CHARACTERIZATION OF MID-OLEIC SUNFLOWER OIL PRODUCED BY BLENDING TWO DIFFERENT TYPES OF SUNFLOWER OIL

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(Manuscript received 2 December 2010)

Abstract

This research aims to produce mid-oleic sunflower oil (MOSO) and improve oil oxidative stability by blending technology. High oleic sunflower oil (HOSO) was blended with traditional sunflower oil (TSO) at different ratios: B1 [HOSO 30: TSO 70)], B2 [HOSO 50: TSO 50] and B3 [HOSO 70: TSO 30]. The increase of oleic acid content in the oil blands lead to improve their oxidative stability. The stability of TSO was 7.88 h and increased by increasing HOSO percent in the blends to reach, 11.32 h (B1), 12.60 h (B2) and 13.89 h (B3). Oil blends B2 and B3 were nearly the same as mid-oleic sunflower produced by breeding technology. HOSO was characterized by the highest content of nature antioxidant, i.e., total tocopherol, total polyphenols and unsaponifabile matter whilst the lowest content of these substances were presented in (TSO).

Keywords: High-oleic sunflower oil, traditional sunflower oil (mid-oleic sunflower oil, oil blends, oxidative stability, fatty acid composition, tocopherols.

INTRODUCTION

Technology is now available to alter the fatty acid composition of oil seeds by genetic modification or traditional breeding. Lowering the linolenic acid content in canola and soybean oils has been the objective of plant breeders to improve the flavor quality and oxidative stability of these oils. Safflower and sunflower oils have also been modified to improve their oxidative stability by increasing oleic acid levels to 70-90% (Warner *et. al.* 1997).

Blending technology was used by many authers to improve oxidative stability (Frankel and Huang, 1994; Kleingarther and Warner 2001). Consequently the sunflower oil quality is assessed by determining the saturated and unsaturated fatty acid ratio (Joita *et. al.* 2005).

The fatty acid composition of traditional sunflower oil, Nusun [mid- oleic sunflower] and high-oleic sunflower oil according to the codex Alimentarius (2001) are as follows : oleic acid ranging from 14.0 to 39.4%, 43.1 to 71.8% and 75.0 to 90.7%, linoleic acid from 48.3 to 74.0%, 18.7 to 45.3% and 2.1 to 17.0%, palmitic acid from 2.0 to 7.6%, 4.0 to 5.5% and 2.6 to 5.0 % and stearic acid from 1.0 to 6.5%, 2.1 to 5.0% and 2.9 to 6.2%, respectively.

Expeller mid- oleic sunflower oil provides a better flavor intensity and quality in fried food products compared to high- oleic sunflower oil, due to its higher linoleic acid (C18: 2) content. Mid-oleic sunflower oil has been shown to give higher flavor intensity and quality to fried foods (Warner *et. al.,* 1997).

Mid-oleic sunflower oil is distinguished by containing high level of healthy monounsaturated fats and free from trans fatty acid due to non-hydrogenated technique. Non genetically modified sunflower oil naturally contains high level of antioxidants and tocopherols (vitamin E) (Kiatsrichart *et. al.,* 2003). This oil genotype significantly reduce the amount of [Low-density Lipoprotein Cholesterol] LDLC compared to traditional sunflower oils, therefore helping to reduce the risk of coronary heart disease (Gupta, 2007).

Oils and fats intended for commercial frying applications must be stabilized to prevent deterioration caused by oxidation, polymerization, and hydrolysis at high-temperature. Modifying the fatty acid composition of the oil, the most common method to stabilize frying oils can be conducted by several methods. For example, blending polyunsaturated oils with more saturated or monounsaturated oils is an option to adjust fatty acid to optimal levels, such as combining high-oleic sunflower oil with corn oil or completely hydrogenated soybean oil with soybean oil (Warner and Knowlton, 1997).

The objective of this research was to prepare mid-oleic sunflower oil by blending technology and to investigate the effect of oleic and linoleic acid composition of traditional sunflower oil, high oleic sunflower oil and their blends on oxidative stability phenomenon.

MATERIALS AND METHODS

Materials

Traditional sunflower oil: [TSO]

Sunflower oil was obtained from Misr Gulf oil processing Company (MiGOPC) Atakah, Suez Governorate.

High-oleic sunflower oil : [HOSO]

High-oleic sunflower oil was obtained from Egyptian General Organization for Export and Import Control.

Oil blends:

Traditional sunflower oil (TSO) and high oleic sunflower oil were blended at different percentages:

Blend 1 = 70% TSO+ 30% HOSO

Blend 2 = 50% TSO + 50% HOSO

Blend 3 = 30% TSO + 70% HOSO

Solvents: All solvents in this study were of analytical grade (Merck).

Analytical Methods :

Physical and chemical characteristics:

- Refractive index : of the oils was determined at 25°C according to A.O.A.C. (2000) by using refrectometer [NYRL -3 Poland].
- Acid, peroxide, iodine and saponification values and unsaponifiable matter (%) were determined according to the methods described in A.O.A.C (2000).
- **Absorbancy in ultraviolet**

The ultraviolet (UV) absorption of 1% solution of the oil in cyclohexane was measured according to FAO/ WHO (1970) at 232 and 270 nm- using Shemadzu sepectrophotometer uv.vis (20-02).

- Fatty acid composition

The fatty acids of the oil samples were determined by GC instrument equipped with DB-23 capillary column (60m x 0.32mm x 0.25um film thickned according to the method mentioned by IOOC, (2001).

- **Total tocopherols and polyphenols:**

The total tocopherols and polyphenols of oils were determined according to the methods of Wong *et. al.,* (1988) and Gutfinger, (1981), respectively.

- Stability

The oxidative stability of oils was estimated by Rancimat apparatus (Metrohn Herisou, Co., Switzerland) at 100°C with an air flow rate of 20L/hr. according to the method described by Mendez *et. al.* (1997).

Color:

A lovibond tintometer was used to measure the color using 5.25 inch cell according to the method of the A.O.A.C, (2000).

RESULTS AND DISCUSSION

Physical and chemical properties of oils :

Physical and chemical properties of traditional sunflower oil (TSO), high-oleic sunflower oil (HOSO), B1, B2 and B3 oil blends were carried out and the results are given in Table (1). From these results it is clear that there were a little changes in refractive index, color, absorbances at 232 and 270nm, acid value, peroxide value and saponification value. The highest iodine value was observed in TSO (137.5), followed by B1 (125.90), B2 (117.04) B3 (110.62) and HOSO (90.13). This finding was due to the high amount of polyunsaturated fatty acid in TSO than in HOSO. Thus the more concentration of TSO, the higher iodine value in the blend. These results are in agreement with those reported by Warner *et. al.* (1997), Gupta (1998) and Kiatsrichart *et. al.* (2003).

Table 1. Physical and chemical characteristics of traditional sunflower oil (TSO), high - oleic sunflower oil (HOSO) and their oil blends.

Property	TSO (a)	HOSO (b)	Oil blends		
			B1 70a+30b	B2 50a+50b	B3 30a+70b
Refractive index at 25°C	1.4690	1.4674	1.4685	1.4682	1.4679
Color Yellow Red	10 0.8	7.2 0.5	9.1 0.7	8.5 0.6	8.3 0.6
Acid value (mg KOH/g oil)	0.104	0.086	0.090	0.088	0.083
Peroxide value (meq/kg oil)	3.60	2.25	3.34	3.57	2.85
Iodine value (g I_2/ 100g oil)	137.5	90.13	125.90	117.04	110.62
UV-aabsorbance at 232 nm	0.446	0.351	0.414	0.382	0.365
UV-absorbance at 270 nm	0.190	0.152	0.185	0.163	0.155
Saponification value [mg KOH/ g oil]	189.2	192.0	189.5	190.2	191.4

(a) Traditional sunflower oil.

(b) High oleic-sunflower oil.

Fatty acid composition of oils :

The fatty acid compositions of TSO, HOSO, B1, B2 and B3 are presented in Table (2) and Fig (2) The results indicate that HOSO was rich in oleic acid 75.42% followed by oil blends B3, B2, B1 and TSO (58.66, 49.63, 38.64 and 23.72% respectively). On the other hand, the major polyunsaturated fatty acid, linoleic acid (18: 2) was observed at the highest concentration in TSO (64.34%) followed by oil blends B_1 (50.45), B_2 (40.03), B_3 (32.46) and HOSO (14.96%). These results are in agreement with those reported by Codex Standard (2001) and Frank (2005).

From these results it was clear that oleic acid and linoleic acid contents were changed by blending. Oleic acid levels ranged from 38.64 to 58.66 and linoleic acid from 32.46 to 50.45% in the studied oils and their blends. The fatty acid pattern gave the way to study the effect of these changes on the oxidative stability and at the same time distinguish the oil blend which is more suitable to be mid-oleic sunflower oil (MOSO).

According to the fatty acid composition ranges of TSO, mid-oleic sunflower oil and HOSO from Codex Standard (2001) for vegetable oils, the oleic acid and lenoleic acid contents of mid-oleic acid sunflower oil were from 43.1 to 71.8% and 18.7 to 45.3%, respectively. From the data in Table (2) and Fig (1) it is clear that the levels of monounsaturated and polyunsaturated fatty acid of oil blends B2 and B3 were 50.47, 59.01 % and 40.15, 32.57%, respectively. These obtained values fall in the above range of codex standard. It means that B2 and B3 oil blends were the best blends to be mid-oleic sunflower oil without breading or genetical modification.

One can use the fatty acid composition obtained by GLC analysis to elucidate the rate of oil oxidation. The equation reported by Fatemi and Hammond (1980) with minor modification was applied in the present study, to calculate oxidisability rates of oils under study.

Table 2. Fatty acid composition (%) of traditional sunflower oil (TSO), high oleic sunflower oil (HOSO) and their oil blends.

Fatty acid %	TSO (a)	HOSO (b)	Oil blends		
			B1 70a+30b	B2 50a+50b	B3 30a+70b
$C_{14:0}$	0.15	0.05	0.12	0.09	0.08
$C_{16:0}$	6.55	4.55	5.77	5.29	4.25
$C_{16:1}$	0.2	0.06	0.17	0.11	0.10
$C_{18:0}$	4.15	3.8	3.89	3.78	3.45
$C_{18:1}$	23.72	75.42	38.64	49.63	58.66
$C_{18:2}$	64.34	14.96	50.45	40.03	32.46
$C_{18:3}$	0.14	0.12	0.13	0.12	0.11
$C_{20:0}$	0.28	0.25	0.26	0.27	0.21
$C_{20:1}$	0.17	0.29	0.20	0.23	0.25
$C_{22:0}$	0.3	0.5	0.37	0.45	0.43
TS	11.43	9.15	10.41	9.88	8.42
TU	88.57	90.85	89.59	91.12	91.58
18:1/18:2	0.36	5.04	0.77	1.24	1.8
COX	6.89	2.32	5.71	4.64	3.95
AI	0.076	0.051	0.065	0.060	0.047

TS and TU refer to total amount of saturated and unsaturated fatty acids respectively.

COX refer to calculated oxidisability value as reported by Fatemi and Hammond (1980)

COX = 1 [16:1% + 18:1% + 20:1+ 22: 1%] + 10.3 (18:2%) + 21.6 (18:3%)/100

AI : indicates the atherogenic index and calculated as outlined by De Lorenzo *et. al.* (2001).

AI : (12:0 + 14: 0 + 16: 0)/ (ω-3 PuFA+ ω-6 PufA + MUFA)

The calculated oxidisability index (COX) for TSO, HOSO, B1, B2 and B3 were 6.89, 2.23, 5.71, 4.64 and 3.95, respectively. These values indicated that mixing TSO with HOSO at difference level lead to increase its stability towards rancidity, and the stability increased as the HOSO increase in the blend.

One has to look at another parameter resulted from the fatty acid analysis by GLC, i.e., atherogenic index (AI). This factor is important from the human health point of view, the lower value is in the favour of good health Radwan et al. (2010). According to GLC data, the oils under study can be arranged according to the benefit of human health as follow: B3 (0.047) > HOSO (0.051) > B2 (0.060) > B1 (0.065) > TSO (0.076). Hence, oil blend (3) is the best one towards decreasing the problems related with coronary heart disease. As shown in Table (2), blending of HOSO with TSO led to lower the values of atherogenic index. It seems that the types of fatty acid consumed with diet affect the diseases of cardiovascular system.

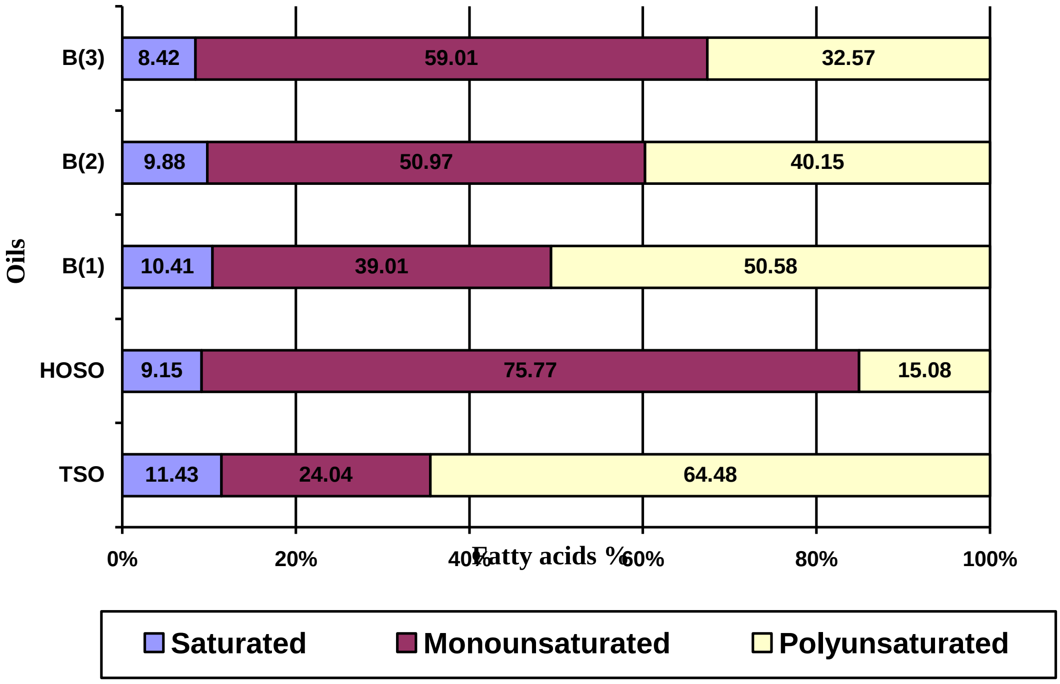

Fig. 1. Saturated, monounsaturated and polyunsaturated fatty, acid contents of traditional sunflower oil (TSO), high-oleic sunflower oil (HOSO) and their blends.

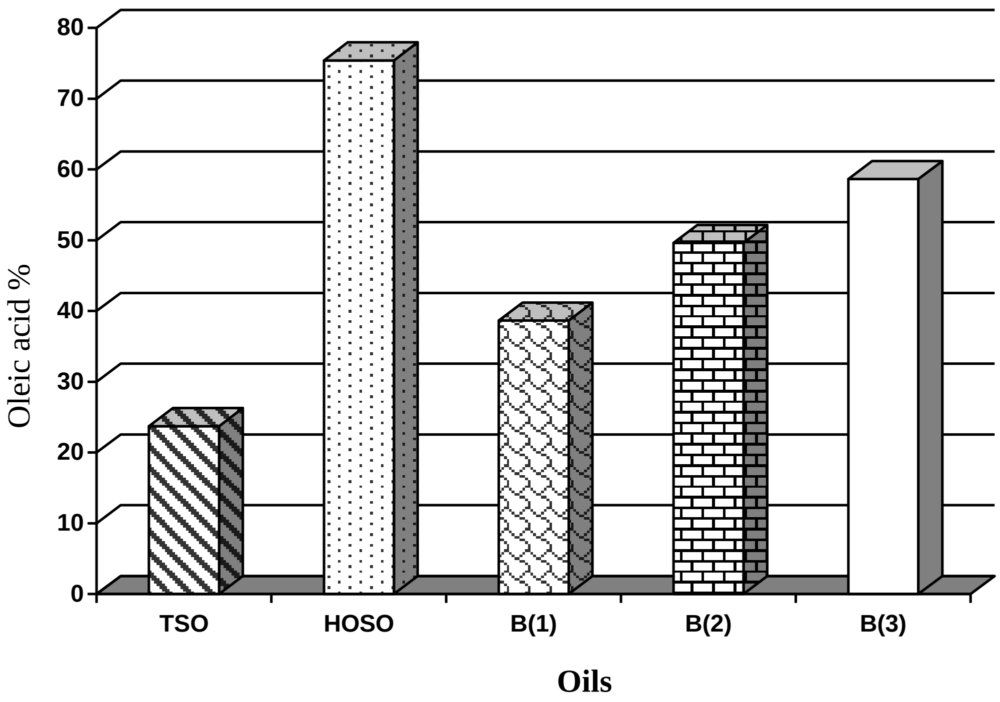

Fig. 2. Oleic acid content of traditional sunflower oil (TSO), high -oleic sunflower oil (HOSO) and their blends.

Oxidative stability of traditional sunflower oil (TSO) high-oleic sunflower oil (HOSO) and their blends:

The effect of fatty acid compositions of TSO, HOSO and their oil blends on oxidative stability phenomenon was studied using Rancimt 976. From the data in Table (3) and Fig. (3) it was observed that the oxidative stability of oils increased as oleic acid content increased. The highest oxidative stability was noted for HOSO (14.76 h at 100°C) and the lowest value was recorded for TSO (7.88 h). Meanwhile, the oxidative stability of oil blends B1, B2 and B3 were fallen in between being 11.32, 12.00 and 13.89 h, respectively). These data are in agreement with that reported by Demurin *et. al.* (1996). Data in Table (3) also demonstrates that the natural antioxidants, tocopherols (mg/kg), phenols (ppm) and unsaponipable matter (%) possessed the same trend of the oxidative stability. The highest content of these compounds was found in HOSO, while TSO contained the lowest quantity. The levels of these antioxidant materials in oil blends B1, B2 and B3 were fallen in between. These data are in agreement with that described by Gupta, (1998).

From these result one can conclud that the increase of both monounsaturated fatty acid and natural antioxidant content and the decrease of polyunsaturated fatty acid level lead to improve the oxidative stability of the oil. Concerning oil blends B2 and B3 which represent the mid oleic-sunflower their oxidative stability increased to 1.6 and 1.76 times as great as that of TSO. In addition one has to realise their advantages as frying media as recorded by Frankle and Huang, (1994); Kleingartner and Warner, (2001).

Table 3. Natural antioxidant and oxidative stability of traditional sunflower oil (TSO), high oleic sunflower oil (HOSO) and their oil blends.

Parameter	TSO (a)	HOSO (b)	Oil blends		
			B1 70a+30b	B2 50a+50b	B3 30a+70b
Stability (hr.) at 100°C	7.88	14.76	11.32	12.60	13.89
Total tocopherols [mg/kg]	563.20	624.07	570.36	579.50	594.64
Total polyphenols (ppm)	25.70	29.56	26.60	27.43	27.95
Unsaponifiable matter (%)	1.16	1.25	1.19	1.20	1.22

a) Traditional sunflower oil.

(b) High oleic-sunflower oil.

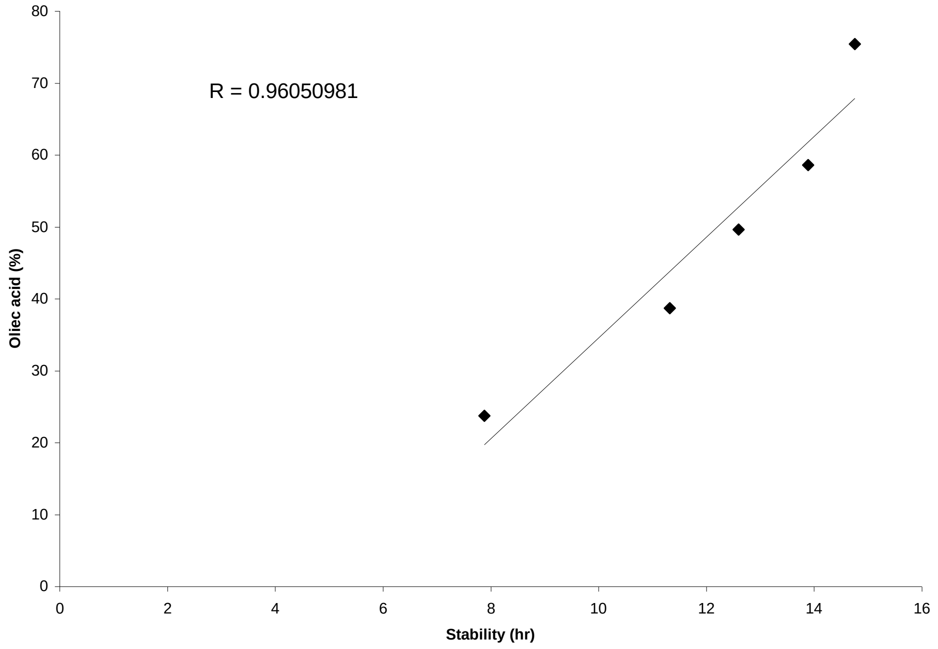

Fig. 3. Relationship between oleic acid content and oxidative stability.

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خواص زيت عباد الشمس متوسط المحتوى من حمض الأوليك الناتج من خلط زيوت صنفين من عباد الشمس

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يهدف هذا البحث إلى إنتاج زيت عباد الشمس متوسط المحتوى من حمض الأوليك وتحسين الثبات الأكسيدى لزيت عباد الشمس التقليدى بواسطة الخلط. تم خلط زيت عباد الشمس العالى المحتوى فى حمض الأوليك مع زيت عباد الشمس التقليدى بنسب مختلفة. المخلوط الأول (زيت عباد الشمس العالى المحتوى فى حمض الأوليك 30%إلى زيت عباد الشمس التقليدى 70%)، المخلوط الثانى (زيت عباد الشمس العالى المحتوى فى حمض الأوليك 50% إلى زيت عباد الشمس التقليدى 50%) المخلوط الثالث (زيت عباد الشمس العالى المحتوى فى حمض الأوليك 70% على زيت عباد الشمس التقليدى 30%). وجد أن زيادة حمض الأوليك قد أدت إلى تحسين الثبات الأكسيدى لزيت عباد الشمس التقليدى حيث كان ثباته 7.88 ساعة وزادت عند زيادة زيت عباد الشمس العالى المحتوى فى حمض الأوليك فى الخليط حيث وصلت إلى 11.32 ساعة فى المخلوط الأول، 12.6 ساعة فى المخلوط الثانى و 13.89 ساعة فى المخلوط الثالث.

وقد وجد أن المخلوط الثانى والثالث الذى أنتج تكنولوجيا بالخلط لهما صفات تقريبا هى نفس صفات زيت عباد الشمس المتوسط المحتوى من حمض الأوليك. كما وجد ارتفاع مضادات الأكسدة الطبيعية فى زيت عباد الشمس العالى المحتوى فى حمض الأوليك مثل توكوفيولارت والفينولات والمواد الغير قابلة للتصبن بينما كانت هذه المواد منخفضة فى زيت عباد الشمس التقليدى.