Zagazig J. Agric. Res., Vol. 51 No. (5) 2024 1021-1032

Food, Dairy and Home Economic Research

Available online at http://zjar.journals.ekb.eg
http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

PHYSICAL, CHEMICAL PROPERTIES AND OXIDATIVE STABILITY OF BLENDED PALM OIL WITH SUNFLOWER AND SOYBEAN OIL

Mohamed A. El-Badawy*, S.M. Abo El-Maaty and Nourhan A. Rabie

Food Sci. Dept., Fac. Agric., Zagazig Univ., Egypt

Received: 25/06/2023 ; Accepted: 00/00/2023

ABSTRACT: This study was conducted to enhancement the oxidative stability of soybean and sunflower oil by blending them with palm oil to form binary blends. The physical and chemical properties, refractive index, free fatty acids, peroxide value, iodine value, saponification value and fatty acid composition of palm oil and its blends with soybean and sunflower oils were determined to evaluate oils and their blends. Results revealed that palm oil was the best oil compared to sunflower oil and soybean oil, as well as blending of palm oil with sunflower oil and soybean oil to form binary blends led to the enhancement of oxidative stability of sunflower and soybean oil. The best binary blend was the blend which consists of 50% palm oil: 50% soybean.

Key words: Oil blends, palm oil, soybean oil, sunflower oil, oxidative stability, peroxide value, saponification value.

INTRODUCTION

The predominant fat used in Egypt today is palm oil. It is a common and often used food ingredient in the global food industry. Due to the amount of saturated fat that provides stability and increased resistance to oxidation when heating at high temperatures, the food processing industries falvour palm oil more than other types of oil **(Azrina *et al*., 2009)**.

Polyunsaturated fatty acids (PUFA), which are more susceptible to oxidative alterations, are present in significant concentrations in the majority of vegetable oils trans fatty acids are one type of oxidation product created by the oxidative modifications in PUFA (TFA). These TFA have negative metabolic side effects that can change cell function and metabolism **(Holohan, 1997)**.

One of the most popular oils in use today is soybean oil. Because it contains a wide range of the essential fatty acids and sterols required by the body to maintain health, soybean oil is also healthier than the majority of other plant oils **(Kailas *et al*., 2013)**. The physical and chemical composition of blended oils as well as blood lipids have previously been claimed to be improved by vegetable oils when blending **(St-Onge *et al*., 2003)**.

Approximately 40-50% of sunflower seeds are made up of oil, which is a significant source of the polyunsaturated fatty acid (linoleic acid) with possible health advantages **(Lopez *et al*., 2000 and Monotti, 2004)**. Sunflower oil is a crucial oil to use for cooking due to the fatty acid structure. Due to its high linoleic acid content (48.3 to 74.0%), moderate oleic acid content (14.0 to 39.4%), and low level of saturated fatty acid content (12%), it is regarded as a highly polyunsaturated oil. Because the body is unable to produce these fatty acids, they are vital to life **(Gunstone, 2002)**.

By delaying or preventing the breakdown of lipids, synthetic antioxidants like butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), tert-butylhydroquinone (TBHQ), and propyl gallate (PG) have been able to modulate oxidation processes thus far **(Taghvaei *et al*., 2015; Metzner Ungureanu *et al*., 2020; Odeh *et al*., 2021)**.

*** Corresponding author: Tel. :** +20106970284
E-mail address: mohamab_habib2020@yahoo.com

Hydrogenation, interesterification, fractionation, and blending are methods that can change an oil's nutritional properties, quality and stability. Blending oils with diverse compositions and attributes is the most straightforward way to get the required oil characteristics because interesterification and fractionation require specialised and expensive equipment, while interesterification leads to the development of trans isomers **(Hashempour-Baltork *et al*., 2016)**. When two or more oils from various vegetable species are combined (in a ratio greater than 5%), an edible oil blend is created **(Guiotto *et al*., 2014)**. Therefore, this study was carried to study and evaluate the physico-chemical properties of blended palm oil with soybean and sunflower oils.

MATERIALS AND METHODS

Materials and Reagents

All chemicals used in the study, were purchased from Sigma–Aldrich (St. Louis, MO, USA). All chemicals and solvents were analytical reagent grade. Refined, bleached and deodorized RBD sunflower oil (SFO), RBD soybean oil (SBO) and RBD palm oil (PO) were obtained from Tanta Oil and Soap Co., Tanta, Egypt.

Preparation of Oil and Its Blends Containing Antioxidants

Selection of oils

The selection of test oils was based on the presence of varying polyunsaturated fatty acids (PUFA) composition. Thus, PO which includes SFO, SBO and its blending PO 50%: SFO 50%, PO 50%: SBO 50% and SMO 50%: SFO 50% were used in this investigation.

Samples preparation

Three blends of palm oil, soybean oil and sunflower oil were prepared using a mechanical stirrer at 180 rpm for 15 min **(Kumar *et al*., 2009)**. These blends were prepared in the ratio of 1 : 1. These three blends named as:

Sample A = 50% palm oil : 50% sunflower oil.

Sample B = 50% palm oil : 50% soybean oil.

Sample C= 50% soybean oil: 50% sunflower oil.

All oil blends were treated with and without 36 ppm TBHQ in a series of transparent glass bottles having a volume of 200 ml each, to examine their antioxidative activity. Schaal oven test was conducted to evaluate the effect of antioxidants against oxidation during the accelerated oxidative storage of oils.

Physical and Chemical Properties

Refractive index

Abbe refractometer was used for the determination of refractive indices of oil and fat sample. Temperature of the refractometer was maintained at 40 ± 1°C using a thermostatically controlled water bath. Refractive indices were determined following the procedures given by **Cocks and van Rede (1997)**.

Oxidative Stability Test

Free fatty acid

Free fatty acid content (FFAC) was determined according to standard methods of **AOCS (2000)**.

Peroxide value (PV)

The peroxide value (PV) was conducted by referring to the AOAC method 965.33 described by **AOAC (2011)**.

Determination of Iodine Value (IV)

The iodine value (IV) in the oil samples was determined using the Wijs method, as described in the **AOAC (1997)** official method 993.20.

Fatty acid composition

The fatty acid methyl esters were analyzed using to Thermo Ultra Trace GC series gas chromatography and Thermo DSQ‖ mass spectrometer from Thermo Fisher Scientific (Waltham, MA, USA). SGE BP × 70 column 25 m × 0.25 mm, 0.25 μm film thicknesses (65% methyl - 35% phenyl silicone) was used **(Tong *et al*., 2007)**. Area under each fatty acid peak relative to the total area of all fatty acid peaks was used to quantify the fatty acids identified. Results are reported as g fatty acid/100 g of total fatty acids **(Lutterodt *et al*., 2011)**.

Saponification value

The official Method **(AOAC, 2011)** No. 920.160 was used to calculate the oil's saponification value. It required distillation and the manufacture of 0.1 N KOH solutions. A 5g sample of oil was collected, weighed in a conical flask, fixed to an air condenser, and then heated until fully saponified. After cooling, it was titrated with 0.5 M HCl. The indicator used was phenolphthalein.

Accelerated Oxidation Storage Experiments (Rancimat Test)

Rancimat was used to measure storage of oils and blends in accordance with Official Method Cd12b-92 **(AOCS, 1997, 1998)**. Using the Rancimat 743 equipment (Metrohm) and 3g of oil sample that had been heated to 110°C with an air flow of 20 L/h, stability was expressed as the induction time (h).

Statistical Analysis

All data were statistically analyzed using the general linear models procedure of the statistical analysis system **SAS (1998)**. Significances of differences were defined at $p<0.05$. All experiments as well as related analysis results were repeated three times and all obtained data are expressed as an average.

RESULTS

Physical and Chemical Properties for RBD Sunflower, Palm Oil and Soybean Oils

Free fatty acids

According to **Horuz and Maskan (2015)**, the released fatty acids in fried foods are more likely to undergo thermal oxidation, which results in unpleasant smells and odours. The free fatty acids of oils (sunflower, palm, and soybean oils) were revealed to be 0.045%, 0.040% and 0.038%, respectively, according to data presented in Table 1. Among palm oil, sunflower oil and soybean oil, free fatty acids were reported at the lowest levels. **Kathleen and Monoj (2005), Razali (2005), Angeles *et al*. (2017) and Hashem *et al*. (2017)** all concur with these findings. It is important to note that the tested palm oil, soybean oil and sunflower oil all met the requirements of **Egyptian Standard Specifications, Number 999 (2017)** for crude edible oils in terms of free fatty acids.

Peroxide value

The main oxidation product resulting from lipid oxidation is hydrogen peroxide. It could degrade into secondary volatile and nonvolatile compounds, lowering the oil's quality. This signals the beginning of the oxidative alterations **(Gotoh and Wada, 2006)**. The oxidation of iodine ion by hydroperoxide can be used to detect the presence of hydroperoxide in the oil. The oil sample is treated with a saturated iodine solution, which combines with the hydroperoxide that result from the oxidation of the lipids to produce free iodine. Iodine that has been freed is next titrated against sodium thiosulphate. The titration value can be determined and expressed as the mill equivalents of oxygen per kilogram of sample (meq. O_2/kg), which stands for peroxide value **(Zhang *et al*., 2021)**. The Peroxide value is the most common way to detect lipid oxidation. The primary compounds that emerge at the start of the autoxidation are peroxides. PV is largely empirical even though it is applicable in the early stages of oxidation. The test is extremely sensitive to temperature variations. PV rises throughout the oxidation, reaches a maximum, and then starts to fall. The peroxide value (P.V.), which measures the concentration of peroxides and hydroperoxides, is a commonly used tool for tracking the early stages of lipid oxidation. The peroxide value of pure oils was shown in Table 1 (sunflower, palm and soybean oils had values of 0.18 meq. O_2/Kg, 0.20 meq. O_2/Kg, and 0.15 meq. O_2/Kg, respectively) .The least amount of peroxide was found in soybean oil when compared to palm and sunflower oils. These findings concur with those of **Hashem *et al*. (2017), Sabbir *et al*. (2016), Prathibha *et al*. (2018) and Tilahun *et al*., (2018)**. It is important to note that the tested palm oil, soybean oil, and sunflower oil all met the requirements of **Egyptian Standard Specifications, Number 999 (2017)** for crude edible oils in terms of peroxide value.

Iodine value

The literature states that the iodine value (IV) is a measure of the degree of unsaturation and lipid oxidation, with a high value suggesting that the oils are prone to oxidation. Additionally, the unsaturated nature impacts the stability of oils and causes deterioration effects to manifest during storage **(Neagu *et al*., 2013)**. According to the Codex Alimentarius Commission standard for refined oils, the iodine value of each SFO and SBO was between 118 and 141 and 124 and

Table 1. Physical and chemical properties for RBD sunflower, palm oil and Soya bean oils

Properties	Palm oil	Sunflower oil	Soya bean oil
Refractive index (RI)	1.45123±0.01[a]	1.46068±0.02[a]	1.46053±0.02[a]
Colour (R)	2.300±0.06[a]	0.717±0.01[b]	0.616±0.01[c]
Free fatty acids (F.F.A)%	0.040±0.001[b]	0.045±0.00[a]	0.038±0.002[c]
Peroxide value (P.V) meq. O2/Kg	0.20±0.02[a]	0.18±0.01[b]	0.15±0.02[c]
Iodine value (I.V) I2/100g	52.1±1.02[b]	131±1.80[a]	130±2.12[a]
Saponification value (SAP.V) I2/100g	198±1.22[a]	192±1.98[b]	191±2.92[b]
Unsaponification value (UNSAP.V) I2/100g	0.22±0.01[c]	0.49±0.03[b]	0.52±0.01[a]

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

139 g/100g oil, respectively. Iodine value, a gauge of general unsaturation, is frequently used to describe oils and fats. As oil oxidises, the number of double bonds decreases, which is associated with a decline in iodine value. The unsaturation of the oil correlates with the high iodine value **(Che-Man and Tan, 1999)**. Table 1 both display the IV value of RBD sunflower, palm, and soya bean oils. Oils (sunflower, palm and soybean) have iodine values of 131, 52, and 130 I_2/100g, respectively. These findings were in agreement with **Prathibha *et al*. (2018) and Tilahun *et al*. (2018)**. It is important to note that the tested palm, soybean, and sunflower oils all met the requirements of **Egyptian Standard Specifications, Number 999 (2017)** for crude edible oils in terms of iodine content.

Saponification and unsaponification value

Less ester bonds or higher molecular weight fatty acids in glycerides are associated with lower saponification values, and vice versa **(Nangbes *et al*., 2013)**. All three of the examined oil samples are essentially within acceptable limits. The highest saponification values were produced by sunflower oil (192 mg KOH/g) and palm oil (198 mg KOH/g). Sunflower, palm and soybean oils each had an unsaponification value of 0.49, 0.22, and 0.52 I_2/ 100g. These findings concur with those of **Akinola *et al*. (2010)**, **Prathibha *et al*. (2018)**, **Tilahun *et al*. (2018) and El-gazzar *et al*. (2021)**. The saponification values for the tested palm oil, soybean oil, and sunflower oil were in compliance with the **Egyptian Standard Specifications, number 999 (2017)** for the crude edible oils. These results are consistent with those reported before.

Colour

Refined oils have usually soft tastes, clear and transparent appearance **(Suzanne, 2010)**. Table 1 provides the colour values for the three edible oils. The results fell into the R =0.616/Y to R =2.3/Y range. According to the Table 1, palm oil (R=2.30) had the reddest hue in comparison to the global standard. This is possibly a result of the bleaching process's insufficient colour reduction. For any palm oil, for instance, R=1.4/Y=15 is both an acceptable value and a good grade level **(Codex Alimentarius Commission, 1999)**. However, in our investigation, palm tree oil yielded greater red values than anticipated. The presence of carotenoids and other red pigments may be the cause of this. Additionally, oils may become coloured due to warming, dilution ratios, the presence of dissolved contaminants, and other unfinished products **(Nangbes *et al*., 2013)**.

Refractive index

One of the most crucial physical characteristics used to identify fats and oils is the refractive index since it may be used to calculate how saturated oil is. Results in Table 1 demonstrate that for sunflower, palm, and soybean oils, respectively, the values of RI were 1.46068, 1.45123, and 1.46053. These findings concur with those of **El-Anany (2007)**, **Tilahun *et al*. (2018) and El-gazzar *et al*. (2021)**. It is important to note that the tested palm, soybean, and sunflower oils all met the requirements of **Egyptian Standard Specifications, Number 999 (2017)** for crude edible oils in terms of refractive index.

Physical and Chemical Properties for Sunflower Oil, Palm Oil and Soybean Oil Blends

A quick, practical, and affordable strategy to improve the physicochemical and nutritional characteristics of the oil is to blend it. Currently, it is a standard procedure in the food sector. It is an affordable and acceptable approach to supply oil with a balanced fatty acid profile, increased stability, and also improved content of antioxidant and bioactive substances, according to numerous researches **(Fadda *et al*., 2022)**.

Free fatty acids

Data in Table 2 showed that the free fatty acids of triple blended (palm oil, soybean oil, and sunflower oil) 50% palm oil were found to be the following 50% palm oil: 50% soybean oil was 0.039%, 50% sunflower oil: 50% soybean oil was 0.041% and 50% palm oil: 50% sunflower oil. These findings are in agreement with those of **Kailas *et al*. (2012) and El-gazzar *et al*. (2021)**. It is important to note that the tested triple blend of "palm oil, soybean oil and sunflower oil" complied with **Egyptian Standard Specifications, Number 999 (2017)** for the crude edible oils in terms of free fatty acids.

Peroxide value

Data in Table 2 showed that the combined peroxide value of palm, soybean, and sunflower oils. The ratio of 50% palm oil to 50% sunflower oil was 0.18 meq. O_2/Kg. The peroxide value for the tested triple blended "palm oil, soybean oil and sunflower oil" were in compliance with the **Egyptian Standard Specifications, number 999 (2017)** for the edible oils crude. 50% soybean oil was 0.17 meq. O_2/Kg and 50% sunflower oil: 50% soybean oil was 0.16 meq. O_2/Kg.

Iodine value

Data from Table 2 showed that the combined iodine value of palm, soybean, and sunflower oils 50%palm oil: 50% soybean oil was 91 gI_2/ 100g; 50% sunflower oil : 50% soybean oil was 130.5 gI_2/100g; and 50% palm oil: 50% sunflower oil was 91.5 gI_2/100g. The iodine value for the tested triple blended "palm oil, soybean oil and sunflower oil" was in compliance with the **Egyptian Standard Specifications, Number 999 (2017)** for the crude edible oils. These results correlate to those of **Kailas *et al*. (2012) and El-Gazzar *et al*. (2021)**.

Saponification and unsaponification value

Data presented in Table 2 indicated that saponification value of blended (palm oil, soybean oil and sunflower oil). 50% palm oil : 50% sunflower oil was 194 mg KOH/g, 50% palm oil: 50% soybean oil was 193.5 mg KOH/g and 50% sunflower oil : 50% soybean oil was 191.5 mg KOH/g .While unsaponification value of triple blended (palm oil, soybean oil and sunflower oil) 50% palm oil : 50% sunflower oil was 0.35 mg KOH/g, 50% palm oil: 50% soybean oil was 0.38 mg KOH/g and 50% sunflower oil: 50% soybean oil was 0.50 mg KOH/g. The saponification value for the tested triple blended "palm oil, soybean oil, and sunflower oil" was in compliance with the **Egyptian Standard Specifications, number 999 (2017)** for the crude edible oils. These results are consistent with those of **Kailas *et al*. (2012) and El-Gazzar *et al*. (2021)**.

Refractive index

Data presented in Table 2 indicated that refractive index of blended (palm oil, soybean oil and sunflower oil). 50% palm oil: 50% sunflower oil was 1.45593, 50% palm oil: 50% soybean oil 1.45586 and 50% sunflower oil : 50% soybean oil was 1.46060. These results correspond to the results **El-Gazzar *et al*., (2021)**, are worth to mention that the refractive index for the tested triple blended "palm oil, soybean oil and sunflower oil" were in conformity with **the Egyptian Standard Specifications**, **number 999 (2017)** for the crude edible oils.

Colour

Data presented in Table 2 indicated that color values of triple blended (palm oil, soybean oil and sunflower oil) 50% palm oil: 50% sunflower oil was 1.4 R, 50% palm oil : 50% soybean oil 1.13 R and 50% sunflower oil : 50% soybean oil was 0. 60 R. The red values in oils made from

Table 2. Physical and chemical properties for RBD sunflower oil, palm oil and Soybean oil blends

Properties	50% palm oil : 50% sunflower oil	50% palm oil : 50% soybean oil	50% soybean : 50% sunflower oil
RI	1.45593±0.01[a]	1.45586±0.02[a]	1.46060±0.01[a]
Colour	1.4±0.03[a]	1.13±0.05[b]	0.6±0.04[c]
Free fatty acids (F.F.A)	0.042±0.00[a]	0.039±0.002[b]	0.041±0.001[a]
Peroxide value (P.V)	0. 18±0.03[a]	0.17±0.02[a]	0.16±0.02[a]
Iodine value (I.V)	91.5±2.4[b]	91±3.12[b]	130.5±4.5[a]
Saponification value (SAP.V)	194±2.2[a]	193.5±2.6[ab]	191.5±2.4[b]
UNSaponification value (UNSAP.V)	0.35±0.01[c]	0.38±0.01[b]	0.5±0.02[a]

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

palm oil and its derivatives were greater than anticipated. The presence of carotenoids and other red pigments may be the cause of this. Additionally, oils may become coloured due to warming, dilution ratios, the presence of dissolved contaminants, and other unfinished products **(Nangbes *et al*., 2013)**. These outcomes match those of **Tilahun *et al*. (2018)**.

Fatty Acids Composition for Sunflower Oil, Palm Oil and Soybean Oil

The fatty acid composition of polyunsaturated and saturated fatty acid ratio of pure oils used in this studied are presented in Table 3. Palm oil contained (40.0%) oleic acid (C18:1) and 46.08 % palmitic acid (C16:0), these results are in agreement with **Naghshineh *et al*. (2010) and El-gazzar *et al*. (2021)**. whereas sunflower and soybean oils contained a lower level of oleic acid was found to be (23.11%), (20.70 %), respectively. On the other hand, Linoleic acid values were (67.79%) and (59.0%) for sunflower and soybean oils respectively. From Table 3 it noted that samples of soybean oil content of Linolenic acid (6.26%), while this fatty acid nondetect for sunflower and palm oils. According to **Juárez *et al*. (2011)**, fresh soybean oil included 10.3% of palmitic acid (C16:0), 4.9% of stearic acid (C18:0), 21.5% of oleic acid (C18:1), 53.4% of linoleic acid (C18:2), and 5.1% of linolenic acid. These findings are in agreement with their findings (C18:3). **Ferrari *et al*. (1996)** also discovered that the refined soybean oil's fatty acid content was 11.2% C16:0, 0.1% C17:0, 3.5% C18:0, 24.9% C18:1, 50.2% C18:2, 3.5% C18:3, 0.4% C20:0, 0.4% C20:1, 0.5% C22:0, and 0.2% C24:0. **El-gazzar *et al*. (2021)** also discovered that palm oil included (49.70%) oleic acid (C18:1) and (34.90% palmitic acid (C16:0), whereas sunflower and soybean oils contained a lower level of oleic acid, which was found to be (18.80%) and (23.18%), respectively. On the other hand, linoleic acid values were (67.80%) and (49.56%) for sunflower and soybean oils respectively, soybean oil content of linolenic acid (3.50 %), while the percentage of this fatty acid was (0.30%) and (0.30%) for sunflower and palm oils, respectively.

Fatty Acids Composition for Sunflower Oil, Palm Oil and Soybean Oil Blends

Binary blended oils (50% palm oil : 50% sunflower oil, 50% palm oil : 50% soybean oil and 50% soybean oil : 50% sunflower oil) had their fatty acid composition, percentage of saturated fatty acids, percentage of mono-unsaturated fatty acids, and percentage of poly-unsaturated fatty acids determined using GLC apparatus. The results are shown in Table 4. Data indicated that the percent of main components in binary blended (50% palm oil: 50% sunflower oil) were, total saturated fatty acids 29.44%, merestic acid 0.51%, palmetic acid 26.11%, stearic acid 2.66%, arachidic acid 0.16%, oleic acid 34.44%, linoleic acid 35.84% and total-unsaturated fatty acids 70.56% .While the percent of main components in binary blended

Table 3. Fatty acids composition for RBD sunflower oil, palm oil and soybean oil

Fatty acids composition		Palm oil	Sunflower oil	Soybean oil
Caprylic	**C 8:0**	0.00	0.00	0.00
Capric	**C10:0**	0.00	0.00	0.00
Lauric	**C12:0**	0.31±0.02[a]	0.00±0.00[b]	0.00±0.00[b]
Myristic	**C14:0**	0.92±0.05[a]	0.00±0.00[b]	0.00±0.00[b]
Palmitic	**C16:0**	46.08±2.3[a]	5.30±0.9[c]	10.29±1.12[b]
Stearic	**C18:0**	3.5±0.06[ab]	2.70±0.1[b]	3.65±0.04[a]
Arachidic	**C20:0**	0.2±0.02[a]	0.10±0.01[b]	0.10±0.01[b]
SFA		51.00±1.2[a]	8.10±0.85[c]	14.04±1.05[b]
Oleic	**C18:1**	40.0±2.4[a]	23.11±1.5[b]	20.70±1.3[c]
Linoleic	**C18:2**	9.00±1.2[c]	67.79±2.6[a]	59.00±2.3[b]
Linolenic	**C18:3**	0.00±0.00[b]	0.00±0.00[b]	6.26±0.02[a]
Archidonic	**C20:1**	0.00	0.00	0.00
USFA		49.0±1.8[c]	91.40±3.4[a]	85.96±3.6[b]

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

Table 4. Fatty acids composition for RBD sunflower oil, palm oil and soybean oil blends

Fatty acids composition		50% Palm oil : 50% sunflower oil	50% Palm oil : 50% soybean	50% Soybean 50% : sunflower oil
Caprylic	**C 8:0**	0.00	0.00	0.00
Capric	**C10:0**	0.00	0.00	0.00
Lauric	**C12:0**	0.00	0.00	0.00
Myristic	**C14:0**	0.51±0.04[a]	0.45±0.03[b]	0.00±0.02[c]
Palmitic	**C16:0**	26.11±1.3[ab]	27.47±1.1[a]	7.58±1.2[c]
Stearic	**C18:0**	2.66±0.12[b]	3.15±0.16[a]	2.65±0.14[b]
Arachidic	**C20:0**	0.16±0.02[a]	0.17±0.03[a]	0.07±0.02[b]
SFA		29.44±0.85[b]	30.79±1.0[a]	10.30±1.2[c]
Oleic	**C18:1**	34.44±1.6[a]	32.79±1.8[b]	25.00±1.5[c]
Linoleic	**C18:2**	35.84±2.00[b]	33.72±2.04[c]	61.96±3.22[a]
Linolenic	**C18:3**	0.00±0.02[c]	2.05±0.04[b]	2.28±0.05[a]
Archidonic	**C20:1**	0.00	0.00	0.00
USFA		70.56±2.6[b]	69.21±2.9[c]	89.70±3.2[a]

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

(50% palm oil: 50% soybean) were, total saturated fatty acids 30.79%, merestic acid 0.45%, palmetic acid 27.47%, stearic acid 3.15%, arachidic acid 0.17%, oleic acid 32.79%, linoleic acid 33.72%, linolenic acid 2.05% and total-unsaturated fatty acids 69.21%. Also, the percent of main components in binary blended (50% soybean: 50% sunflower oil were, total saturated fatty acids 10.30%, palmetic acid 7.58%, stearic acid 2.65%, arachidic acid 0.07 %, oleic acid 25.0%, linoleic acid 61.96 %, linolenic acid 2.28% and total-unsaturated fatty acids 89.70%. By mixing palm oil with both sunflower oil and soybean oil, it was possible to produce mixtures of good quality, cheap prices and good contents of unsaturated fatty acids, which have a good effect on consumer health. Oil blending's primary goal is to combine the best qualities of many oils into a single oil and to create a product with a balanced fatty acid profile, high stability, a concentration of bioactive substances that are good for human health, high functionality and high industrial value **(Dhyani *et al*., 2018)**.

These findings concur with those of **El-gazzar *et al*. (2021)**, who reported that the primary constituents in binary blended (palm oil and soybean oil) were 80% PO: 20% SB, accounting for 36.07% of the total saturated fatty acids. The percentage of all mono-unsaturated fatty acids was 50.53%. Lauric acid was 0.25%, Merestic acid was 1.11%, Palmetic acid was 28.82%, Stearic acid was 5.65%, and Arachidic acid was 0.24%, Oleic acid was 50.33% and palmetoleic acid was 0.20%; 13.40% of all polyunsaturated fatty acids were present. There were 13.20% of linoleic acid and 0.20% of linolenic acid.

Thermophilic Stability for Sunflower Oil, Palm Oil and Soybean Oil (By Antioxidants and Without Antioxidant) at 110°C

The antioxidative potential of the employed antioxidants was determined by the induction duration. The time needed to reach an end point of oxidation corresponding to either a degree of observable rancidity or a rapid change in the rate of oxidation is known as the induction period (IP), also known as the oxidative stability index (OSI) **(Presa and Lopez, 1995)**. In general, raw vegetable oils are more oxidatively stable than their refined and processed counterparts. In addition to the fatty acid composition, the presence of minor bioactive elements such tocols, sterols, metal ions, polar lipids, and the initial concentration of hydroperoxides affects the oxidative stability of a substance **(Madhujith and Sivakanthan, 2019 and Cai *et al*., 2021)**. The results of induction periods at 110°C for sunflower oil by antioxidant, sunflower oil without antioxidant, palm oil by antioxidant, palm oil without antioxidant, soybean oil by antioxidant and soybean oil without antioxidant were 8.3, 5.0, 5.23, 39.2, 31.6, 10.6 and 7.9 h, respectively (Table 5). Results indicated that the induction period of palm oil was the highest followed by soybean oil and finally sunflower oil. However, the differences between samples were significant. Also, the addition of industrial antioxidants to the oils increased the induction period for the used oils as a result of the effect of antioxidants which preserve fats and oils from deterioration, rancidity/discolouration **(Mujeeda and Prasad, 2016)** by acting as chain-breaking radical scavengers and peroxide decomposers **(De Souza *et al*., 2011: Mujeeda and Prasad, 2016)**. These results are in agreement with **El-gazzar *et al*. (2021)**.

Thermophilic Stability for Sunflower Oil, Palm Oil and Soybean Oil Blends

The results of induction periods at 110°C for 50% palm oil 50%: sunflower oil by antioxidant, 50% palm oil: 50% sunflower oil without antioxidant, 50% palm oil: 50% soybean by antioxidant, 50% palm oil: 50% soybean without antioxidant, 50% soybean: 50% sunflower oil by antioxidant and 50% soybean: 50% sunflower oil without antioxidant were 14.5, 9.9, 15.3, 11.7, 9.8 and 6.25 and respectively (Table 6). Results indicated that the induction period of palm oil was the highest followed by soybean oil and finally sunflower oil. Also, the addition of industrial antioxidants to the oils increased the induction period for the used oils as mentioned earlier. However, blending of different vegetable oil can also improve the content of antioxidant and bioactive lipids and these antioxidants and bioactive components are also improving the stability of vegetable oils **(Abdel-Razek *et al*., 2011; Dhyani *et al*., 2018)**. **Garg *et al*. (2021)**, **González-Gamallo *et al*. (2021)** and **El-gazzar *et al*. (2021)** who found that blending of different vegetable oil improved the stability of vegetable oils.

Table 5. Thermophilic stability for sunflower oil, palm oil and soybean oil (by antioxidants and without antioxidant) at 110°C

par	Palm oil By anti	Palm oil without anti	Sunflower oil By anti	Sunflower oil without anti	Soybean By anti	Soybean without anti
hr.	39.2±1.5[a]	31.6±1.3[b]	8.3±0.74[d]	5±0.22[f]	10.6±0.44[c]	7.9±0.82[e]

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

Table 6. Thermophilic stability for sunflower oil, palm oil and soybean oil blends (by antioxidants and without antioxidant) at 110°C

par	50% Palm oil : 50% sunflower oil By anti	50% Palm oil : 50% sunflower oil without anti	50% Palm oil : 50% soybean By anti	50% Palm oil : 50% soybean without anti	50% Soybean : 50% sunflower oil By anti	50% Soybean : 50% sunflower oil without anti
hr.	14.5±1.04[b]	9.9±0.88[d]	15.3±1.02[a]	11.7±0.95[c]	9.8±0.75[d]	6.25±0.8[e]

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

Conclusion

According to the above results, vegetable oil blending is a physical, economical and simple procedure to change FAC, to increase bioactive components and natural antioxidants, and to make products with specific properties. Sunflower oil and soybean oil, the blends showed higher oxidative stability indicators. The findings imply that combining palm oil with sunflower, soybean and other oils is a suitable substitute for obtaining oils with greater oxidative stability indices.

REFERENCES

Abdel-Razek, A.G., S.M. El-Shami, M.H. El-Mallah and M.M. Hassanien (2011). Blending of virgin olive oil with less stable edible oils to strengthen their antioxidative potencies. Aust. J. Basic and Appl. Sci., 5 (10): 312-318.

American Oil Chemists' Society (AOCS) (1998). Official methods and recommended practices of the AOCS (5th Ed.). Champaign: AOCS Press.

Angeles, G.M., D.M. Carmen, R.M. Victoria and M. Manuel (2017). Chemical and Physical Properties of a Sunflower oil with high levels of oleic and Palmitic acids. Instituto de la Grasa (CSIC), Sevilla, Spain. Eu. J. Lipid Sci. Technol., 105: 130-137.

AOAC (2011). Official Methods of Analysis of the AOAC International.18thed Published by the AOAC. Int. (revised edition), Gaithersburg, Maryland, U.S.A.

AOCS (2009). Official methods and recommended practices of the American Oil Chemists' Society (5th Ed.). Champaign, IL: AOCS Press.

AOCS Official Method Cd 12b-92 (1997). Oil stability index. Sampling and analysis of commercial fats and oils. methods and recommended practices of the American Oil Chemists' Society, 4th Ed., American Oil Chemists' Society, USA.

Azrina, A., P.H. Lim, I. Amin and A. Zulkairi (2009). Vitamin E and fatty acid composition of blended palm oil. J. Food Agric. Environ., 7 (2): 256-262.

Cai, Z., K. Li, W.J. Lee, M.T. Reaney, N. Zhang and Y. Wang (2021). Recent progress in the thermal treatment of oilseeds and oil oxidative stability: a review. Fundamental Res., 1 (6): 767-784.

Che Man, Y.B., G. Setiowaty and F.R. Van de Voort (1999). Determination of iodine value of palm oil by Fourier transform infrared spectroscopy. J. Ame. Oil Chem. Soc., 76 (6): 693-699.

Chu, Y.H. and K. Yu-Lang (1998). A study on vegetable oil blends. Food Chem., 62: 191-195.

De Souza, E.S., G. Belinato, R.L.S. Otero, É.C. A. Simêncio, S.C.M. Augustinho, W. Cupelupi, C. Conconi, L.C.F. Canale and G.E. Toten (2011). Thermal Oxidation Stability of Vegetable Oils as Metal Heat Treatment Quenchants. J. ASTM Int., 9: 1-30.

Dhyani, A., R. Chopra and M. Garg (2018). A Review on Blending of Oils and Their Functional and Nutritional Benefits. Chem. Sci. Rev. Lett., 7(27): 840-847.

Egyptian Standard Specifications (2017). ES: 999/2017 for Crude Edible Oils.

El-Anany, A.M. (2007). Influence of pomegranate (*Punica granatum*) peel extract on the stability of sunflower oil during deep fat frying process. Elect. J. Food and plants Chem., 2 (1): 14-19.

El-gazzar, M.I., M.G. Taha, H.Y. Yousef and H.E. Ali (2021). Physical and chemical properties of blended palm oil with other vegetable oils. Al-Azhar J. Agric. Res., 46 (2): 207-218.

Fadda, A., D. Sanna, E.H. Sakar, S. Gharby, M. Mulas, S. Medda, N.S. Yesilcubuk, A.C. Karaca, C.K. Gozukirmizi and M. Lucarini (2022). Innovative and Sustainable Technologies to Enhance the Oxidative Stability of Vegetable Oils. Sustainability, 14: 849: 1-29.

Ferrari, R.A., E. Schulte, W. Esteves, L. Brühl and K.D. Mukherjee (1996). Minor constituents of vegetable oils during industrial processing. J. Ame. Oil Chemists' Soc., 73 (5): 587-592.

Garg, M.; Wason, S.; Meena, P.L.; Chopra, R.; Sadhu, S.D. and Dhyani, A. (2021). Effect of frying on physicochemical properties of sesame and soybean oil blend. Journal of Applied and Natural Science, 13(3): 820-829.

González-Gamallo, S.; Salvador, M.D. and Fregapane, G. (2021). Design and Characteristics of Novel Sensory and Nutritionally Oriented Olive, Seed and Nut Virgin Oils' Blendings. European Journal of Lipid Science and Technology, 123(8): 2100008

Gotoh, N. and Wada, S. (2006). The importance of peroxide value in assessing food quality and food safety. JAOCS, Journal of the American Oil Chemists' Society, 83(5): 473-474.

Guiotto, E., Ixtaina, V., Nolasco, S. and Tomás, M. (2014). Effect of storage conditions and antioxidants on the oxidative stability of sunflower-chia oil blends. Journal of the American Oil Chemists' Society, 91: 767-776.

Gunstone, E. (2002). Sunflower seed and its products in form. 13: 159-163.

Hashem, H.A.; Shahat, M.; El-Behairy, S.A. and Sabry, A. (2017). Use of palm olein for improving the quality properties and oxidative stability of some vegetable oils during frying process. Middle East J. Appl. Sci., 7(1): 68-79.

Hashempour-Baltork, F.; Torbati, M.; Azadmard-Damirchi, S. and Savage, G.P. (2016). Vegetable oil blending: A review of physicochemical, nutritional and health effects. Trends in Food Science and Technology, 57: 52-58.

Heidarpour, M. and Farhoosh, R. (2018). A preliminary Rancimat based kinetic approach of detecting olive oil adulteration. LWT-Food Science and Technology, 90: 77-82.

Holohan, O.D.R. (1997). Malaysian palm oil: the story of major edible vegetable oil and its role in human nutrition. Kuala Lumpur: Malaysian Palm Oil Promotion Council.

Horuz, T.I. and M. Maskan (2015). Effect of the phytochemical's curcumin, cinnamaldehyde, thymol and carvacrol on the oxidative stability of corn and palm oils at frying temperatures. J. Food Sci. and Technol., 52 (12): 8041-8049.

Juárez, M.D.; Osawa, C.C.; Acuña, M.E.; Sammán, N. and Gonçalves, L.A.G. (2011). Degradation in soybean oil, sunflower oil and partially hydrogenated fats after food frying, monitored by conventional and unconventional methods. Food Control, 22(12): 1920-1927.

Kailas, M.; Talkit, D.; Mahajan, I. and Masand, V.H. (2013). Physicochemical Properties of Soybean oil and their Blends with Vegetable oils for the Evaluation of Lubrication Properties. India. J. chem. Biolog. Sci., 3: 490-497.

Kathleen, W. and Monoj, G. (2005). Potato Chips Quality and Frying Oil Stability of High Oleic Acid Soybean Oil. Journal of Food Science. 70(6): 395-400.

Kumar, P.P.; Bhatnagar, A.S.; Hemavathy, J. and Krishna, A.G. (2009). Changes in physico-chemical characteristics of some vegetable oils upon blending with coconut oil. J. Lipid Sci. Technol., 41(4): 136-142.

Lopez, P.M.; Trapani, N. and Sadras, V. (2002). Genetic improvement of sunflower in Argentina between 1930 and 1995. Dry matter partitioning and achene composition. Field Crop Res., 67(3): 215-221.

Lutterodt, H.; Slavin, M.; Whent, M.; Turner, E. and Yu, L.L. (2011). Fatty acid composition, oxidative stability, antioxidant and antiproliferative properties of selected cold-pressed grape seed oils and flours. Food Chemistry, 128(2): 391-399.

Madhujith, T. and Sivakanthan, S. (2019). Oxidative stability of edible plants oils. Springer Nature.

Metzner-Ungureanu, C.R.; Poiana, M.A.; Cocan, I.; Lupitu, A.I.; Alexa, E. and Moigradean, D. (2020). Strategies to Improve the Thermo-Oxidative Stability of Sunflower Oil by Exploiting the Antioxidant Potential of Blueberries Processing Byproducts. Molecules, 25(23): 5688.

Mohdaly, A.A.A.; Sarhan, M.A. and Mahmoud, A. (2010). Antioxidant efficacy of potato peels and sugar beet pulp extracts in vegetable oils protection. Food Chem., 123: 1019-1026.

Monotti, M. (2004). Growing non-Food sunflower in dry land conditions. Ital. J. Agro., 8(1): 3-8.

Mujeeda, B.; Prasad N., Hatna, S. (2016). Effect of antioxidant on thermal stability of vegetable oils using ultrasonic studies. Int. Food Res. J., 23: 528-536.

Naghshineh, M.; Ariffin, A.A.; Ghazali, H.M.; Mirhosseini, H. and Mohammad, A.S. (2010). Effect of saturated/unsaturated fatty acid ratio on physicochemical properties of palm olein-olive oil blend. J. Ame. Oil Chem. Soc., 87(3): 255-262.

Nangbes, J.G.; Nvau, J.B.; Buba, W.M. and Zukdimma, A.N. (2013). Extraction and characterization of castor (*Ricinus communis*) seed oil. Int. J. Eng. and Sci., 2(9): 105-109.

Neagu, A.A.; Nita, I., Boteze, E. and Geacais, S. (2013). A physico-chemical study for some edible oils properties. Ovidius University Ann. Chem., 24 (2): 121-126.

Odeh, D.; Kralji´c, K.; Benussi S.A. and Škevin, D. (2021). Oxidative Stability, Microbial Safety, and Sensory Properties of Flaxseed (*Linum usitatissimum* L.) Oil Infused with Spices and Herbs. Antioxidants, 10(5): 785.

Prathibha, S.V.; Anusha, R.; Jessie, S.W.; Anila, K.B.; Vijaya, L.V. and Uma, M.K. (2018). Physic-chemical, Functional and Sensory Properties of Vegetable Oil Blends. Current J. Appl. Sci. and Technol., 29 (4): 1-11.

Presa, O.S. and Lopez, M.C.S. (1995). Shelf-life prediction of an infant formula using an accelerated stability test (Rancimat). J. Agric. Food Chem., 43: 2879-2882.

Ramadan, M.F. and Mörsel, J.T. (2004). Oxidative stability of black cumin (*Nigella sativa* L.), coriander (*Coriandrum sativum* L.) and niger (*Guizotia abyssinica* Cass.) crude seed oils upon stripping. Eur. J. Lipid Sci. Technol., 106: 35-43.

Razali, I. (2005). Palm oil and palm olein Frying applications. Malaysian Palm Oil Board, No. 6, Persiaran Institute, Bandra Bar Bangi, Kajang, Selangor, Malaysia. Asia Pac. J. Clin. Nutr. 14(4): 414-419.

Sabbir, M.d.H.; Rownok, J.; Ashraful, A.M.D.; Khodeza, K.M.S. and Sharif, M.A. (2016). Study on physicochemical properties of Edible Oils Available in Bangladeshi Local Market. Department of Applied Chemistry and Chemical Technology, Islamic University, Kushit, Bangladesh. P. 2-5.

Sathianathan, R.V.; Kannapiran, A.; Govindan, J. and Periasamy, N. (2014). Profiling of fatty acid compositional alterations in edible oils upon heating using gas chromatography. Journal of Physical Science, 25(2): 1.

St-Onge, M.P.; Lamarche, B.; Mauger, J.F. and Jones, P.J. (2003). Consumption of a functional oil rich in phytosterols and medium-chain triglyceride oil improves plasma lipid profiles in men. J. Nutrition, 133(6): 1815-1820.

Taghvaei, M. and Jafari, S.M. (2015). Application and stability of natural antioxidants in edible oils in order to substitute synthetic additives. J. Food Sci. Technol., 52: 1272-1282.

Tilahun, M.; Agegnehu, A. and Alemayehu, M. (2018). Comparison of Physicochemical Properties of edible Vegetable Oils Commercially available in Bahir Dar, Ethiopia. Department of Chemistry, Science College, Bahir Dar University, P.O. Box79, Ethiopia. P. 130-134.

Tong, L.; Zhang, L.; Yu, S.H.; Chen, X.H. and Bi, K.S. (2007). Analysis of the fatty acids from Periploca sepium by GC-MS and GC-FID. Asian J. Tradit. Med., 2: 110-114.

Zhang, Na; Li, Y.; Wen, S.; Sun, Y.; Chen, J.; Gao, Y.; Sagymbek, A. and Yu, X. (2021). Analytical methods for determining the peroxide value of edible oils: A mini-review. Food Chemistry, 358: 129834.

الخصائص الفيزيائية والكيميائية والثبات التأكسدي لزيت النخيل المخلوط بزيت دوار الشمس وزيت فول الصويا

محمد أحمد البدوي – سامي محمد أبو المعاطي – نورهان عبدالحميد ربيع

قسم علوم الأغذية – كلية الزراعة – جامعة الزقازيق – مصر

أجريت هذه الدراسة لتعزيز الثبات التأكسدي لزيت فول الصويا وزيت عباد الشمس عن طريق مزجهما مع زيت النخيل لتكوين خلطات ثنائية. تم قياس الخواص الفيزيائية والكيميائية، معامل الانكسار، الأحماض الدهنية الحرة، قيمة البيروكسيد، قيمة الرقم اليودي، قيمة رقم التصبن وتركيب الأحماض الدهنية لزيت النخيل وخلطاته مع فول الصويا وزيوت عباد الشمس لتقييم الزيوت النقية وخلطاتها. أظهرت النتائج أن زيت النخيل النقي كان أفضل زيت مقارنة بزيت عباد الشمس وزيت فول الصويا، وكذلك خلط زيت النخيل بزيت دوار الشمس وزيت فول الصويا لتكوين خلطات ثنائية أدت إلى تعزيز الاستقرار التأكسدي لزيت عباد الشمس وزيت فول الصويا. وكان أفضل مزيج ثنائي يتكون من 50% زيت نخيل : 50% فول الصويا.

الكلمات الإسترشادية: مخاليط الزيوت، زيت النخيل، زيت دوار الشمس، زيت الصويا، الثبات التأكسدي، رقم البيروكسيد، رقم التصبن.

المحكمـــــون:

1- أ.د. أشرف مهدي عبدالحميد شروبة أستاذ الصناعات الغذائية - كلية الزراعة بمشتهر – جامعة بنها.

2- أ.د. عبدالرحمن محمد أحمد سليمان أستاذ الصناعات الغذائية – كلية الزراعة – جامعة الزقازيق.