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Scientific Research

Trans Fatty Acid Content of Iranian Edible Oils*

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ABSTRACT

Clinical and epidemiologic studies showed that among dietary factors the type of fatty acids (FAs) in the diet plays an important role in determining risk of chronic disease. The aim of our study was to determine the levels of Trans FA (TFA) in edible oil samples consumed in Tehran, Iran analyzed by gas chromatograph (GC). The mean of total TFA was 0.45% ranging from (0.11% - 1.61%) for liquid frying oils and 2.92% ranging from (0.46% - 5.40%) for solid oils. The major TFA observed in these two groups was elaidic acid in solid oils. The highest content of total saturated fatty acid (SFA) was detected in solid oils with average of 32.07 and palmitic acid was the major SFA in these four groups. Linoleic and linolenic acid are the most important poly unsaturated fatty acid (PUFA). The variance in the percentage of TFA in the edible oils probably resulted from differences in the type of oils, quality, heating, processing technique and storage condition of the edible oils. The results indicated that, edible oils contain considerable proportions of trans fatty acids. Therefore, it is important to assess the content of TFA in edible oils in Iran.

Keywords: Trans Fatty Acid; Gas Chromatography; Solid Oil; Liquid Frying Oil

1. Introduction

The interest in dietary fat is widespread, and fatty compound analysis is a basic requirement in testing food material [1]. Animal fats tend to have a larger proportion of long chain saturated acids and are solids at room temperature [2]. The different kinds of FA are saturated fatty acid (SFA), monounsaturated (MUFA), polyunsaturated (PUFA) and trans (TFA) [3]. The most widely used accurate and repeatable method for FA analysis is GC equipped with flame ionization detector (FID) [4].

TFAs are defined as unsaturated FA (UFA) with at least a double bond in the trans configuration resulting in a more rigid molecule close to a SFA [5]. Fats from plant sources contain a higher proportion of unsaturated acids and are often liquids at room temperature due to hydrogen bonding [6]. Industrial hydrogenation which is performed to improved texture, stability and other economically desirable properties is the major cause of TFA creation [7]. Also, microbial transformation of UFA in ruminants, heating and frying above 180˚ and deodorization of edible oil are the other causes of TFA creation [8]. Hydrogenation is a process that reduces the relative unsaturation of the oils and promotes geometric and positional isomeration [9]. Several clinical studies have shown that a TFA diet increase unfavorable LDL (low density lipoprotein)/HDL (high density lipoprotein) ratio and lipoprotein (a) and plasma triglyceride levels, which are independently associated with the increase risk of coronary heart disease (CHD) [10]. The risk of ischemic heart disease increases 25% by daily intake of TFA as little as 5 g [8]. Moreover, TFA intake promotes inflammation, increases body mass index, raises C-reactive protein, causes endothelial dysfunction and relates to the risk of diabetes. Replacing saturated or trans fat with polyunsaturated or monounsaturated fat is favorable in lowering serum cholesterol and reducing risk of CAD (Cardiac attack death) [11].

In Iran, TFA accounts 4.2% of all calories consumed by Iranians, which is much higher than US and many European populations do [12]. Between 11% and 39% of coronary heart disease referring to consumption of TFA

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and also, elimination of TFA in hydrogenated vegetable oils (HVOs) might be prevented 8% - 39% of cardiovascular disease events among Iranians [13]. In US populations TFA account for 2% - 3% of total energy intake [14].

In spite of the TFA disadvantages, limited data on the TFA contents of Iranian foods are available and it seems that the amount of TFA in edible oil requires more attention in developing countries [15].

Therefore, the aim of this study was to determine and compare TFA content in the branded liquid frying and solid oils that are commonly consumed by Iranian and also comparison of the achieved amount with approved standard in Iran and the other countries.

2. Materials and Methods

2.1. Sampling

Eight brands of liquid frying oils and four brands of solid oils that are commonly consumed in Iran were selected and each brand was coded with a letter (A, B, C, D, and…). Lot numbers were checked to ensure that each unit belonged to a different lot. All oil samples were stored, labeled and analyzed before expiry dates. Samples were selected to include the major manufacturers of the oils in Iran. The composition of studied oils was mixture of palm oil, soybean oil, canola oil, and sunflower oil. However solid oils contain more percentage of saturated fat.

2.2. Reagents and Standards

All solvents and reagents were used of analytical grade. Methanol, n-Hexane, sodium hydroxide, methanolic boron trifluoride and sodium chloride were purchased from Merck, (Darmstadt, Germany).

The certified standard mixture of 37 component FA methyl ester C4-C24 was purchased from (Accuastandard, USA), also linoleic and linolenic acid methyl ester isomer were purchased from (Sigma, USA).

2.3. Sample Preparation

Methyl-esterification of samples used in the analyses was performed by BF_3-MeOH method according to AOCS (American oil chemist society) [16]. In to a 125 mL flask, one g of oil was weighted and added ten mL of 0.5 (N) methanolic sodium hydroxide solutions, the mixture was heated at 100˚C for 10 min, then 12 mL BF_3-MeOH reagent was added, and heated for extra 2 min. After cooling five mL of n-hexane was added. The reaction was stopped by adding 15 mL saturated solution of NaCl and shaking the flask for about 15 seconds. One mL of the upper organic phase was selected and anhydrous Na_2SO_4 was added. The sample solution was injected to the gas chromatography (GC) after filtering through 0.22 µm disposable syringe filter.

2.4. GC-FID Analysis

The GC-FID analyses were performed on an Agilent model 7890 GC instrument equipped with a flame ionization detector. A highly polar capillary column (100 m × 0.25 mm i.d × 0.25 µm film thickness) of HP-88 (Agilent, USA) was used to separate the FAMEs. Nitrogen was used as the carrier gas at a flow rate of 1.0 mL/min. A split ratio of 100:1 was used and 1 µL of the sample was injected into the GC for analysis. The following oven temperature program was used: 180˚C for 30 min, then increase to 200˚C at a rate of 1.5˚C/min and kept at 200˚C for 30 min. The temperature was set at 220˚C for the injector and at 250˚C for the detector. The samples were analyzed triplicate and the results were expressed as mean values ± standard deviation (SD).

2.5. Data Analysis

Data were analyzed using statistical package for social sciences, version 16 (SPSS Inc., Chicago, IL, USA). Three independent oil samples of each cultivar were analyzed three times. Data are expressed as mean _ SDs. T-test was used for determining the differences between means inliquid frying oils and the solid oils. Statistical significance was set at $p < 0.05$.

3. Results and Discussion

3.1. Liquid Frying Oils

The FA compositions of various brands of liquid frying oils in Iran are presented in **Table 1**. The mean of SFA in the brands ranged from 11.67% in C to 36.12% in A. Among the SFA palmitic acid presented the highest value ranging from 6.86% in C to 30.34% in D. High oleic oils (C18:1c) have better oxidative stability in deep frying applications and extended shelf life and reduced LDL [17]. Group A had maximum content of oleic (36.20%).

Table 1 shows that UFA ranged from 27.36% in A to 54.24% in C. Linoleic and linolenic acid are the most important PUFA. As nutritional point of view the amount of PUFA in oils is very important. Linoleic and linolenic have useful influence on human health and improve cardiovascular function. They also have positive effect on lipid profile [7]. Despite of these positive effects, high levels of multiple double bond FA increase oxidation oil sensitivity in liquid frying oil [17]. Therefore, high linolenic content was found in group C (3.85%) due to more oxidation tendency. According to the acceptable range of linolenic in Iran, standard reference and also Wolff report [18] on only C group with 3.85% mean percentage was

Table 1. The Fatty acid compositions of various brands of liquid frying oils (%).

Fatty Acid	Brand							
	A	B	C	D	E	F	G	H
C6:0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C8:0	0.02 ± 0.00	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
C10:0	0.02 ± 0.00	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.00 ± 0.01	0.00 ± 0.00	0.01 ± 0.00
C12:0	0.2 ± 0.06	0.08 ± 0.04	0.02 ± 0.04	0.12 ± 0.04	0.11 ± 0.01	0.08 ± 0.02	0.08 ± 0.01	0.1 ± 0.01
C14:0	0.8 ± 0.17	0.43 ± 0.18	0.07 ± 0.00	0.57 ± 0.01	0.52 ± 0.03	0.43 ± 0.11	0.39 ± 0.01	0.52 ± 0.03
C14:1c	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C15:0	0.03 ± 0.00	0.02 ± 0.00	0.02 ± 0.01	0.03 ± 0.00	0.03 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.03 ± 0.00
C15:1c	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C16:0	30.34 ± 4.90	20.72 ± 7.25	6.86 ± 1.40	24.70 ± 3.73	23.98 ± 1.72	20.81 ± 3.75	18.88 ± 0.49	24.22 ± 1.07
C16:1c	0.14 ± 0.02	0.09 ± 0.01	0.1 ± 0.06	0.13 ± 0.03	0.11 ± 0.02	0.09 ± 0.02	0.1 ± 0.01	0.11 ± 0.01
C17:0	0.08 ± 0.02	0.06 ± 0.01	0.05 ± 0.01	0.07 ± 0.00	0.06 ± 0.01	0.06 ± 0.01	0.05 ± 0.01	0.07 ± 0.02
C17:1c	0.03 ± 0.00	0.03 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	0.03 ± 0.01	0.03 ± 0.00	0.03 ± 0.00	0.04 ± 0.00
C18:0	4.18 ± 0.21	4.37 ± 0.31	3.53 ± 0.86	4.08 ± 0.36	4.24 ± 0.15	4.44 ± 0.28	4.00 ± 0.18	4.57 ± 0.05
C18:1t	0.06 ± 0.01	0.03 ± 0.00	0.15 ± 0.19	0.11 ± 0.1	0.07 ± 0.03	0.13 ± 0.13	0.03 ± 0.01	0.06 ± 0.01
C18:1c	36.20 ± 4.32	25.84 ± 1.54	33.61 ± 17.53	34.43 ± 7.97	30.33 ± 4.32	28.18 ± 5.72	28.38 ± 0.73	30.00 ± 2.69
C18:2t	0.01 ± 0.01	0.00 ± 0.01	0.01 ± 0.01	0.02 ± 0.02	0.00 ± 0.01	0.01 ± 0.01	0.00 ± 0.01	0.02 ± 0.01
C18:2t	0.17 ± 0.07	0.05 ± 0.04	0.06 ± 0.06	0.40 ± 0.41	0.07 ± 0.03	0.11 ± 0.08	0.06 ± 0.02	0.19 ± 0.11
C18:2t	0.12 ± 0.05	0.07 ± 0.11	0.09 ± 0.05	0.36 ± 0.39	0.04 ± 0.01	0.08 ± 0.05	0.02 ± 0.00	0.12 ± 0.08
C18:2c	25.76 ± 8.15	45.89 ± 9.14	49.24 ± 21.23	31.40 ± 5.80	37.97 ± 2.87	42.50 ± 10.51	46.40 ± 0.65	35.79 ± 4.49
C18:3t	0.08 ± 0.05	0.03 ± 0.02	0.20 ± 0.21	0.32 ± 0.34	0.04 ± 0.01	0.12 ± 0.08	0.02 ± 0.01	0.22 ± 0.12
C18:3t	0.10 ± 0.06	0.04 ± 0.02	0.22 ± 0.23	0.34 ± 0.35	0.05 ± 0.00	0.14 ± 0.09	0.03 ± 0.00	0.24 ± 0.12
C18:3c	0.89 ± 0.61	1.27 ± 0.48	3.85 ± 3.70	1.60 ± 0.16	1.24 ± 0.12	1.59 ± 0.06	0.52 ± 0.02	2.53 ± 0.02
C20:0	0.30 ± 0.06	0.24 ± 0.02	0.37 ± 0.24	0.44 ± 0.23	0.28 ± 0.09	0.25 ± 0.11	0.24 ± 0.07	0.38 ± 0.08
C20:2c	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.00
C20:3c	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C20:3c	0.19 ± 0.12	0.39 ± 0.12	0.48 ± 0.20	0.27 ± 0.05	0.32 ± 0.06	0.32 ± 0.05	0.41 ± 0.09	0.29 ± 0.00
C20:4c	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C20:5c	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01
C21:0	0.15 ± 0.02	0.11 ± 0.01	0.59 ± 0.74	0.29 ± 0.21	0.24 ± 0.07	0.21 ± 0.14	0.13 ± 0.03	0.14 ± 0.03
C22:0	0.01 ± 0.01	0.03 ± 0.04	0.04 ± 0.03	0.02 ± 0.01	0.02 ± 0.01	0.01 ± 0.01	0.01 ± 0.00	0.02 ± 0.01
C22:1c	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C22:2c	0.02 ± 0.01	0.03 ± 0.01	0.02 ± 0.00	0.02 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.01	0.03 ± 0.01
C22:6c	0.00 ± 0.00	0.00 ± 0.00	0.07 ± 0.09	0.01 ± 0.02	0.01 ± 0.01	0.11 ± 0.12	0.00 ± 0.00	0.11 ± 0.22
C23:0	0.00 ± 0.01	0.00 ± 0.00	0.14 ± 0.20	0.04 ± 0.05	0.06 ± 0.02	0.07 ± 0.08	0.00 ± 0.00	0.00 ± 0.00
C24:0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C24:1c	0.10 ± 0.04	0.15 ± 0.04	0.19 ± 0.04	0.15 ± 0.02	0.14 ± 0.02	0.14 ± 0.01	0.17 ± 0.01	0.14 ± 0.01
Trans-FA	0.56 ± 0.21	0.23 ± 0.13	0.73 ± 0.68	0.22 ± 0.03	0.27 ± 0.09	0.58 ± 0.43	0.17 ± 0.04	0.84 ± 0.44
Cis-FA	63.34 ± 5.01	73.70 ± 7.71	87.60 ± 0.68	68.05 ± 2.12	70.15 ± 1.62	72.97 ± 4.74	76.02 ± 0.24	69.07 ± 1.64
TFA/Cis-FA	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.01 ± 0.01
PUFA	27.36 ± 8.32	47.79 ± 8.88	54.24 ± 17.10	34.76 ± 4.40	39.75 ± 2.69	44.98 ± 10.17	47.48 ± 0.57	39.56 ± 3.89
UFA	63.89 ± 5.05	73.93 ± 7.81	88.33 ± 0.96	68.27 ± 2.15	70.43 ± 1.70	73.55 ± 4.31	76.19 ± 0.27	69.91 ± 1.20
SFA	36.12 ± 5.05	26.08 ± 7.81	11.69 ± 0.94	30.39 ± 3.73	29.58 ± 1.72	26.38 ± 4.31	23.82 ± 0.25	30.08 ± 1.21
PUFA/SFA	0.80 ± 0.35	2.30 ± 1.74	4.59 ± 1.30	1.14 ± 0.01	1.34 ± 0.01	1.79 ± 0.69	1.99 ± 0.02	1.32 ± 0.18

not approved. Also United Kingdom department of health recommends a minimal PUFA/SFA ratio value of 0.45 for frying oil; therefore all of liquid frying oils were in the range of UK standard [10,19].

The amount of total TFA in the liquid frying oils ranged from 0.17% in G to 0.84% in H. The higher amount of trans FA observed in these samples was elaidic acid (C18:2 trans 12) at maximum of 0.78 in D group. Trans-FA/Cis-FA ratio in liquid frying oil was very low level (0.01). Therefore, in this study, we found that the percentage of total trans fatty acid in branded liquid frying oils was very low.

3.2. Solid Oils

The FA compositions of four brands of solid oils in Iran are presented in **Table 2**. The amount of SFA ranged from 30.25% in A to 34.46% in D group. Among the SFA, palmitic acid presented the highest value ranging from 20.95% in A to 26.32% in D. UFA ranged from 65.77% in D to 69.81% in A. Therefore, high linolenic content was found in group D (3.02%) due to more oxidation tendency. According to the acceptable range of linolenic in Iran standard reference, which is less than five percentage (standard), all of the groups were in the range of Iran standard.

Table 2. The FA compositions of four brands of solid oils in Iran (%).

Fatty Acid	Brand			
	A	B	C	D
C6:0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C8:0	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
C10:0	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
C12:0	0.07 ± 0.01	0.08 ± 0.02	0.08 ± 0.01	0.09 ± 0.00
C14:0	0.38 ± 0.03	0.47 ± 0.04	0.46 ± 0.03	0.52 ± 0.01
C14:1c	0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C15:0	0.01 ± 0.01	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00
C15:1c	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C16:0	20.95 ± 0.85	24.80 ± 2.87	23.53 ± 1.26	26.32 ± 0.36
C16:1c	0.1 ± 0.01	0.09 ± 0.02	0.1 ± 0.01	0.09 ± 0.01
C17:0	0.01 ± 0.00	0.09 ± 0.01	0.09 ± 0.01	0.09 ± 0.01
C17:1c	0.04 ± 0.00	0.04 ± 0.01	0.04 ± 0.00	0.04 ± 0.01
C18:0	7.88 ± 1.35	6.47 ± 1.40	6.31 ± 0.78	6.91 ± 0.63
C18:1t	0.82 ± 0.5	0.73 ± 0.64	1.52 ± 1.06	1.98 ± 2.17
C18:1c	26.24 ± 2.27	25.15 ± 3.98	27.34 ± 1.72	24.56 ± 3.88
C18:2t	0.04 ± 0.01	0.04 ± 0.08	0.04 ± 0.02	0.02 ± 0.02
C18:2t	0.61 ± 0.2	0.36 ± 0.46	0.53 ± 0.31	0.26 ± 0.19
C18:2t	0.44 ± 0.23	0.27 ± 0.39	0.40 ± 0.26	0.20 ± 0.16
C18:2c	36.73 ± 3.36	37.02 ± 3.15	35.27 ± 3.27	34.33 ± 5.92
C18:3t	0.75 ± 0.04	0.25 ± 0.13	0.33 ± 0.15	0.30 ± 0.01
C18:3t	0.81 ± 0.05	0.28 ± 0.15	0.37 ± 0.18	0.33 ± 0.02
C18:3c	2.73 ± 0.81	2.86 ± 1.11	2.44 ± 0.71	3.02 ± 1.07
C20:0	0.64 ± 0.17	0.36 ± 0.09	0.43 ± 0.09	0.35 ± 0.11
C20:2c	0.01 ± 0.00	0.01 ± 0.01	0.01 ± 0.01	0.00 ± 0.01
C20:3c	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C20:3c	0.30 ± 0.03	0.33 ± 0.14	0.36 ± 0.08	0.26 ± 0.08
C20:4c	0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C20:5c	0.00 ± 0.00	0.00 ± 0.01	0.00 ± 0.00	0.00 ± 0.00
C21:0	0.16 ± 0.02	0.12 ± 0.04	0.14 ± 0.02	0.11 ± 0.03
C22:0	0.02 ± 0.01	0.02 ± 0.01	0.02 ± 0.01	0.02 ± 0.01
C22:1c	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C22:2c	0.03 ± 0.00	0.02 ± 0.01	0.04 ± 0.05	0.03 ± 0.00
C22:6c	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C23:0	0.01 ± 0.01	0.00 ± 0.00	0.01 ± 0.04	0.00 ± 0.00
C24:0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C24:1c	0.12 ± 0.01	0.11 ± 0.04	0.14 ± 0.02	0.12 ± 0.02
Trans-FA	3.48 ± 0.85	1.93 ± 1.57	3.19 ± 1.76	3.08 ± 2.58
Cis-FA	66.34 ± 2.43	65.63 ± 3.94	65.73 ± 2.45	62.68 ± 3.00
Trans-FA/Cis-FA	0.05 ± 0.01	0.03 ± 0.01	0.05 ± 0.03	0.05 ± 0.04
PUFA	42.48 ± 3.97	42.16 ± 3.10	39.79 ± 2.49	38.75 ± 6.50
UFA	69.81 ± 2.03	67.55 ± 3.95	68.92 ± 1.74	65.77 ± 0.44
SFA	30.25 ± 2.13	32.45 ± 3.95	31.12 ± 1.67	34.46 ± 0.45
PUFA/SFA	1.42 ± 0.21	1.32 ± 0.21	1.28 ± 0.12	1.13 ± 0.20

TFA in the solid oils ranged from 1.93% in B to 3.48% in A. The higher amount of trans FA observed in these samples was eleidic acid (C18:1 trans) at mean of 1.98% in D and maximum of 3.93% in D. Trans-FA/Cis-FA ratio in solid oils. Oil was 0.05 in three brands and 0.03 in B. In fact partial hydrogenated oils had more content of total TFA/total Cis. **Figure 1** shows the chromatogram of fatty acids found in one randomly selected solid oil sample by gas chromatography.

In particular, the three trans-geometrical isomers of C18:2 (C18:2 trans 9,12, C18:2 trans 12, C18:2 trans 9) and two trans-geometrical isomers of C18:3 (C18:3 trans 12, C18:3 trans 9) were present in studied samples. As expected Group A had higher content of trans PUFA. The average and also range of each fatty acid are illustrated in **Table 3**.

In Iranian households the TFA content of HVOs is 23% - 36%, with average per-person intake of 14 g per 1000 kcal [11] while in Western Europe the TFA intake contributes between 0.5% and 2.1% and 2% of energy intake in the US [20].

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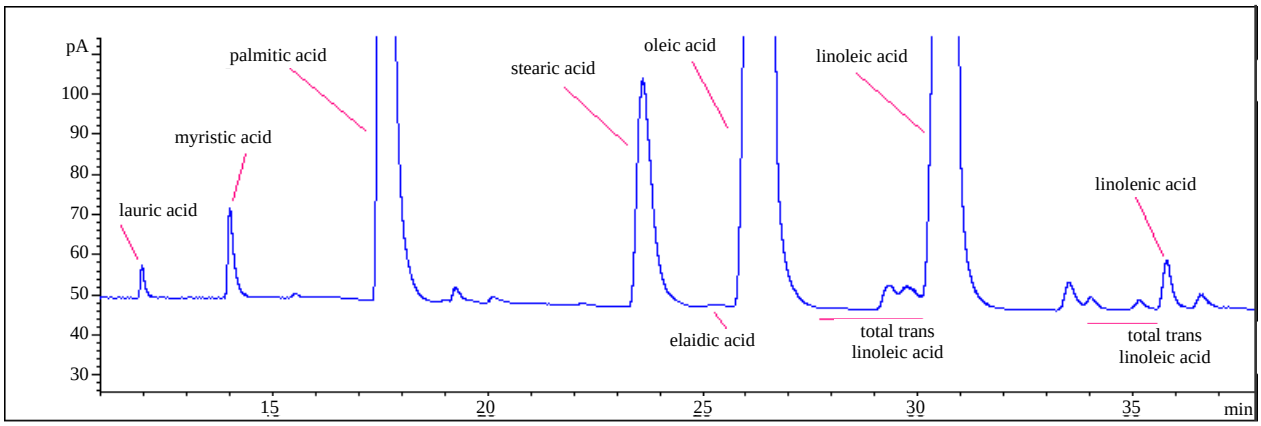

Figure 1. Chromatogram of fatty acids found in one randomly selected solid oil sample by gas chromatography.

Table 3. Comparison between fatty acid of studied liquid and solid oil (%).

Fatty acid	Liquid oil		Solid oil	
	Range	Mean	Range	Mean
C6:0	0.00 - 0.00	0.00	0.00 - 0.00	0.00
C8:0	0.00 - 0.02	0.01	0.01 - 0.02	0.01
C10:0	0.00 - 0.02	0.01	0.00 - 0.01	0.01
C12:0	0.00 - 0.28	0.10	0.01 - 0.10	0.08
C14:0	0.07 - 1.03	0.46	0.35 - 0.55	0.46
C14:1c	0.00 - 0.00	0.00	0.00 - 0.03	0.00
C15:0	0.01 - 0.05	0.03[*1]	0.00 - 0.28	0.02[*]
C15:1c	0.00 - 0.00	0.00	0.00 - 0.00	0.00
C16:0	5.40 - 37.34	21.31	20.22 - 30.31	23.90
C16:1c	0.05 - 0.19	0.11	0.06 - 0.11	0.09
C17:0	0.03 - 0.17	0.06[*]	0.06 - 0.11	0.09[*]
C17:1c	0.02 - 0.07	0.03	0.02 - 0.05	0.04
C18:0	2.44 - 4.70	4.18	4.71 - 9.42	6.89
C18:1t	0.02 - 0.40	0.08	0.03 - 3.93	1.26
C18:1c	20.83 - 56.18	30.87	17.69 - 29.54	25.82
C18:2t	0.00 - 0.04	0.01	0.00 - 0.22	0.03

Continued

C18:2t	0.00 - 0.78	0.14	0.07 - 1.41	0.44
C18:2t	0.00 - 0.73	0.11	0.03 - 1.17	0.33
C18:2c	13.97 - 66.09	39.37	29.15 - 41.37	35.84
C18:3t	0.01 - 0.62	0.13	0.02 - 0.80	0.41
C18:3t	0.01 - 0.64	0.14	0.02 - 0.90	0.45
C18:3c	0.19 - 8.4	1.69*	0.44 - 3.99	2.76*
C20:0	0.15 - 0.68	0.31*	0.23 - 0.98	0.45*
C20:2c	0.01 - 0.02	0.00	0.00 - 0.02	0.01
C20:3c	0.00 - 0.00	0.00*	0.00 - 0.00	0.00*
C20:3c	0.06 - 0.73	0.33	0.16 - 0.62	0.00
C20:4c	0.00 - 0.00	0.00	0.00 - 0.02	0.01
C20:5c	0.00 - 0.02	0.00	0.00 - 0.03	0.00
C21:0	0.08 - 1.54	0.23	0.05 - 0.20	0.01
C22:0	0.00 - 0.12	0.02*	0.00 - 0.04	0.31*
C22:1c	0.00 - 0.00	0.00	0.00 - 0.00	0.00
C22:2c	0.00 - 0.05	0.02*	0.00 - 0.00	0.00*
C22:6c	0.00 - 0.43	0.04	0.00 - 0.00	0.00
C23:0	0.00 - 0.41	0.04	0.00 - 0.16	0.03
C24:0	0.00 - 0.00	0.00	0.00 - 0.00	0.00
C24:1c	0.03 - 0.24	0.15	0.03 - 0.18	0.12
Trans-FA	0.11 - 1.61	0.45	0.46 - 5.40	2.92
Cis-FA	56.31 - 88.30	72.61	58.79 - 71.83	65.09
Trans-FA/Cis-FA	0.00 - 0.02	0.01	0.01 - 0.09	0.05
PUFA	14.90 - 67.31	41.99	33.08 - 46.04	40.80
UFA	56.70 - 89.31	73.06	60.33 - 71.83	68.01
SFA	10.71 - 43.30	26.77*	28.17 - 39.67	32.07*
PUFA/SFA	0.34 - 5.85	1.91	0.95 - 1.60	1.29

[1*]Values are significantly different (*t-test*, $p < 0.05$).

dard suggested that the total amount of TFAs in edible oils must not be more than 10 percent. But more TFA restrictions of edible oils were approved in other countries such as Denmark which set a requirement of less than 2 percent TFAs of the total fats [21].

According to Iranian TFA standard all the analyzed samples in this study were acceptable but regarding to Denmark standard, A, C and D were rejected. Publicity about adverse effects of TFA on blood lipoproteins decreased household's usages of the TFA significantly in Netherland [22] but trans fat content of partially HVOs used for cooking and preparing commercially fried, processed, bakery and street foods was reported to be almost 40% in India [23].

The statistical analysis between the liquid frying oil and the solid oil was shown in **Table 3** (t-test, p-value < 0.05). Despite low level of TFA in studied samples, high amounts of cholesterol-raising FAs are consumed daily by people since oils are the most commonly used in Iranian food. As a result, partial hydrogenated oils should be eliminated from the food supply, or their intake must be reduced as much as possible, substantial improvement of these products must be done and the people should be warned about the adverse health effects of TFA.

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