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Improving quality of the Egyptian subsidized oil

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Abstract

Palm olein (PO) was blended with sunflower (SFO) and soybean oil (SBO) at different three ratios. These oils and their blends were fried at 180ºC ±5ºC for 32hr (4hr per day). These oil blends were periodically analyzed at zero time and every 8hr wherefrom refractive index (at 25ºC), acidity (as oleic acid %), peroxide value (meq.O_2/kg oil), polar content (%), polymer content (%), oxidized fatty acids content (%) and oxidative stability (hr). The fatty acids composition of fresh oils and their blends were determined by using gas chromatography (GC). Results clearly revealed that the oil blend samples contained palm olein showed an increment in the oxidative stability during the frying process and also improvement had occurred in some physicochemical properties of these blends.

Introduction

Deep-fat frying is one of the most common processes in the preparation and manufacture of foods. The aim of deep-fat frying is to seal the food by immersing it in hot oil so that all the flavors and juices are retained within the crispy crust. The quality of products cooked using this method depends not only on the frying conditions, such as the temperature of the heated oil, frying time, food weight, and frying oil volume, but also on the types of oil and the kinds of foods used (Varela, 1994). During deep-fat frying, the fat is continuously being exposed to elevated temperatures (150-180ºC) in the presence of the substrates air and water. A complex series of reactions such as hydrolysis, oxidation, polymerization, isomerization, and cyclization takes place during the deep-fat frying. These reactions result in the formation of volatile and nonvolatile compounds affecting the sensory, functional and nutritional qualities of the frying oil (Alireza *et al.*, 2010). In general, deep-fat frying decreases the content of unsaturated fatty acids in frying fat and oil (Naghshineh *et al*., 2009).

Palm olein (PO), the liquid fraction of palm oil, which is highly monounsaturated and rich in oleic acids (Nor Aini *et al*., 1993), is currently touted to be oxidative stable. PO, besides being marketed as liquid oil, can be promoted for blending with other edible oils (Lin, 2002). Because it's moderately low linoleic acid content that is admirably suited for blending with oils with a high polyunsaturated content. Ideal edible oil is one in which the ratio of saturated, monounsaturated and polyunsaturated fatty acids in proper proportions, can achieve such a ration (Grundy, 1988).

Sunflower oil (SFO) and soybean oil (SBO) have a good nutritional profile, with poor oxidative stability and is, accordingly, prone to flavor deterioration because of their high proportion of unsaturated fatty acids, especially, linolenic acid in SBO (White, 2000). Various method to improve oxidative stability of soybean oil has been developed and studied, for example, partial hydrogenation, fatty acid modification and blending with more saturated or monounsaturated oils to reduce the amount of polyunsaturated fatty acids (Hunter and Applewhite, 1991; Cuesta *et al.*, 1993; Su and White, 2004).

Blending has been used to modify oils and fats to improve their functionalities and thus optimize their application in food products. It modifies the physicochemical properties of oils but without changing their chemical composition (Chu and Kung, 1997). With the rising concerns over the natural products and emphasis on nutritional enrichment, blending of vegetable oils and fats has emerged as an economical way to produce edible oils devoid of any chemical treatment but possessing natural flavor and characteristics as well as nutritional value. The importance nutritional properties of oils are based on essential fatty acid contents, omega-3 to omega-6 ratio, saturated to unsaturated ratio and contents of monounsaturated and polyunsaturated fatty acids (Myat *et al*., 2009).

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Table 1. Blending oils at different proportions

Sample No.	Sample type	Palm olein	Sunflower oil	Soybean oil
1	PO	100.00		
2	SBO			100.00
3	SFO		100.00	
4	PO+SFO	25.00	75.00	
5	PO+SFO	50.00	50.00	
6	PO+SFO	75.00	25.00	
7	PO+SBO	25.00		75.00
8	PO+SBO	50.00		50.00
9	PO+SBO	75.00		25.00
10	SFO+SBO		25.00	75.00
11	SFO+SBO		50.00	50.00
12	SFO+SBO		75.00	25.00
13	PO+SFO+SBO	25.00	50.00	25.00

As regards to the important factors of subsidized oil blend are the quality or stability on the shelf life and free from rancidity. PO is known by good keeping frying performance properties and is improvement frying oil quality by blending with oil. In 2011, the Egyptian subsidized oil had 25% SFO + 75% SBO while, in 2012 the Egyptian government occurred changes in this ratio. The gradually increments in the ratio of SFO and decrements in SBO until the ratio reached to 75:25% (SFO: SBO). On the other hand, this ratio in the first of 2013 became 100% SFO (Ministry of Supply and Internal Trade, 2013). The volume of Egyptian subsidized oil was about one million tones 100% SFO during 2013.

The average world prices for PO, SFO and SBO, in 2013 were 767.5, 1046.25 and 1012.75 US dollars, respectively (Oils and Fats International, 2013). The Egyptian government usually subsidized edible oils in Egypt. The subsidized oil mostly consists of 100% SFO used for frying purpose. Hence, if PO (melting point = 20˚C) can be used in the content of subsidized oil as substitute of SFO up to 25% in the winter (temperature in the winter around 18˚Ch) and up to 50% in the summer(temperature in the summer around 36˚C), it will be decreased the production cost of Egyptian subsidized oil to about 69 million $ US (at ratio of 25% PO + 75% SFO) or about 139 million $ US (at ratio of 50% PO + 50% SFO) per year.

The aim of this work was to improve the quality of Egyptian subsidized oil (100% SFO) by blending it's with palm olein (PO) up to 50% to enhance the oxidative stability as well as to improve some physiochemical properties and to rise the efficiency of this oil as frying process, beside, to reduce the production cost.

Materials and Methods

Source of oils

Palm olein was obtained from Arma Company for Food Industries, 10th of Ramadan, Sharkia Governorate, Egypt, while, sunflower and soybean oils were purchased from Oil Tec. Company for Oils and Detergents, Sadat City, Monufya Governorate, Egypt.

Potatoes sample preparation

Potatoes were peeled and then sliced using a Mandolin Slicer (Matfer model 2000, France) to a thickness gage (Mi tutoyo thickness Gage, Japan), and cut into a diameter of 5.08 cm using a cylindrical metal cutter. The potato slices were rinsed with distilled water to eliminate starch material on the surface and then blotted with paper towels before each experiment. The samples were placed in aluminum foil to avoid any moisture loss before further processing.

Oil blends preparation

The oil blends were prepared at 30ºC by adding palm olein (PO) to sunflower oil (SFO) and soy bean oil (SBO) at different ratios. The oil blended samples were tabulated in Table (1).

Frying performance

A known amount (2 kg) of the oil sample was separately placed in a thermostatically temperature-controlled fryer (Philips comfort, Germany, 26 cm diameter X 20 cm height) and heated at 180 ± 5°C. The potatoes cut into a uniform strips (5 mm thickness X 50 mm long) then, soaked in sufficient quantity of distilled water to cover the surface and fried for about 10 min. The frying period was 4 h daily. The weight of potato strips fried for each batch was about 200 g. This process was repeated for 8 consecutive days and the total frying period was 32 h. Oil samples were left to cool down then stored in brown glass bottles at -18°C till analyses.

Quality tests of fresh and fried oils

Refractive index at 25ºC, acidy (as oleic acid %) and peroxide value (meq.O_2/ kg oil) were determined according to A. O. A. C. (2005). Oxidized fatty acids, polymer and polar contents in the oil samples were

Table 2. Fatty acids composition (%) of palm olein, sunflower, and soybean oils and their blends

Sample No.	Fatty acids (%)							
	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C18:3	C20:0
1	0.28±0.10	0.94±0.10	38.82±3.55	4.28±0.90	41.50±5.10	12.73±1.02	0.87±0.10	0.38±0.10
2	0.10±0.0001	0.30±0.01	7.60±0.90	6.20±1.13	30.41±3.30	54.50±5.50	0.20±0.0001	0.60±0.15
3	0.00± 0.00	0.08±0.0001	11.27±0.80	5.55±0.90	19.70±2.15	55.65±6.04	7.11±0.88	0.56±0.11
4	0.21±0.01	0.79±0.10	30.50±2.01	5.51±0.85	39.65±3.90	22.30±2.07	0.62±0.99	0.42± 0.12
5	0.16±0.01	0.52±0.11	23.26±1.90	5.60±0.93	35.80±2.95	33.60±3.70	0.50±.10	0.53± 0.19
6	0.11±0.0001	0.43±0.07	13.57±0.75	6.28±1.00	34.80±2.40	43.90±4.01	0.32±0.07	0.59±0.15
7	0.24±0.01	0.73±0.10	33.40±3.15	5.00±0.78	36.40±3.45	21.10±1.90	1.70±.13	0.42±0.10
8	0.19±0.01	0.50±0.09	27.81±2.00	4.97±0.45	30.93±3.09	31.49±3.52	3.60±0.81	0.64±0.15
9	0.15±0.0001	0.27±0.01	19.20±1.94	4.65±0.59	25.50±2.00	43.80±4.19	5.80±0.91	0.51±0.14
10	0.09±0.0001	0.26±0.01	7.83±0.65	5.97±1.00	24.89±1.89	54.62±5.31	4.72±0.90	0.45±0.11
11	0.05±0.0001	0.19±0.01	8.43±1.01	5.89±0.85	26.60±1.50	54.43±5.91	3.57±0.75	0.50±0.13
12	0.02±0.0001	0.13±0.0001	9.51±1.15	6.29±1.02	23.48±1.18	53.31±5.19	5.93±1.00	0.54±0.15
13	0.18±0.0001	0.45±.08	19.80±1.80	4.75±0.85	30.76±3.02	40.72±4.1	2.82±0.10	0.52±0.17

Results are the means of three replications ± SD.

determined according to the methods of Waltking and Wessels (1981) and Wu and Nawar (1986) All physical and chemical determinations of oil samples (fresh and after fried) were carried out three times and the results are presented as average values.

Fatty acids composition

The fatty acid methyl esters were prepared as described in (IOC, 2009). The Methyl esters were analyzed by GC (Pye-Unicam model 104) equipped with FID detector and glass coiled column (1.6 X 4 mm) supported on chromosorb W-AW 100-200 mesh. The gas chromatographic conditions for isothermal analysis were: temperatures: column 170˚C detector 300˚C and injector 250˚C, flow rate: hydrogen 33 ml/ min., nitrogen 30 ml/ min and air 330 ml/ min. Peak areas were measured using a spectra physics chronjet integrator according to the method of Farag *et al*., (1984).

Statistical analysis

Statistical analysis for all values are expressed as mean ± standard error for three independent samples for fresh and at the end of heating period (n = 3 ± SE). Analysis of variance (ANOVA) and the least significant difference (LSD) test at $P < 0.05$ were calculated to allow comparison between the mean values of the studied parameters using the COSTAT software package (Cohort Software, CA, USA). Differences between studied parameters were considered significant if $P < 0.05$.

Results and Discussion

Fatty acids composition of fresh oil samples

The results in Table 2 show that the fatty acid composition of fresh oil samples under investigation at zero time. The fatty acids composition of oil was divided into 3 main categories, i.e.; trace (< 1%), minor (< 10%) and major (>10%). Fresh palm olein contained C12:0, C14:0, C18:3, C22:0) in trace amounts. However, C18:0 occurred as minor amount whereas, C16:0, C18:1 and C18:2 were present as major constituents. These finding are almost agreement with those reported by (Che Man and Tan, 1999).

Sunflower oil contained C12:0, C14:0, C18:3, C20:0 and C22:0 in trace amounts. While, C16:0 and C18:0 occurred as minor amount; whereas, C18:1 and C18:2 were presented as major constituents. Soybean oil fatty acids, C12:0, C14:0, C20:0 and C22:0 were found amount as trace. The fatty acids of C18:0 and C18:3 occurred as minor amount while, C16:0, C18:1 and C18:2 were represented as major. Also, Table 2 shows the fatty acids composition of fresh palm olein and it mixed with various levels of fresh SFO and SBO oils. Blending palm olein with oils under this study at different levels led to increase its stability against oxidation and the extent of this phenomenon was basically depending on the mixing ratio. These results may be due to the fatty acids composition proportion of palm olein. These results are agreement with those found by (Alireza *et al*., 2010).

Changes in the contents of refractive index, acidity and peroxide value during frying process

The refractive index is a measure of the unsaturation of the oils. It is one of the parameters used to measure the oil quality. Table 3 demonstrates the refractive index of original and blended oils during frying process at 180ºC± 5ºC. The initial refractive index (60ºC) of palm olein, sunflower and soybean oils was 1.4562, 1.4739, and 1.4710, respectively. Blending palm olein with various levels of sunflower or soybean oils caused significant decrease in refractive index values. These decreases may be due to the increase of mono-unsaturated fatty acids of palm olein in the blended oils. Frying process induced significant gradual decrease in the refractive index in all samples. On the other hand, palm olein and its mixtures with sunflower and soybean oils recorded significantly the lowest reduction in refractive index

Table 3. Changes in the contents of refractive index (at 25ºC), acidity and peroxide values of fresh oils and their blends during frying process

Sample No.	Frying time (hr.)				
	Zero time	8	16	24	32
Refractive index at (25°C)					
1	1.4562±0.001	1.4560±0.001	1.4558±0.001	1.4551±0.001	1.4547±0.001
2	1.4739±0.001	1.4728±0.001	1.4723±0.001	1.4718±0.001	1.4715±0.001
3	1.4710±0.001	1.4708±0.001	1.4700±0.001	1.4698±0.001	1.4695±0.001
4	1.4585±0.001	1.4580±0.001	1.4571±0.001	1.4589±0.001	1.4546±0.001
5	1.4624±0.001	1.4619±0.001	1.4614±0.001	1.4610±0.001	1.4600±0.001
6	1.4711±0.001	1.4700±0.001	1.4693±0.001	1.4683±0.001	1.4677±0.001
7	1.4680±0.001	1.4578±0.001	1.4575±0.001	1.4572±0.001	1.4565±0.001
8	1.4616±0.001	1.4611±0.001	1.4607±0.001	1.4600±0.001	1.4590±0.001
9	1.4690±0.001	1.4687±0.001	1.4682±0.001	1.4678±0.001	1.4671±0.001
10	1.4728±0.001	1.4723±0.001	1.4719±0.001	1.4717±0.001	1.4715±0.001
11	1.4721±0.001	1.4720±0.001	1.4616±0.001	1.4716±0.001	1.4713±0.001
12	1.4717±0.001	1.4715±0.001	1.4714±0.001	1.4713±0.001	1.4711±0.001
13	1.4681±0.001	1.4671±0.001	1.4671±0.001	1.4668±0.001	1.4665±0.001
Acidity values					
1	0.02±0.0001	0.09±0.0001	0.13±0.001	0.18±0.001	0.33±0.13
2	0.04±0.0001	0.14±0.001	0.17±0.001	0.23±0.01	0.44±0.15
3	0.03±0.0001	0.10±0.0001	0.20±0.001	0.23±0.11	0.40±0.01
4	0.27±0.01	0.10±0.0001	0.14±0.001	0.21±0.01	0.34±0.11
5	0.26±0.01	0.14±0.001	0.14±0.001	0.19±0.01	0.33±0.12
6	0.25±0.01	0.12±0.001	0.15±0.001	0.20±0.01	0.31±0.10
7	0.29±0.01	0.12±0.001	0.16±0.001	0.22±0.01	0.33±0.07
8	0.26±0.01	0.11±0.001	0.16±0.001	0.21±0.01	0.35±0.09
9	0.25±0.01	0.10±0.001	0.18±0.01	0.20±0.01	0.37±0.01
10	0.35±0.01	0.35±0.01	0.18±0.01	0.23±0.01	0.41±0.11
11	0.37±0.01	0.37±0.01	0.19±0.01	0.23±0.01	0.42±0.10
12	0.39±0.01	0.14±0.01	0.20±0.01	0.24±0.01	0.43±0.10
13	0.02±0.0001	0.10±0.01	0.14±0.001	0.18±0.001	0.39±0.10
Peroxide values					
1	1.00±0.10	2.85±0.20	4.35±0.39	6.24±0.61	10.57±0.94
2	2.20±0.19	5.96±0.55	6.94±0.55	10.62±0.82	12.89±1.00
3	2.40±0.18	4.55±0.50	6.20±0.51	10.02±0.91	15.90±1.50
4	1.73±0.11	5.00±0.20	5.10±0.28	9.30±0.69	12.00±0.95
5	1.61±0.13	4.00±0.34	5.22±0.25	8.12±0.71	11.43±0.94
6	1.30±0.20	3.20±0.49	4.88±0.28	7.20±0.89	11.23±1.03
7	2.01±0.10	4.11±0.29	5.63±0.29	9.46±0.65	14.23±1.20
8	1.70±0.12	3.73±0.27	4.48±0.28	8.23±0.73	13.00±1.30
9	1.32±0.13	3.30±0.35	4.00±0.42	7.10±0.84	12.15±1.41
10	2.26±0.19	4.90±0.44	6.40±0.49	10.12±0.91	13.50±1.60
11	2.31±0.20	5.30±0.45	6.57±0.67	10.31±0.90	13.92±1.77
12	2.36±0.22	5.58±0.45	6.80±0.59	10.49±0.88	14.61±1.82
13	1.80±0.11	4.90±0.29	6.50±0.35	9.12±0.61	12.20±0.75

Results are the means of three replications ± SD

at the end of frying period (Chu and Kung, 1997).

Acidity is used to asses frying oil degradation and is related to fried food quality. The changes in the acidity values of original and blended oils during frying process at 180ºC ± 5ºC for 32 h are given in Table 3. The initial acidity values of the fresh oils under this investigation were seen to range 0.02 to 0.39%, respectively. Generally, the frying process of oils under this study led to a gradual and significant increase in the acidity values. The highest change in the acidity value at the end of frying period was shown for soybean oil (sample No. 2), whereas the lowest changes was observed for palm olein (sample No. 1). Blending palm olein with different portions of sunflower oil (oil samples No. 4, 5 and 6) led to significant decrease in acid values during frying periods compared to the other oil samples No. 7, 8 and 9 (blending PO with different ratios of SBO) recorded increments in acidity. These increments are attributed to the high content of unsaturated fatty

Table 4. Changes in the polar, polymer and oxidized fatty acids contents (%) of fresh oils and their blends during frying process

Sample No.	Frying time (hr.)				
	Zero time	8	16	24	32
Polar content (%)					
1	0.00±0.00	1.25±0.23	6.11±0.54	13.89±1.13	22.80±2.22
2	0.19±0.001	5.89±0.48	14.83±1.13	17.74±1.17	28.74±2.88
3	0.09±0.001	6.49±0.56	14.76±1.11	25.08±2.54	35.16±3.33
4	0.07±0.10	5.61±0.43	13.10±1.64	24.30±2.45	33.92±3.12
5	0.04±0.00	4.00±0.33	11.00±0.93	21.19±2.016	31.00±3.42
6	0.03±0.01	2.55±0.19	8.91±0.79	18.00±1.64	27.10±2.11
7	0.15±0.19	4.79±0.43	13.00±1.15	16.57±1.96	27.00±2.98
8	0.0.11±0.11	3.57±0.27	10.81±0.99	15.80±1.55	25.66±2.16
9	0.04±0.01	2.15±0.23	8.97±0.89	14.87±1.43	24.00±2.14
10	0.13±0.13	6.33±0.55	14.80±1.77	19.50±1.88	29.13±2.34
11	0.14±0.10	6.22±0.68	14.75±1.64	21.11±2.19	31.90±3.00
12	0.05±0.00	6.00±0.72	14.70±1.98	23.50±2.04	33.00±3.17
13	0.05±0.00	6.00±0.19	12.51±0.57	19.78±1.00	29.35±2.07
Polymer content (%)					
1	0.00±0.00	1.00±0.20	1.52±0.20	2.39±0.21	5.53±0.56
2	0.00±0.00	1.75±0.21	2.03±0.22	3.89±0.33	7.30±0.68
3	0.70±0.50	1.30±0.22	1.75±0.16	5.91±0.51	9.30±0.89
4	0.10±0.001	1.29±0.19	1.86±0.18	3.17±0.33	6.83±0.71
5	0.03±0.001	1.24±.13	1.78±0.13	2.85±0.28	6.51±0.54
6	0.00±0.00	1.10±0.10	1.65±0.15	2.50±0.21	5.97±0.54
7	0.57±0.19	1.25±0.16	1.71±0.13	4.00±0.38	8.15±0.73
8	0.30±0.10	1.21±0.14	1.66±0.14	3.50±0.29	7.52±0.75
9	0.17±0.01	1.10±0.11	1.60±0.16	2.60±0.22	6.39±0.59
10	0.55±0.17	1.41±0.16	1.77±0.18	5.25±0.58	8.99±0.78
11	0.35±0.15	1.50±0.13	1.82±0.16	4.89±0.47	8.61±0.74
12	0.20±0.06	1.63±0.15	1.90±0.18	4.11±0.43	8.00±0.78
13	0.19±0.01	1.00±0.10	1.56±0.13	3.10±0.29	6.91±0.60
Oxidized fatty acids (%)					
1	0.01±0.00	0.14±0.01	0.27±0.02	0.68±0.18	1.01±0.23
2	0.21±0.01	0.36±0.11	0.56±0.20	0.92±0.20	1.11±0.18
3	0.19±0.01	0.31±0.10	0.53±0.15	0.76±0.14	1.22±0.22
4	0.15±0.01	0.18±0.09	0.31±.12	0.76±0.17	1.08±0.16
5	0.11±0.01	0.25±0.10	0.43±0.13	0.82±0.14	1.07±0.13
6	0.06±0.01	0.31±0.12	0.51±0.11	0.89±0.18	1.03±0.19
7	0.14±0.01	0.27±0.11	0.50±0.16	0.75±0.15	1.18±0.16
8	0.12±0.01	0.23±0.10	0.41±0.15	0.72±0.13	1.12±0.13
9	0.06±0.01	0.18±0.08	0.34±0.19	0.70±0.11	1.08±0.11
10	0.21±0.13	0.35±0.14	0.55±0.16	0.90±0.14	1.16±0.21
11	0.20±0.10	0.33±0.12	0.54±0.13	0.86±0.17	1.18±0.13
12	0.20±0.11	0.32±0.15	0.53±0.16	0.83±0.13	1.21±0.18
13	0.13±0.01	0.26±0.01	0.43±0.13	0.82±0.16	1.08 ±0.25

Results are the means of three replications ± SD

acids in soybean oil. On the other hand, sample No. 3 led to significant decreases in acidity value during frying period. Generally, FFA showed a little changed during frying process for all blends and it does not reach to the limits of 2.5% (in the limits of discard frying the oil). A significant level of FFA may be present in unrefined oils before use and increase due to hydrolysis and to some extent of formation of acidic products. However, poor correlation of FFA with total polar materials and polymer has been reported for frying oil (Gertz, 2000).

Determination of peroxide value can give an idea about the primary oxidation of oil. Table 3 shows the peroxide values of fresh palm olein, sunflower and soybean oils and other blended during deep-fat frying at 180ºC ± 5ºC for 32 hrs. The peroxide values for the fresh oil were very low which indicate the high quality of the oils used in this study. The peroxide values for the fresh oils ranged from 1.00 to 2.4 meq.O_2 /kg oil. The peroxide values for the fried oil were significantly increased during the frying process. Soybean oil had significantly the highest value of peroxide value which was 15.90 meq.O_2/ kg oil at the end of frying period (32 hrs), whereas,

Table 5. Changes in the oxidative stability (hr.) of fresh oils and their blends during frying process

Sample No.	Frying time (hr.)				
	Zero time	8	16	24	32
1	39.20±3.09	30.30±3.01	22.60±2.16	15.40±1.12	7.20±0.79
2	7.20±1.06	5.08±0.56	2.03±2.11	1.25±0.24	0.00±0.00
3	8.90±1.12	4.70±0.43	1.75±0.11	1.20±0.34	0.50±0.16
4	17.40±2.15	14.40±1.24	9.70±1.01	5.10±0.54	1.15±0.18
5	25.10±2.01	22.00±2.20.	13.00±1.96	9.60±1.10	3.20±0.23
6	32.30±3.14	29.10±2.09	19.30±2.00	12.50±1.12	5.20±0.44
7	16.60±2.22	15.00±1.16	10.00±1.29	5.50±0.49	1.50±0.19
8	25.70±2.18	22.00±2.44	16.00±1.68	10.00±1.53	3.60±0.28
9	32.70±3.32	29.50±2.09	20.00±2.76	12.80±1.25	5.70±0.65
10	7.50±0.89	5.00±0.49	1.95±0.17	1.23±0.13	0.15±0.01
11	8.00±0.85	4.90±0.35	1.85±0.15	1.24±0.14	0.25±0.01
12	8.55±0.76	4.80±0.44	1.80±0.17	1.25±0.18	0.40±0.13
13	16.00±2.19	12.30±2.22	7.80±1.65	3.10±1.32	1.25±0.56

Results are the means of three replications ± SD.

the lowest values were recorded for samples No.1, 6, 5, 9 and 8. These decrements in peroxide value may be attributed to the high content of palm olein in these samples. The P.V is useful measure of fresh oil quality. The heating during of frying processes, the P.V increases, but the P.V. is rapidly breakdown at high temperature so P.V. is not relying in correlation during the oil deterioration (Myat *et al.*, 2009).

Changes in the polar, polymer and oxidized fatty acids contents (%) during frying process

The polar compounds is good indicator of the overall quality of frying oils, providing critical information about the total amount of newly formed compounds having higher polarity than triacylglycerols. Table 4 shows the polar compounds of fresh oils and their blends during frying at 180ºC ± 5ºC for 32 hrs. Fresh oils under study had a polar compounds ranged from 0.00 to 0.19%. Frying process caused significant and gradual increase in the polar compounds content with frying time. Sunflower oil had significantly the highest value of polar compounds which was (35.16%) at the end of frying period (32 hrs). The lowest values of polar compounds were observed for palm olein (22.8%) and its blends with sunflower and soybean oils which were 22.80% and 24.00%, respectively. These decrements in the polar compounds content are almost due to the fatty acids composition of palm olein which had a low content of linolenic acid. Total polar materials are major importance because a limit of 24-27% has been adapted officially in member of countries (Billek *et al.*, 1978). Palm olein and their blends induced reduction in total polar materials during the frying.

The changes in the polymer content of palm olein, sunflower and soybean oils and their blends during the frying process at 180ºC ± 5ºC are shown in Table 4. An increase in the polymer content of all oil samples under this study was observed with prolonging the frying time. The highest value for polymer content was recorded for soybean oil (9.30%) at the end of frying period. On the other hand, samples No. 1 and 6 had significantly the lowest values (5.53 and 5.97%) at the end of frying period, respectively. These decrements are nearly due to the high content of palm olein in these oil samples. Measurement of polymeric triglycerides (TG) has set limits of 10-12%, where the color and viscosity are increased due to the formation of large molecules through polymer (Tompkins and Perkins 1999).

Data in Table 4 demonstrated the oxidized fatty acids of palm olein, sunflower and soybean oils and their blends at different portions during frying process at 180ºC ± 5ºC. The initial oxidized fatty acids values of oil samples ranged from 0.01% to 0.21%, respectively. The frying process led to a gradual and significant increase in the oxidized fatty acid values. The findings also appear that addition of palm olein to sunflower or soybean oils happened significant decrease in the oxidized fatty acid values (Frega *et al.*, 1999).

Changes in the oxidative stability during frying process

Table 5 shows the changes of oxidative stability of original and blended oils during frying process at 180ºC ± 5ºC for 32 h which measured by Rancimat method at 100ºC ± 2ºC. Fresh palm olein had highest oxidative stability 39.20 h however; soybean oil had the lowest value of the oxidative stability (7.20 hrs). Frying caused gradual and significant decrease of oxidative stability in all oil samples under study. Blending palm olein with sunflower or soybean oils induced significant increases in the oxidative stability of the oil blends.

Conclusion

From all the above data in this work, it can

be concluded that using palm olein up to 50% as substitute to sunflower oil in the Egyptian subsidized oil (100% sunflower oil) induced improvements in the levels of acidity , peroxide value , R.I, polar, polymer and oxidized fatty acids. Therefore, it can be recommended that palm olein can be used up to 50% from the Egyptian subsidized oil (which contains 100% sunflower oil) to rise the performance efficiency as a frying oil and to decrease the production cost of Egyptian subsidized oil.

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