INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 4, No. 1, p. 238-243, 2014

RESEARCH PAPER OPEN ACCESS

Effect of conventional heat treatment on fatty acid profile of different edible oils using gas chromatography

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Key words: Vegetable oils, fatty acid analysis, *Trans*-fat, gas chromatography.

doi: http://dx.doi.org/10.12692/ijb/4.1.238-243 Article published on January 05, 2014

Abstract

The adverse effect of excess intake of *trans*-fatty acids on human health, mainly on cardiovascular system is a growing concern worldwide. Edible oils, which are a part of human diet have shown significant changes in the quantity of *trans*-fat while giving the heat treatment (cooking or multiple cooking). During the process of cooking, oxidation degrades the organoleptic quality of oils and reduces their nutritional value. Therefore, the objective of this study was to evaluate any change that occurs on fatty acid composition, while giving heat treatment to the edible oils. Soybean, Olive, Almond and Rice bran oils were investigated in this study by giving heat treatment up to their respective boiling points for 0, 15, 30 and 60 minutes respectively. The results showed that among all oils tested, Rice bran, Olive and Almond oil showed an increase in *trans*-fat (2.05, 1.13 and 1.11%), while Soybean oil showed no changes in *trans* fat content for heat treatment of 60 minutes respectively.

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Introduction

"Vegetable oil" is the term given to any oil from a plant source such as soybean oil, olive oil etc (Gunstone *et al.,* 2004). In recent years, there has been an increased focus on the role of specific dietary fatty acids and their effect on human health and disease. There have been tremendous changes in US food supply with respect to fats and oils and significant efforts have been made in recent years by food manufacturers, food service establishments, the oil seed industry and oil processors to reduce or remove partially hydrogenated fats and oils (Ahuja *et al.,* 2009). Fatty acids constitute the main class of lipids in the human diet, being found in nature mainly as glycerol esters that originate tri-acylglycerols (Martin *et al.,*2007). In order to assess the intake of *trans*-fatty acids from edible oil, the *trans*-fatty acids induced during cooking should be considered. Recent studies have suggested that a significant amount of *trans* fatty acids are produced during cooking and frying processes, and that acids accumulates considerably only when these oils are subjected to severe conditions of heating (Tsuzuki W., 2012). The formation of *trans*-fatty acids during food frying is closely related to the process temperature and oil use time, when partially hydrogenated fats are used, the formation of *trans* fatty acids are generally lower. There are several studies which showed a significant increase of *trans*- fats in different edible oils (rice bran, safflower, sesame, palmolein and canola) during heating (Bansal G *et al.,* 2009 & Alireza S *et al.,* 2010). Additionally, analysis and formation of *trans* fatty acids in hydrogenated soybean oil by heating has been previously reported (Liu WH *et al.,* 2007). Fatty acids with one or more unsaturations in the *trans* configuration are called *trans* fatty acids (Martin *et al.*, 2007). *Trans* fatty acid molecules stay straight at the double bond and thus behave biologically like saturated rather than unsaturated fatty acids, there is evidence that *trans* fatty acids increase low density lipo-protein (bad cholesterol) and decrease high density lipo-protein "good cholesterol" (Stender & Dyerrberg *et al.*, 2003). There is an ample epidemiological evidence and case control studies, which have revealed that an extra intake of *trans* fatty acids is associated with the risk of coronary heart disease (Khor *et al.*, 2008 & Mozaffarain *et al.*, 2009). The quantitative determination of the major and minor constituents of vegetable oils is done by gas chromatography (GC) and high performance liquid chromatography (HPLC) (Aluyor *et al.,* 2009). GC is more convenient and precise method of analysis for fatty acid methyl esters than HPLC (Kowalski *et al.*, 2007).

Thus it is important to consider the heating and repeated use of edible oils while cooking the food for longer duration. Based up on the available data on the change in *trans* fat value of edible oils during heat treatment, it becomes mandatory to study more and more of these edible oils. Therefore, the aim of this study was to investigate and evaluate the effect of conventional heating on fatty acid composition of edible oils (soybean oil, olive oil, almond oil and rice bran oil) by using Gas Chromatography Flame Ionization detector (GC-FID).

Material and method

Preparation of test oils

Commercially available soybean oil, olive oil, almond oil and rice bran oil were procured from the local market of New Delhi (INDIA). Heating of oils was done over gas stove to their respective boiling point for different time periods (0, 15, 30, 60 minutes) and the changes occur in fatty acid profile were quantified by Gas Chromatography FID.

Gas chromatography analysis

Chromatography was performed with Agilent 6890N series gas chromatograph equipped with flame ionization detector and fused silica capillary column PB×70, 50m×0.22mm×0.25µm film thickness, 70% cyano-propyl-polysilphenylene-siloxane.

Split injection ratio (1:50) was performed, with carrier gas flow rate 1ml min^{-1} and detector temperature 250°C, injector temperature 250°C. Chemstation were used for quantification of fatty acid composition. Fatty acid composition was determined by preparing the methyl esters of the fatty acids and

then extracting with petroleum ether. Detailed fatty acid composition of the samples was determined by injecting the extracted methyl esters in gas chromatograph using flame ionization detector.

Preparation of Fatty acid methyl ester (FAME)

0.1 gm of oil sample and FAME mix standard (having 37 compounds traceable from Fluka) were taken in screw-capped test tube. 0.2 ml of 2N KOH in methanol was added. Kept in water bath at 50°C for 10 minute with occasional shaking. Tubes were cooled in fridge for 10 minutes. To the cooled samples, 1ml 5% HCl in methanol were added. The samples were kept again at 70°C for 10 minutes with occasional shaking. 2ml petroleum ether was added to the cooled samples and shaken vigorously for the extension of FAME. Sodium sulphate was added to avoid moisture gain. Ether layer was collected and filled into the vials for further analysis of fatty acid composition through GC- FID.

Result and discussion

The results of this study indicate that long term heat treatment had an adverse effect on the quantitative fatty acid composition of the tested edible oils. This has direct implication on the use of cooking oil. The results of fatty acid compositions of untreated as well as thermally treated samples (different edible oils) are presented in Table 1 and 2.

Table 1. Effect of conventional heating on fatty acid composition.

Fatty acid composition (%)	Time (Minutes)			
	0	15	30	60
		Soybean oil		
SFA	16.05	15.51	17.59	17.17
Palmitic acid	12.18	12.02	13.09	13.31
Stearic acid	3.46	3.29	3.67	3.86
MUFA	27.04	27.36	30.91	31.32
Palmitoleic acid	0.14	ND	ND	ND
Oleic Acid	27.2	26.7	29.48	31.32
PUFA	56.61	56.69	51.48	51.5
Linoleic	50.74	51.21	47.74	48.06
α-linolenic	3.71	3.43	2.12	1.8
γ- linolenic	2.26	1.95	1.62	1.64
ω-3 and ω-6 fatty acid				
ω-3	3.71	3.43	2.12	1.8
ω-6	53	53.16	49.36	49.7
Trans fat	ND	ND	ND	ND
		Olive oil		
SFA	13.42	15.43	15.53	15.81
Palmitic acid	11.45	12.03	12.71	13.33
Stearic acid	1.97	3.12	2.7	2.83
MUFA	78.96	77.31	77.18	77.36
Palmitoleic acid	1	1.06	1.06	1.03
Oleic Acid	76.77	75.8	75.88	75.23
Eicosanoic acid	0.23	0.28	0.24	0.3
PUFA	7.61	7.18	6.54	5.93
	4.74	5.48	4.52	4.42
α-linolenic	0.9	0.85	0.71	0.68
γ- linolenic	1.97	0.53	0.59	ND
ω-3 and ω-6 fatty acid				
ω-3	0.9	0.85	0.71	0.68
ω-6	6.71	6.01	5.11	4.42
Trans fat (Eladic acid)	ND	ND	0.76	1.13

Soybean oil- Our results showed that untreated sample of soybean oil contains more than 16% of saturated fat and retains its saturated fat content even after 15, 30 and 60 minutes of heat treatment respectively. However, there was a slight increase in palmitic and stearic acid content after giving 30 and 60 minutes treatment as, 13.09, 13.31 and 3.67, 3.86 respectively. Saturated fat is having more impact on

raising blood cholesterol than any other fatty acid. The most effective way to reduce the blood cholesterol level is to reduce the amount of saturated fat in the diet. As noted, the major saturated fatty acids (SFA) in soybean oil are palmitate, which constitutes about 70% of the total SFA. (De Man *et al.,*1992). Mono-unsaturated fatty acids (MUFA) in soybean oil showed an increased trend while heating with an increase in time period. Palmitoleic and oleic acid found in untreated soybean oil sample were 0.14 and 27%, while palmitoleic acid detected only in untreated sample. Increment in oleic acid content was observed 26.70, 29.48 and 31.32% with the increase in time periods 15, 30 and 60 minutes respectively. A diet high in MUFA may help to reduce elevated levels of total plasma cholesterol without reducing the high density lipo-protein level (Grundy *et al.,* 1988). Poly-unsaturated fatty acids (PUFA) in soybean oil decreases with increase in heating time period. Studies have shown that the oxidation rate of MUFA is much slower than that of the PUFA, which oxidize quickly and are the major contributors to the poor stability of soybean oil. (White *et al.,* 2000 & Fatemi *et al.,* 1980).

Table 2. Effect of conventional heating on fatty acid composition.

Fatty acid composition (%)	Time (Minutes)			
	0	15	30	60
		Almond oil		
SFA	7.42	7.48	7.52	7.79
Palmitic acid	6.07	6.17	6.3	6.42
Stearic acid	1.33	1.25	1.22	1.34
MUFA	75.54	76.6	77.81	77.96
Palmitoleic acid	0.66	0.67	0.47	0.52
Oleic Acid	75.45	75.79	77.1	77.2
Eicosanoic acid	0.09	0.14	0.24	0.25
PUFA	16.3	15.41	13.58	13.05
Linoleic	14.4	12.87	10.78	10.04
α-linolenic	0.09	0.09	0.08	0.67
γ- linolenic	1.81	2.45	2.72	2.33
ω-3 and ω-6 fatty acid				
ω-3	0.09	0.09	0.09	0.06
ω-6	16.21	15.32	13.5	13.72
Trans fat (Eladic acid)	ND	0.38	1.09	1.11
		Rice bran oil		
SFA	18.39	19.7	19.74	21.22
Palmitic acid	16.36	17.06	17.06	18.17
Stearic acid	1.25	1.62	1.69	1.98
MUFA	45.6	44.87	45.41	47.57
Palmitoleic acid	0.44	0.29	0.33	0.28
Oleic acid	45.16	43.96	43.89	45.62
Eicosanoic acid	ND	0.62	0.77	1.25
PUFA	36	34.71	34.3	28.6
Linoleic	36	33.73	33.18	27.73
α-linolenic	ND	0.98	1.12	0.87
γ- linolenic	ND	ND	ND	ND
ω-3 and ω-6 fatty acid				
ω-3	0.63	0.98	1.12	0.87
ω-6	36	33.73	33.18	27.73
Trans fat	ND	0.45	0.53	2.05
Linolelaidic acid	ND	ND	ND	1.03
Eladic acid	ND	0.45	0.53	1.02

Olive oil- Contrary to the majority of the other edible oils, olive oil can be consumed in crude form conserving all beneficial properties like vitamins, phenols, sterols and other important natural compounds (Ricardo *et al.,* 2009). Our results reveal that the olive oil tested contained large amounts of unsaturated fatty acids mainly MUFA, almost (79%). SFA increases with the increase in heating time period in olive oil, while palmitic acid is the major part of SFA and stearic acid being the minor. In olive oil the MUFA was found to be most abundant comprising about 78% **(**oleic, Palmitoleic, and ecosanoic acid). After the heat treatment the amount of MUFA did not show any significant change (Table-1). However, the amount of PUFA decreases (7.61, 7.18, 6.54 and 5.93%) with an increase in heating time (0, 15, 30 and 60 minutes) respectively. It was observed that *trans*-fat (Elaidic acid) were not detected in untreated sample and initially treated (15 minutes) sample. However with the increase in time duration of heating 30 and 60 minutes 0.76 and 1.13% *trans* fat was detected. This suggests that olive oil may not be suitable for long duration of cooking or frying.

Almond Oil- The results of almond oil revealed an increase in saturated fatty acid content (palmitic and stearic acid) with increase in heating time period. MUFA was found to be 75% in untreated samples and showed a progressive increase during an increase in the heating time period. Additionally, the *trans* fats were not detected in untreated samples while with the increase in heating time period 15, 30 and 60 minutes there was an increase in *trans* fat content 0.38, 1.09 and 1.11% respectively, which shows that with longer periods of heating, there may be an increase in the *trans* fat content.

Rice bran oil- showed an increase in SFA with the increase in heating time period. Both palmitic and stearic acid showed an increased trend during heat treatment. MUFA was found to be more than 45% in the fresh sample and did not show any change while heat treatment and was found to be more than 47% in 30 minutes heating. Palmitoleic and oleic acid retained in the samples while, ecosanoic acid was not detected in fresh sample and followed increased trend with heating period. Additionally, PUFA was found to be 36% in untreated sample, which showed a decrease with an increase in heating time period. *Trans*-fat was not detected in fresh sample but randomly increased with heating duration (table 2).

Conclusion

The conclusion of the present study is based on following observations: since, the present investigation was aimed to study the changes in major component of fatty acids (SFA, MUFA, PUFA and *Trans*-fat) of soybean, almond, olive and rice bran oil during different heat treatment periods. Study of fatty acid profile of fresh oil samples of soybean, almond, olive and rice bran oil revealed that soybean oil was found to be better among the four oils, having highest PUFA content which demonstrates its wide range of health related benefits. The study also revealed soybean oil as best edible oil in which MUFA and PUFA increased with heat treatment with no detection of *trans*-fat while, the almond, olive and rice bran oil showed an increase in trans fat while different heat treatment period.

References

Ahuja JKC, Linda L, Joseph DG, Alanna JM. 2009. The impact of revising fats and oils data in US Food and Nutrient database for Dietary Studies. Journal of Food Composition and Analysis, **22S,** S63-S67. doi:10.1016/j.jfca.2009.02.005

Alireza S, Tan CP, Hamed M, Che Man YB. 2010. Effect of frying process on fatty acid composition and iodine value of selected vegetables oils and their blends. International Food Research Journal **17,** 295-302

Aluyor EO, Ozigagu CE, Oboh OI, Aluyor P. 2009. Chromatographic analysis of vegetable oils. R Scientific Research and Essay **4 (4),** 191-197.

Bansal G, Zhou W, Tan TW, Neo FL, Lo HL. 2009. Analysis of trans fatty acids in deep frying oils

by three different approaches. Food Chemistry **116(2),** 535-541. doi:10.1016/j.foodchem.2009.02.083

DeMan JM, Chow CK. 1992. Fatty Acids in Foods and Their Health Implications, . 17–46.

Fatemi SH, Hammond EG. 1980. Lipids. **15,** 379–385.

Grundy SM, Florentin L, Nix D, Whelan MF. 1988. American Journal of Clinical Nutrition **47**, 965–969.

Gunstone FD. 2004. The Chemistry of Oils and Fats; Sources, Composition, Properties and Use **23-24,**107-112.

Khor GL, Mohd EN. 2008. Trans fatty acids intake: Epidemiology and health implications. 25–45.

Kowalski R. 2007. Gas Chromatography analysis of changes in the fatty acid composition of sunflower and olive oils heated with quercetin, caffeic acid, protocatechuic acid, and butylatedhydroxyanisole. Acta Chromatography, No. **18**. 15-23.

Liu WH, Inbaraj BS, Chen BH. 2007. Analysis and formation of trans fatty acids in hydrogenated soybean oil during heating. Food Chemistry **104,** 1740-1749. doi:10.1016/j.foodchem.2006.10.069

Martin CA, Maria CM, Jesui VV, Makoto M, Nilson ED. 2007. Trans fatty acids-forming processes in foods. Annals of the Brazilian Academy of Sciences, **79 (2)**, 343-350.

Mozaffarian D, Aro A, Willett WC. 2009. Health effects of trans-fatty acids: experimental and observational evidence. European Journal Of Clinical Nutrition**63**, S5-S21. doi:10.1038/sj.ejcn.1602973

Ricardo M, Ivo O, Miguel VB, Soraia F, Albino B, Jose AP. 2009. Effect of microwave heating with different exposure times on physical and chemical parameters of olive oil. Food and Chemical Toxicology **47,** 92–97. doi: 10.1016/j.fct.2008.10.014

Stender S, Dyerrberg J. 2003. The influence of trans fatty acids on health. Danish Nutrition Council **34(4)** .

Tsuzuki W. 2012. Study of formation of trans-fatty acids in model oils (triglycerols) and edible oils during heating process. Japan Agricultural Research Quarterly **46(3)**, 215-220.

White PJ, O'Brien RD, Farr WE, Wan PJ, eds. 2000. Fats and Oils Technology. American Oil Chemists Society **2,** 341–353.