. There was a significant increase ( $P \leq 0.05$ ) in the FFA% among the storage for 20 and 60 days at 25,45°C in mentioned oils which shows the effect of temperature and time on forming free fatty acids, and also confirm the previous investigations [13,29,9,11]. FFA% had increased significantly ( $P \leq 0.05$ ) in presence or absence of the plastic pieces in the oils. Releasing lower molecular acids from plastic pieces which are stimulated by increasing temperature cause the Increasing of FFA %. These results were in accordance with earlier research [13]. In National standard of Iran, the maximum permissible level of free fatty acids in sunflower, canola and blended oil are 0.2, 0.2 and 0.1%, respectively, thus the blended oil which had been stored at 45°C for 20 and 60 days with and without plastic pieces was deteriorated [15,16,17]. It is necessary to be noticed that the presence of free fatty acids increases the hydrolysis which leads deterioration of oils and make them unsuitable for human consumption. Results show that the canola oil has the maximum level of free fatty acids in comparison with the other oils.

**Table 1:** Profile of fatty acids in sunflower oil in different conditions of storage

Storage conditions									
fatty acid	Original* oil	20 days Without PET pieces**		20 days With PET pieces***		60 days Without PET pieces		60 days With PET pieces	
		25 °C	45 °C	25 °C	45 °C	25 °C	45 °C	25 °C	45 °C
		C14:0	0.08	0.08	0.08	0.08	0.08	0.07	0.07
C16:0	7.55	7.93	8.02	8.06	7.98	7.81	7.85	8.08	8.07
C16:1	0	0.09	0.08	0.09	0.09	0.08	0	0.08	0.08
C17:0	0.05	0.05	0.05	0.05	0.05	0.04	0	0.05	0.05
C18:0	2.97	4.03	4.10	4.03	3.93	3.63	3.63	3.94	4.01
T-C18:1	0	0.04	0.06	0	0.03	0	0.02	0	0
C18:1	23.37	24.95	24.96	25.23	24.69	24.32	24.10	24.95	25.15
Iso-C18:1	1.73	1.07	1.15	1.00	1.23	1.63	1.90	1.11	1.19
T-C18:2	0.26	0.33	0.35	0.36	0.35	0.24	0.21	0.35	0.35
C18:2	61.76	57.94	57.94	57.87	58.20	59.33	59.42	58.25	57.83
C20:0	0.16	0.30	0.30	0.31	0.29	0.22	0.21	0.2	0.30
T-C18:3	0	0.18	0.18	0.09	0.18	0.15	0.15	0.14	0.16
C18:3	1.67	1.98	1.94	1.97	1.97	1.87	1.87	1.96	1.93
Iso-C18:3	0	0.07	0.04	0	0.06	0	0	0	0
Ga-C18:3	0.18	0.17	0.16	0.16	0.15	0.1254	0.12	0.14	0.15
C22:0	0.20	0.61	0.58	0.59	0.56	0.35	0.32	0.53	0.57

Original oil \*: The oil which has no treatment

Without PET pieces\*\*: The oil which has not been in contact with PET pieces

With PET pieces\*\*\*: The oil which has been in contact with PET pieces

**Table 2:** Profile of fatty acids in blended oil in different conditions of storage

Storage conditions									
fatty acid	Original oil	20 days Without PET pieces**		20 days With PET pieces***		60 days Without PET pieces		60 days With PET pieces	
		25 °C	45 °C	25 °C	45 °C	25 °C	45 °C	25 °C	45 °C
		C14:0	0.11	0.12	0.12	0.11	0.12	0.11	0.12
C16:0	9.43	9.65	9.62	9.65	9.77	9.4221	9.77	9.60	9.63
C16:1	0.07	0.10	0.10	0.09	0.10	0.08	0	0.09	0.10
C17:0	0.04	0.06	0.06	0.06	0.06	0.04	0	0.06	0.06

C18:0	3.33	4.00	4.03	4.05	3.96	3.41	3.28	4.04	4.06
T-C18:1	0	0.07	0.05	0	0	0	0	0.12	0.05
C18:1	23.80	24.85	24.83	24.7	24.74	24.25	24.55	24.79	24.86
Iso-C18:1	1.75	1.25	1.18	1.27	1.29	1.64	1.47	1.25	1.20
T-C18:2	0.25	0.34	0.30	0.33	0.34	0.25	0.15	0.34	0.30
C18:2	58.00	55.56	55.54	55.53	55.55	57.50	57.93	55.54	55.56
C20:0	0.20	0.30	0.31	0.35	0.31	0.21	0.17	0.31	0.31
T-C18:3	0.18	0.24	0.28	0.24	0.25	0.20	0	0.243	0.24
C18:3	2.42	2.64	2.70	2.677	2.69	2.47	2.32	2.68	2.67
Iso-C18:3	0	0	0	0	0	0	0	0	0
Ga-C18:3	0.10	0.16	0.17	0.161	0.16	0.11	0	0.16	0.17
C22:0	0.23	0.49	0.52	0.53	0.50	0.25	0.18	0.52	0.53

Original oil \*: The oil which has no treatment

Without PET pieces\*\*: The oil which has not been in contact with PET pieces

With PET pieces\*\*\*: The oil which has been in contact with PET pieces

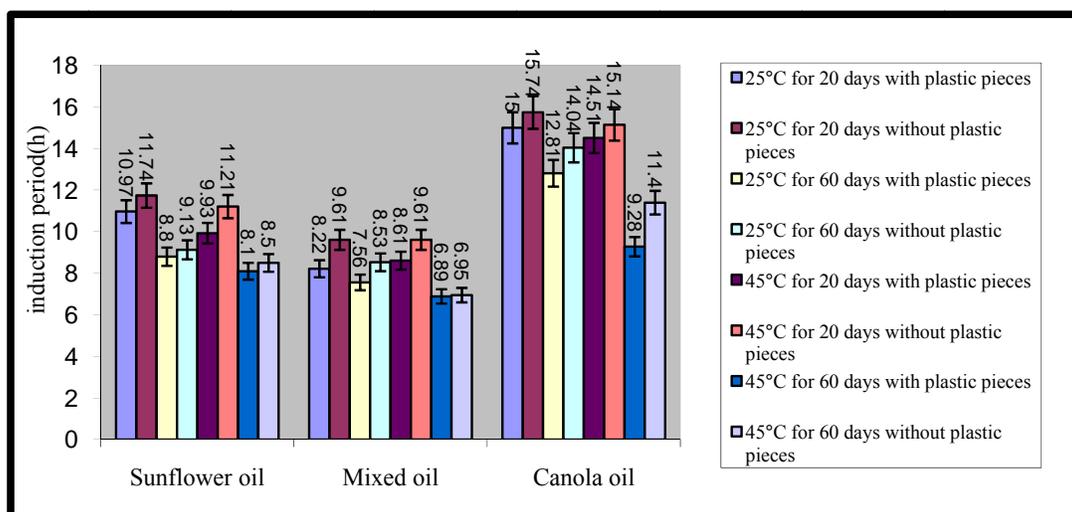
**Table 3:** Profile of fatty acids in canola oil in different conditions of storage

fatty acid	Storage conditions								
	Original oil	20 days Without PET pieces**		20 days With PET pieces***		60 days Without PET pieces		60 days With PET pieces	
		25 °C	45 °C	25 °C	45 °C	25 °C	45 °C	25 °C	45 °C
C14:0	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
C16:0	5.07	5.02	4.95	5.10	5.09	4.92	4.85	5.06	5.00
C16:1	0.19	0.19	0.18	0.18	0.18	0.17	0.17	0.18	0.17
C17:0	0.04	0.49	0.049	0.04	0.04	0.03	0.03	0.04	0
C18:0	2.03	2.06	2.05	2.04	2.03	1.86	1.74	2.04	2.08
T-C18:1	0.13	0.126	0.12	0.11	0.12	0.10	0.09	0.12	0.12
C18:1	56.01	55.85	55.91	55.61	55.59	55.59	56.07	56.08	55.85
Iso-C18:1	3.47	3.45	3.27	3.54	3.54	4.10	4.21	3.50	3.39
T-C18:2	0.10	0.10	0.10	0.10	0.11	0.07	0.07	0.10	0.10
C18:2	20.94	20.85	20.84	21.06	21.10	21.22	21.33	20.82	20.87
C20:0	0.55	0.57	0	0.57	0.57	0.45	0.43	0.57	0.58
T-C18:3	0.56	0.6	0.60	0.60	0.58	0.52	0.51	0.57	0.59
C18:3	9.15	9.16	9.17	9.17	9.23	9.05	9.06	9.07	9.16
Iso-C18:3	0.05	0.04	0.05	0.06	0.05	0.04	0.03	0.05	0.05
Ga-C18:3	1.09	1.18	1.20	1.17	1.16	0.99	0.97	1.09	1.20
C22:0	0.29	0.29	0.30	0.30	0.31	0.17	0.15	0.30	0.30

Original oil \*: The oil which has no treatment

Without PET pieces\*\*: The oil which has not been in contact with PET pieces

With PET pieces\*\*\*: The oil which has been in contact with PET pieces



**Fig. 1:** The induction periods of sunflower, blended (Mixed) and canola oils during different storage conditions

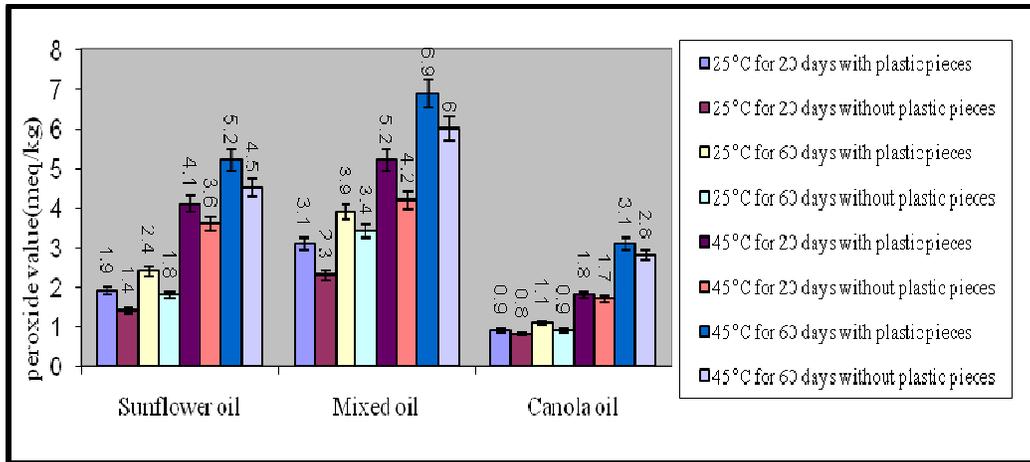


Fig. 2: The peroxide values of sunflower, blended (Mixed) and canola oils during different storage conditions

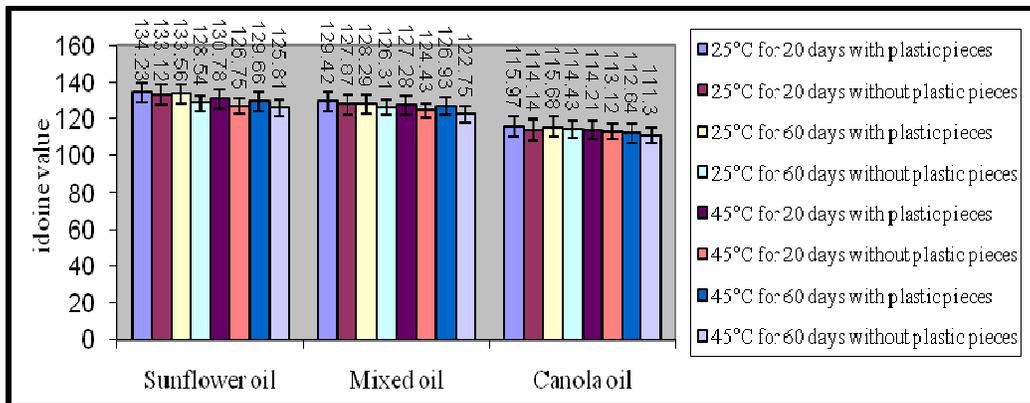


Fig. 3: The iodine values of sunflower, blended (Mixed) and canola oils during different storage conditions

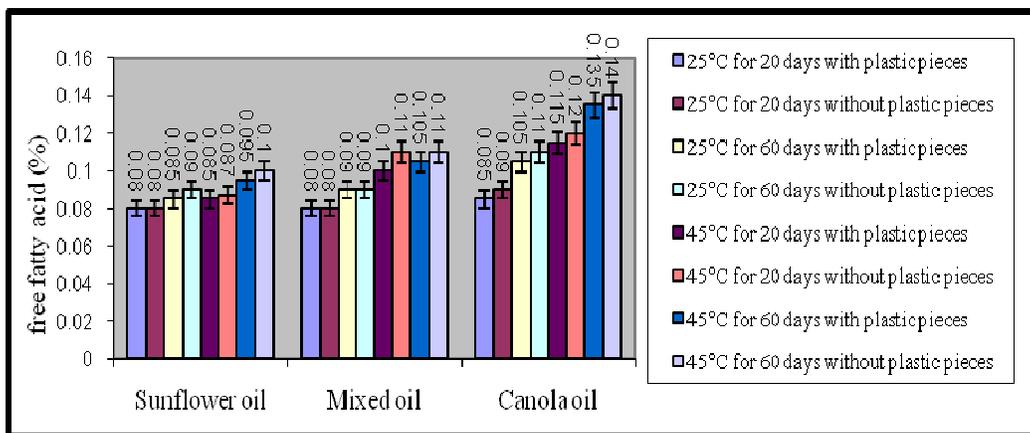


Fig. 4: The amount of free fatty acids of sunflower, blended (Mixed) and canola oils during different storage conditions

Conclusion:

On the examination of fatty acid profile, quality factors such as free fatty acids, peroxide value, induction period and iodine value, some results

clearly emerged. Increasing storage period and temperature and presence of PET pieces has some effects on FFA%, PV, induction period and Iodine value. It is concluded from this study that the stability of vegetable oils is dependent on the type of

oil and its initial physical and chemical properties, time and temperature of storage and the type of packaging (PET and Glass). In addition increasing storage temperature and time accelerated the deterioration and limited the stability of vegetable oils. Results show the quality of oil has been decreased after the storage at high temperature (45°C) and long time of storage. So for preventing of deterioration, the oils which were packed in PET bottles should be stored at a temperature lower than 25°C. If the temperature is raised (T<45°C) the shelf life of product should be limited. Difference between these effects in the mentioned oils can be explained by their nature, initial physical and chemical properties of oils. Oil stability can be enhanced by selection of a suitable package.

More studies should be done on shelf life of oils, so the best storage condition must be defined with attention to maintenance of oil's quality. It is of great important to conduct storage experiments by choosing different conditions (e.g. Time, Temperature and other type of oils) to evaluate the PET packaging to extend shelf life and quality of products.

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#### References

1. AOAC method 963.22. 2000. Methyl Esters of Fatty Acids in Oils and Fats, Official Methods of Analysis of the AOAC, (17<sup>th</sup> ed), AOAC, Arlington, Virginia USA.
2. AOAC method 969.33. 2000. Fatty Acids in Oils and Fats, Official Methods of Analysis of the AOAC, (17<sup>th</sup> ed), AOAC, Arlington, Virginia USA.
3. Baner, A., W. Bieber, K. Figge, R. Franz, and O. Piringer, 1992. Alternative fatty food simulant for migration testing of polymeric food contact materials, Food additives and contaminants, 9: 137-148.
4. Cinquanta, L., M. Esti and M. Di Matteo, 2001. Oxidative stability of virgin olive oils. Journal of American oil chemists' society, 78(12): 1197-1202.
5. Coutelieri, F.A. and A. Kanavouras, 2006. Experimental and theoretical investigation of packaged olive oil: Development of a quality indicator based on mathematical predictions. Journal of Food Engineering, 73:85-92.
6. Crosby, N.T., 1981. Food packaging materials, Aspects of Analysis and Migration of Contaminates, Applied Science Publisher Ltd, London, pp: 89.
7. Firestone, D., 1994. Official methods & recommended practice of the American oil chemists society, (4<sup>th</sup> ed), AOCS, Champaign, IL, USA.
8. Frankel, E.N., 1982. Volatile lipid oxidation products. Progress in lipid Research, 22: 1-33.
9. Frankel, E.N., 1991. Recent advances in lipid oxidation, Journal of the Science of Food and Agriculture, 54: 495-511.
10. Freytag, W.K. Figge and W.D. Bieber, 1984. Migration of different plastics additives from various plastic into isooctane and into olive oil. Deutsche Lebensmittel – Rundschau, 80: 333-335.
11. Ghasemnezhad, A. and B. Honermeier, 2007. Influence of storage conditions on quality and viability of high and low oleic sunflower seeds. International Journal of Plant Production, 4(3): 39-48.
12. Gilbert, S.G., 1985. Food package compatibility. Food Technology, 39: 54-56, 63.
13. Gilbert, S.G. and C.H. Mannheim, 1982. Shelf life testing of foods, P. Al. Center for professional advancement. E. Brunswick, NJ.
14. Huang, A.S., O.A.L. Hsieh, C.L. Huang, and S.S. Chang, 1981. A comparison of the stability of sunflower oil and corn oil, Journal of American Oil chemists Society, 58: 997-1001.
15. Institute of Iran Standard and Industrial Researches, Characteristics of edible canola oil, 1999. Standard no. of 4935, 1<sup>st</sup> revision.
16. Institute of Iran Standard and Industrial Researches, Characteristics of edible sunflower oil, 1981. Standard no. of 1300, 1<sup>st</sup> edition.
17. Institute of Iran Standard and Industrial Researches, Characteristics of blended oil, 2007. Standard no. of 5950, 1<sup>st</sup> revision
18. Kadivar, Sh., M. Ghavami, M. Gharachorlou, and B. Delkhosh, 2010. Chemical Evaluation of the Oil Extracted from Various Kinds of canola seed. Journal of Food Technology and Nutrition, 7(2): 56-66.
19. Kaya, A., A.R. Tekin, and M.D. Oner, 1993. Oxidative stability of sunflower and olive oil: comparison between modified active oxygen, Method and long term storage. Lebensmittel-Wissenschaft und-Technologie, 26: 464-468.
20. Kiritsakis, A.K., 1984. Effect of selected storage conditions and packaging material on olive oil quality. Journal of American Oil chemists Society, 61: 1868-1870.
21. Kucuk, M. and C. Caner, 2005. Effect of packaging materials and storage conditions on sunflower oil quality. Journal of Food Lipids, 12: 221-231.
22. Leo, D.A., 1983. Effect of packaging on oil product quality. Journal of American oil chemists' society, 60(2): 301-302.

23. Mahadeviah, M., 1975. Plastic containers for processed food products, *Indian Food Packer*, pp: 35.
24. Miltz, J., P. Hojjat, J.K. Han, J.R. Giacini, B.R. Harte, and I.J. Gray, 1988. Loss of antioxidants from high density polyethylene: Its effect on oatmeal cereal oxidation, In: Hotchkiss, J. H. (ed), *Food and packaging interaction*, American Chemical Society, Washington, DC. Pp: 83-89.
25. Niebergall, H. and M. Hartmann, 1993. Determination and specific migration of antioxidant and plasticizers, *Lebensmittel-Wissenschaft und-Technologie*, 17: 254.
26. Ramezani, R., 2004. The effect of packaging materials and storage condition on the oxidative stability of refined sunflower oil. *Food Science and technology research*, 10(3): 350-354.
27. Piergiovanni, L. and S. Limbo, 2010. Packaging and the shelf life of vegetable oils, In: Robertson G. L. (ed), *Food packaging and shelf life: a practical guide*, Taylor & Francis., pp: 332-334.
28. Satue, M.T., S.W. Huang, and E.N. Frankel, 1995. Effect of natural antioxidants in virgin olive oil on oxidative stability refined bleached and deodorized olive oil. *Journal of American Oil chemists Society*, 72: 1131-1137.
29. Sharma, G.K., C.V. Madhura, and S.S. Arya, 1990. Interaction of plastic films with foods, Effect of polyethylene and poly propylene films on the stability of vegetable oils, *Journal of Food Science and Technology*, 27: 328-331.
30. Sirokhman, X., 1983. Storage ability of palm and coconut oils. *Tovaravedenie*, 16: 68-72.
31. Tarzi, B.G., A. Elhamirad. E. Hossaini, M. Salaminia and M. Ghavami, 2006. Stability of vegetable oils available in Iranian markets. *Journal of Food Technology & Nutrition*, 3(4): 37-46.
32. Tawfik, M.S. and A. Huyghebaert, 1999. Interaction of Packaging Materials and Vegetable Oils: oil stability. *Journal of Food Chemistry*, 64: 451-459.
33. Tawfik, M.S., 2005. Interaction of Packaging Materials and Vegetable Oils: Global Migration and Oil Absorption. *Journal of Food Technology*, 3(4): 506-510.
34. Tsimis, D.A., N.G. Karakasides, 2002. How the choice of container affects olive oil quality-A review. *Packaging Technology and science*, 15(3): 147-157.