Physical and Chemical Properties of Blended Palm Oil with Other Vegetable Oils.

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ABSTRACT

This study was conducted to enhancement the oxidative stability of soybean and sunflower oil by blending them with palm oil to form binary and triple 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 pure oils and their blends. Results revealed that pure 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 and triple blends led to the enhancement of oxidative stability of sunflower and soybean oil. The best binary blend was the blend which consists of 60% palm oil: 40% soybean, while the best triple blend was the blend which consists of 60% palm oil: 20% soybean: 20% sunflower oil.

Keywords: Palm Oil, Soybean Oil, Sunflower Oil, Blending, Free Fatty Acids, Frying Process.

INTRODUCTION

Palm oil is the major fat used in Egypt nowadays. It is one of the popular and increasingly used food ingredients by the food industries worldwide. Food processing industries have higher preference for palm oil due to the level of saturated fat that offers stability and higher resistant to oxidation when heating at high temperature (Azrina *et al*.,2009). Most of the vegetable oils contain a high level of polyunsaturated fatty acids (PUFA) which are more vulnerable to oxidative changes. The oxidative changes of PUFA produce various oxidation products such as trans fatty acids (TFA). These TFA possess undesirable metabolic side effects such as alteration of cellular metabolism and cell function (Holohan, 1997).

Soybean oil is one of the most widely used oil in the world. Soybean oil also is healthier than most other plant oils because of a good variety of essential fatty acids and sterol needed by the body to stay healthy (Kailas *et al.,* 2013). Previous studies also reported the importance of blended vegetable oils for improving the physical and chemical composition of blended oils and the blood lipids (St-Onge *et al.,* 2003).

Sunflower seeds contain a high amount of oil (40-50%) which is an important source of polyunsaturated fatty acids (linoleic acid) of potential health benefits (Lopez *et al,.* 2000 and Monotti, 2004).

The fatty acid composition of sunflower oil makes it very important oil to be used for cooking.it is considered highly polyunsaturated oil due to its high linoleic acid content (48.3 to 74.0%) and its moderate oleic acid content (14.0 to 39.4%) and low level of saturated fatty acid content (12%). These fatty acids are essential fatty acid to the body because it cannot be synthesized by the body. (Gunstone, 2002).

Therefore, this study was carried to study and evaluate the physico-chemical properties of blended palm oil with soybean and sunflower oils during potato frying.

MATERIALS AND METHODS

Materials:

Palm oil and sunflower oil were obtained from Egypt Foods Group for food industries. Soybean oil was purchased from Tanta Company of Oil and Soap. Potatoes were obtained from Egypt Foods Group for food industries.

Blended palm oil with sunflower and soybean oil were prepared by mixing palm oil with soybean and sunflower oils in different ratio as follow:

Methods:

Refractive index, free fatty acids, peroxide value, iodine value, saponification value were determined according to the A.O.A.C. (2011).

Preparation and identification of fatty acids were detected according to Hamed *et al.,* (2012).

RESULTS AND DISCUSSION

Physical and chemical properties of pure oils. "Palm oil, soybean oil and sunflower oil".

Free fatty acids:

During frying, oil is exposed to air and moisture at elevated temperatures resulting in hydrolysis of triacylglycerol. This causes the release of free fatty acids. The released fatty acids are more susceptible to thermal oxidation and cause off flavors and odors in the frying medium and fried foods Horuz and Maskan, (2015).

Data presented in Table (2) and Fig. (1) revealed that the free fatty acids of oils increased with increasing frying time. The free fatty acids of oils (palm oil, sunflower and soybean oil were 0.047%, 0.056% and 0.048%, respectively) increased after frying, but palm oil recorded the least free fatty acids compared to soybean oil and sunflower oil (palm oil, sunflower and soybean oil were 0.15% , 0.158% and 0.156%, respectively). These results are in agreement with Hashem *et al.,* (2017); Razali Ismail. (2005); Kathleen Warner and Monoj Gupta. (2005) and Angeles Guinda *et al*., (2003).

It is worth to mention that the free fatty acids for the tested palm oil, soybean oil and sunflower oil were in conformity with the Egyptian Standard Specifications, number 999(2017) for the crude edible oils.

Peroxide value:

Peroxide value (P.V) is a widely-used method in monitoring the initial stage of lipid oxidation and reflects the concentration of peroxides and hydroperoxides.

Data in Table (2) and Fig (1) exhibited the peroxide value of pure oils (palm oil, sunflower and soybean oil were 0.39 meq. O2/Kg, 0.40 meq. O2/Kg and 0.39 meq.O2/Kg, respectively). It could be observed that the P.V of all samples was elevated after frying, but palm oil exhibited the least peroxide value compared to soybean oil and sunflower oil (palm oil, sunflower and soybean oil were 0.48 meq.O2/Kg, 0.51 meq.O2/Kg and 0.49 meq.O2/Kg, respectively).

These results are in agreement with Hashem *et al.,* (2017); Sabir Hasan. *et al.,* (2016); Prathibha *et al.,* (2018) and Tilahun Mengistie *et al.,* (2018).

It is worth to mention that the peroxide value for the tested palm oil, soybean oil and sunflower oil were in conformity with the Egyptian Standard Specifications, number 999 (2017) for the crude edible oils.

Iodine value:

Iodine value is a measure of overall unsaturation and is widely to characterize oils and fats. Thus, a decrease in iodine value of consistent with the decreasing number of double bonds in oil as it becomes oxidized. The high in the iodine value is corresponding with unsaturation of the oil (Che- Man and Tan, 1999).

The effect of frying on IV value is showed in Table (2) and Fig. (1) during the course of frying. It was revealed from the obtained data that the iodine values decreased after the period of frying. The initial value of iodine value of oils (palm oil, sunflower and soybean oil) before frying were 51, 132 and 140 I2/100g, respectively, while a dropping into 49, 130 and 137 I2/100g for oils (palm oil, sunflower and soybean oil respectively) after the period of frying.

These results were in close agreement with those reported by Tynek *et al.* (2001) who reported that the decrease in iodine value with the increase of frying cycle could be attributed to the changes occurred in fatty acids during frying process.

It is worth to mention that the iodine value for the tested palm oil, soybean oil and sunflower oil were in conformity with the Egyptian Standard Specifications, number 999 (2017) for the crude edible oils.

Saponification value:

Data presented in Table (2) and Fig. (1) indicated that the saponification value were before frying 200 mg KOH/g and after frying 199 mg KOH/g, before frying 192 mg KOH/g and after frying 190 mg KOH/g and before frying 191 mg KOH/g after frying 189 mg KOH/g, for palm oil, soybean oil and sunflower oil, respectively, Akinola *et al.,* (2010) These results correspond to the results, It is worth to mention that the saponification value for the tested palm oil, soybean oil and sunflower oil were in conformity with the Egyptian Standard Specifications, number 999 (2017) for the crude edible oils.

Refractive index:

Refractive index is one of the most important physical parameters which used in the identification of fats and oils, as it is useful for estimating the degree of saturation of oils. Results in Table (2) and Fig. (1) show that there is a mild increase in the RI of oils and blends

during that course of frying process. The initial value of RI were 1.4460, 1.4630 and1.4630 for palm oil, sunflower and soybean oils, respectively against 1.4540, 1.4730 and 1.4730 at the end of frying process.

These results are in agreement with El-Anany (2007) who reported that frying process caused conversion of some of the non-conjugated double bonds into conjugated ones. This reaction led to mild increase in the refractive index.

It is worth to mention that the refractive index for the tested palm oil, soybean oil and sunflower oil were in conformity with the Egyptian Standard Specifications, number 999 (2017) for the crude edible oils.

Fatty acid composition of pure oils.

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 (49.70%) oleic acid ($C_{18:1}$) and 34.90% palmitic acid ($C_{16:0}$), these results are in agreement with Naghshineh *et al.* (2010). whereas sunflower and soybean oils contained a lower level of oleic acid was found to be (18.80 %), (23.18 %), respectively. On the other hand Linoleic acid values were (67.80 %) and (49.56 %) for sunflower and soybean oils respectively. From the Table (3) it noted that samples of 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.

These results are in agreement with Juárez *et al.* (2011) who found that fresh soybean oil was composed of 10.3% of palmitic acid ($C_{16:0}$), 4.9% of stearic acid ($C_{18:0}$), 21.5% of oleic acid ($C_{18:1}$), 53.4% of linoleic acid ($C_{18:2}$) and 5.1% of linolenic acid ($C_{18:3}$). also Ferrari *et al.* (1996) found that the fatty acids composition of refined soybean oil were 11.2% $C_{16:0}$, 0.1% $C_{17:0}$, 3.5% $C_{18:0}$, 24.9% $C_{18:1}$, 50.2% $C_{18:2}$, 3.5% $C_{18:3}$, 0.4% $C_{20:0}$, 0.4% $C_{20:1}$, 0.5% $C_{22:0}$ and 0.2% $C_{24:0}$. The obtained data fatty acid profile is shown in Table (3).

The effect of frying process on the fatty acid composition in pure oils are presented in Table (3), mild changes were found for all fatty acids, the level of polyunsaturated fatty acids such as linoleic acid (18:2) decreased, whereas saturated fatty acids such as palmitic acid (16:0) increased in close agreement with Suleiman *et al*. (2006).

Data presented in Table (3) showed that the change percentage of total saturated fatty acids (TSFA), and total unsaturated fatty acids (TUSFA).

Physical and chemical properties of binary blends:

Free fatty acids:

Free fatty acids (FFAs) are the primary initial breakdown products resulting from triglyceride degradation the percentage of FFA is not linearly related to the degradation of the oil, so it should not be the only one index of the oil quality during process. As the result of heat, light, and oxidation, the FFAs are converted into a variety of other polar molecules. Results in Table (4) and Figure (3) indicate that the changes in free fatty acids content of binary blends during frying period. The initial values of FFA 0.02 and 0.06 for PO: SO and PO: SF blends respectively. Concerning fried SO and SF oil after 210 min were 0.53 and 0.49 respectively. Regarding PO: SF, commercial sample and PO: SF: SO blends FFA were 0.36, 0.38 and 0.39 respectively. These results are in agreement with Che-Man and Tan (1999) they reported that the increase in FFA levels were due to the cleavage and oxidation of double bonds to form carbonyl compounds which oxidized to low molecular fatty acids during frying treatments Furthermore, it is expected that water supplied from fried potato accelerated the hydrolysis cleavage of the oil.

Data presented in Table (4) and Fig. (3) indicated that the changes in free fatty acids content of binary blends during frying period. The initial value of free fatty acids of binary blended (palm oil and soybean oil) 80% palm oil : 20% soybean oil, 70% palm oil : 30% soybean oil and 60% palm oil : 40% soybean oil were 0.045%, 0.046 and 0.047% respectively. Concerning blends 80% palm oil: 20% soybean oil, 70% palm oil: 30% soybean oil and 60% palm oil: 40% soybean oil were 0.148, 0.151 and 0.138, respectively.

peroxide value:

The PV is expressed as mill equivalents oxygen per kg of fat/oil (Nawar, 1996).

Data presented in Table (4) and Fig. (3) illustrated that peroxide value of binary blended (palm oil and soybean oil) 80% palm oil : 20% soybean oil, 70% palm oil : 30% soybean oil and60% palm oil : 40% soybean oil were 0.45 meq.O2/Kg, 0.38 meq.O2/Kg and 0.38 meq.O2/Kg, respectively. At the end of the frying period, PV increased significantly, where the blends recorded 0.58 meq.O2/Kg, 0.54 meq.O2/Kg and 0.48 meq.O2/Kg of 80%

palm oil : 20% soybean oil, 70% palm oil : 30% soybean oil and 60% palm oil : 40% soybean oil, respectively. This is in agreement with the findings of Guillén and Ruiz (2005).

Iodine value:

Data presented in Table (4) and Fig. (3) illustrated that iodine value of binary blended (palm oil and soybean oil) 80% palm oil : 20% soybean oil, 70% palm oil : 30% soybean oil and 60% palm oil : 40% soybean oil were 72 gI2/100g, 84 gI2/100g and 103 gI2/100g, respectively. After frying the iodine value decreased into 70 gI2/100g, 82 gI2/100g and 101 gI2/100g of 80% palm oil : 20% soybean oil, 70% palm oil : 30% soybean oil and 60% palm oil : 40% soybean oil, respectively. these results were in close agreement with those reported by Tynek *et al.,* (2001) who reported that the decrease in iodine value with the increase of frying cycle could be attributed to the changes occurred in fatty acids during frying process.

Saponification value:

Data presented in Table (4) and Fig. (3) indicated that saponification value of binary blended (palm oil and soybean oil) 80% palm oil: 20% soybean oil was 198 mg KOH/g before frying and 196 mg KOH/g after frying, 70% palm oil: 30% soybean oil was 196 mg KOH/g before frying and 195 mg KOH/g after frying, 60% palm oil: 40% soybean oil was 196 mg KOH/g before frying and 194 mg KOH/g after frying. These results correspond to the results, Kailas Talkit *et al.,* (2012), is worth to mention that the saponification value for the tested binary blended "palm oil and soybean oil " were in conformity with the Egyptian Standard Specifications, number 999 (2017) for the crude edible oils.

Refractive index:

Data presented in Table (4) and Fig. (3) indicated that refractive index of binary blended (palm oil and soybean oil) 80% palm oil : 20% soybean oil, 70% palm oil : 30% soybean oil and 60% palm oil : 40% soybean oil were1.4550, 1.4550 and 1.4590, respectively. After frying the refractive index changed into 1.4560, 1.4560 and 1.4610, of 80% palm oil: 20% soybean oil, 70% palm oil: 30% soybean oil and 60% palm oil: 40% soybean oil, respectively.

Fatty acid composition of Binary blended:

Fatty acid composition, percent of saturated fatty acids, percent of mono-unsaturated fatty acids and percent of poly-unsaturated fatty acids of binary blended (palm oil and soybean oil) were identified by GLC apparatus and the obtained results are summarized in Table (5) and Fig. (4).

Data presented in Table (5) and Fig. (4) indicated that the main components in binary blended (palm oil and soybean oil) before frying 80%PO:20%SB were percent of total saturated fatty acids were 36.07%.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%., percent of total mono-unsaturated fatty acids were 50.53%. Palmetoleic acid was 0.20%. and Oleic acid was 50.33%. and percent of total poly-unsaturated fatty acids were 13.40%. Linoleic acid was 13.20%. and Linolenic acid was 0.20%. and after frying 80%PO:20%SB were percent of total saturated fatty acids were 36.43%.Lauric acid was 0.18%.,Merestic acid was 0.85%.,Palmetic acid was 28.75%.,Stearic acid was 6.45%. and Arachidic acid was 0.20%., percent of total mono-unsaturated fatty acids were 48.56%. Palmetoleic acid was 0.20%. and Oleic acid was 48.36%. and percent of total poly-unsaturated fatty acids were 15%. Linoleic acid was 14.80%. and Linolenic acid was 0.21%., before frying 70%PO:30%SB were percent of total saturated fatty acids were 34.37%.Lauric acid was 0.20%.,Merestic acid was 1.15%.,Palmetic acid was 27.10%.,Stearic acid was 5.76%. and Arachidic acid was 0.16%., percent of total mono-unsaturated fatty acids were 51.95%. Palmitoleic acid was 0.15%. and Oleic acid was 51.80%. and percent of total poly-unsaturated fatty acids were 13.68%. Linoleic acid was 13.50%. and Linolenic acid was 0.18%. and after frying 70%PO:30%SB the percentage of total saturated fatty acids were 36.28%. Lauric acid was 0.20%., Merestic acid was 0.80%., Palmetic acid was 28.60%., Stearic acid was 6.40%. and Arachidic acid was 0.28%., percent of total mono-unsaturated fatty acids were 47.48%. Palmetoleic acid was 0.18%. and Oleic acid was 47.30%. and percent of total poly-unsaturated fatty acids were 16%. Linoleic acid was 15.88%. and Linolenic acid was 0.36%., before frying 60%PO:40%SB the percent of total saturated fatty acids were 33.51%. Lauric acid was 0.20%., Merestic acid was 1.16%., Palmetic acid was 26.20%., Stearic acid was 5.80%. and Arachidic acid was 0.15%., percent of total mono-unsaturated fatty acids were 52.37%. Palmetoleic acid was 0.12%. and Oleic acid was 52.25%. and percent of total poly-unsaturated fatty acids were 14.12%. Linoleic acid was 13.90%. and Linolenic acid was 0.22%. and after frying 60%PO:40%SB the percent of total saturated fatty acids were 35.74%. Lauric acid was 0.16%., Merestic acid was 0.75%., Palmetic acid was 28.16%., Stearic

acid was 6.30%. and Arachidic acid was 0.37%., percent of total mono-unsaturated fatty acids were 47.31%. Palmetoleic acid was 0.11%. and Oleic acid was 47.20%. and percent of total poly-unsaturated fatty acids were 17%. Linoleic acid was 16.53%. and Linolenic acid was 0.42%.

Physical and chemical properties of Triple blended:

Free fatty acids:

Data presented in Table (6) and Fig. (5) revealed that free fatty acids of triple blended (palm oil, soybean oil and sunflower oil) 80% palm oil : 10% soybean oil : 10% sunflower oil was 0.050% before frying and 0.157% after frying, 70% palm oil : 15% soybean oil : 15% sunflower oil was 0.051% before frying and 0.157% after frying and 60% palm oil : 20% soybean oil : 20% sunflower oil was 0.047% before frying and 0.158% after frying, These results correspond to the results, Kailas Talkit *et al*., (2012). It is worth to mention that the free fatty acids 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.

Peroxide value:

Data presented in Table (6) and Fig. (5) revealed that peroxide value of triple blended (palm oil, soybean oil and sunflower oil) 80% palm oil : 10% soybean oil : 10% sunflower oil was 0.49 meq.O2/Kg before frying and 0.54 meq.O2/Kg after frying, 70% palm oil : 15% soybean oil : 15% sunflower oil was 0.49 meq.O2/Kg before frying and 0.58 meq.O2/Kg after frying and60% palm oil : 20% soybean oil : 20% sunflower oil was 0.41 meq.O2/Kg before frying and 0.61 meq.O2/Kg after frying. are worth to mention that the peroxide value 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 edible oils crude

Iodine value:

Data presented in Table (6) and Fig. (5) illustrated that iodine value of triple blended (palm oil, soybean oil and sunflower oil) 80% palm oil : 10% soybean oil : 10% sunflower oil was 73 gI2/100g before frying and 71 gI2/100g after frying, 70% palm oil : 15% soybean oil : 15% sunflower oil was 83 gI2/100g before frying and 80 gI2/100g after frying and 60% palm oil : 20% soybean oil : 20% sunflower oil was 93 gI2/100g before frying and 90 gI2/100g after frying, These results correspond to the results, Kailas Talkit *et al.*, (2012), is worth to mention that the iodine value 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.

Saponification value:

Data presented in Table (6) and Fig. (5) indicated that saponification value of triple blended (palm oil , soybean oil and sunflower oil) 80% palm oil : 10% soybean oil : 10% sunflower oil was 196 mg KOH/g before frying and 192 mg KOH/g after frying, 70% palm oil : 15% soybean oil : 15% sunflower oil was 194 mg KOH/g before frying and 190 mg KOH/g after frying and 60% palm oil : 20% soybean oil : 20% sunflower oil was 193 mg KOH/g before frying and 188 mg KOH/g after frying. These results correspond to the results, Kailas Talkit et al., (2012), is worth to mention that the saponification value 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.

Refractive index:

Data presented in Table (6) and Fig. (5) indicated that refractive index of triple blended (palm oil, soybean oil and sunflower oil) 80% palm oil: 10% soybean oil: 10% sunflower oil was 1.4540 before frying and 1.4560 after frying, 70% palm oil: 15% soybean oil: 15% sunflower oil was 1.4560 before frying and 1.4590 after frying and 60% palm oil: 20% soybean oil: 20% sunflower oil was 1.4590 before frying and 1.4610 after frying. 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.

Fatty acid composition of triple blended:

Fatty acid composition, percent of saturated fatty acids, percent of mono-unsaturated fatty acids and percent of poly-unsaturated fatty acids of triple blended (palm oil, soybean oil and sunflower oil) were identified by GLC apparatus and the obtained results are summarized in Table (7) and Fig.(6) .

Data presented in Table (7) and Fig. (6) indicated that the main components in binary blended (palm oil, soybean oil and sunflower oil) before frying 80%PO:10%SB:10%SF were percent of total saturated fatty acids were 38.84%.,Lauric acid was 0.25%.,Merestic acid was 1.26%.,Palmetic acid was 32.90%., Stearic

acid was 4.17%. and Arachidic acid was 0.26%., percent of total mono-unsaturated fatty acids were 48.31%. Palmetoleic acid was 0.11%. and Oleic acid was 48.20%. and percent of total poly-unsaturated fatty acids were 12.85%. Linoleic acid was 12.55%. and Linolenic acid was 0.30%. and after frying 80%PO:10%SB:10%SF were percent of total saturated fatty acids were 35.73%.,Lauric acid was 0.22%.,Merestic acid was 1.16%.,Palmetic acid was 30.60%., Stearic acid was 3.43%. and Arachidic acid was 0.32%., percent of total mono-unsaturated fatty acids were 51.16%. Palmetoleic acid was 0.21%. and Oleic acid was 50.95%. and percent of total poly-unsaturated fatty acids were 13.11%. Linoleic acid was 12.81%. and Linolenic acid was 0.30%., before frying 70%PO:15%SB:15%SF were percent of total saturated fatty acids were 36.10%.,Lauric acid was 0.28%.,Merestic acid was 1.20%.,Palmetic acid was 30.50%., Stearic acid was 3.90%. and Arachidic acid was 0.22%., percent of total mono-unsaturated fatty acids were 50.90%. Palmetoleic acid was 0.10%. and Oleic acid was 50.80%. and percent of total poly-unsaturated fatty acids were 13.00%. Linoleic acid was 12.70%. and Linolenic acid was 0.30%. and after frying 70%PO:15%SB:15%SF the percent of total saturated fatty acids were 34.14%., Lauric acid was 0.20%., Merestic acid was 1.10%., Palmetic acid was 29.30%., Stearic acid was 3.32%. and Arachidic acid was 0.22%., percent of total mono-unsaturated fatty acids were 52.65%. Palmetoleic acid was 0.15%. and Oleic acid was 52.50%. and percent of total poly-unsaturated fatty acids were 13.21%. Linoleic acid was 12.95%. and Linolenic acid was 0.26%. and before frying 60%PO:20%SB:20%SF were percent of total saturated fatty acids were 33.74%.,Lauric acid was 0.30%.,Merestic acid was 1.10%.,Palmetic acid was 28.34%., Stearic acid was 3.80%. and Arachidic acid was 0.20%., percent of total mono-unsaturated fatty acids were 52.90%. Palmetoleic acid was 0.10%. and Oleic acid was 52.80%. and percent of total poly-unsaturated fatty acids were 13.36%. Linoleic acid was 13.10%. and Linolenic acid was 0.26%. and after frying 60%PO:20%SB:20%SF were percent of total saturated fatty acids were 32.44%.,Lauric acid was 0.16%.,Merestic acid was 1.00%.,Palmetic acid was 27.90%., Stearic acid was 3.20%. and Arachidic acid was 0.18%., percent of total mono-unsaturated fatty acids were 53.86%. Palmetoleic acid was 0.10%. and Oleic acid was 53.76%. and percent of total poly-unsaturated fatty acids were 13.70%. Linoleic acid was 13.50%. and Linolenic acid was 0.20%.

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Table 1: proportions sample of PO: SB, PO: SF and PO: SB: SF in blended oils.

	palm oil	soybean		palm oil	Sunflower		palm oil	soybean	sunflower
Group (A)	90	10	Group (B)	90	10	Group (C)	90	5	5
	80	20		80	20		80	10	10
	70	30		70	30		70	15	15
	60	40		60	40		60	20	20
	50	50		50	50		50	25	25

Table 2: Physical and chemical properties of pure oils.

Properties	pure oils					
	PO		SB		SF	
	B.F	A.F	B.F	A.F	B.F	A.F
FFA	0.047	0.15	0.056	0.158	0.048	0.156
PV	0.39	0.48	0.40	0.51	0.39	0.49
IV	51	49	140	137	132	130
SV	200	199	192	190	191	189
RI	1.4460	1.4540	1.4630	1.4730	1.4630	1.4730

Table 3: Fatty acids composition of pure oils.

Fatty Acids	pure oils					
	PO		SB		SF	
	B.F	A.F	B.F	A.F	B.F	A.F
Lauric	0.20	0.23	0.21	0.11	0.30	0.46
Merestic	1.00	0.86	0.43	0.26	1.92	2.00
Palmitic	34.90	36.40	16.50	18.80	6.80	8.70
Palmitoleic	0.10	0.15	1.17	1.09	0.82	0.73
Stearic	4.50	5.45	3.15	2.22	2.90	3.20
Oleic	49.70	47.60	23.18	25.32	18.80	20.10
Linoleic	9.00	8.51	49.56	47.23	67.80	64.20
Linolenic	0.30	0.40	3.50	2.86	0.30	0.24
Arachidic	0.30	0.40	2.30	2.11	0.36	0.37
Total Saturated	40.90	43.34	22.59	23.50	12.28	14.73
Total mono-Unsaturated	49.80	47.75	24.35	26.41	19.62	20.83
Total poly-Unsaturated	9.30	8.91	53.06	50.09	68.10	64.44

Table 4: Physical and chemical properties of binary blended.

Properties	Palm oil: Soybean oil					
	80%PO:20%SB		70%PO:30%SB		60%PO:40%SB	
	B.F	A.F	B.F	A.F	B.F	A.F
FFA	0.045	0.148	0.046	0.151	0.047	0.138
PV	0.45	0.58	0.38	0.54	0.38	0.48
IV	72	70	84	82	103	101
SV	198	196	196	195	196	194
RI	1.4550	1.4560	1.4550	1.4560	1.4590	1.4610

Table 5: Fatty acids composition of Binary blended.

Fatty Acids	Palm oil : Soybean oil					
	80%PO:20%SB		70%PO:30%SB		60%PO:40%SB	
	B.F	A.F	B.F	A.F	B.F	A.F
Lauric	0.25	0.18	0.20	0.20	0.20	0.16
Merestic	1.11	0.85	1.15	0.80	1.16	0.75
Palmitic	28.82	28.75	27.10	28.60	26.20	28.16
Palmitoleic	0.20	0.20	0.15	0.18	0.12	0.11
Stearic	5.65	6.45	5.76	6.40	5.80	6.30
Oleic	50.33	48.36	51.80	47.30	52.25	47.20
Linoleic	13.20	14.80	13.50	15.88	13.90	16.53
Linolenic	0.20	0.21	0.18	0.36	0.22	0.42
Arachidic	0.24	0.20	0.16	0.28	0.15	0.37
Total Saturated	36.07	36.43	34.37	36.28	33.51	35.74
Total mono-Unsaturated	50.53	48.56	51.95	47.48	52.37	47.31
Total poly-Unsaturated	13.40	15.01	13.68	16.24	14.12	16.95

Table 6: Physical and chemical properties of triple blended.

Properties	Palm oil: Soybean oil : Sunflower oil					
	80%PO:10%SB:10%SF		70%PO:15%SB:15%SF		60%PO:20%SB:20%SF	
	B.F	A.F	B.F	A.F	B.F	A.F
FFA	0.05	0.147	0.051	0.157	0.047	0.158
PV	0.49	0.54	0.49	0.58	0.41	0.61
IV	73	71	83	80	93	90
SV	196	192	194	190	193	188
RI	1.4540	1.4560	1.4560	1.4590	1.4590	1.4610

Table 7: fatty acids composition of triple blended oils.

Fatty Acids	Palm oil : Soybean oil : Sunflower oil					
	80%PO:10%SB:10%SF		70%PO:15%SB:15%SF		60%PO:20%SB:20%SF	
	B.F	A.F	B.F	A.F	B.F	A.F
Lauric	0.25	0.22	0.28	0.20	0.30	0.16
Merestic	1.26	1.16	1.20	1.10	1.10	1.00
Palmetic	32.90	30.60	30.50	29.30	28.34	27.90
Palmetoleic	0.11	0.21	0.10	0.15	0.10	0.10
Stearic	4.17	3.43	3.90	3.32	3.80	3.20
Oleic	48.20	50.95	50.80	52.50	52.80	53.76
Linoleic	12.55	12.81	12.70	12.95	13.10	13.50
Linolenic	0.30	0.30	0.30	0.26	0.26	0.20
Arachidic	0.26	0.32	0.22	0.22	0.20	0.18
Total Saturated	38.84	35.73	36.10	34.14	33.74	32.44
Total mono-Unsaturated	48.31	51.16	50.90	52.65	52.90	53.86
Total poly-Unsaturated	12.85	13.11	13.00	13.21	13.36	13.70

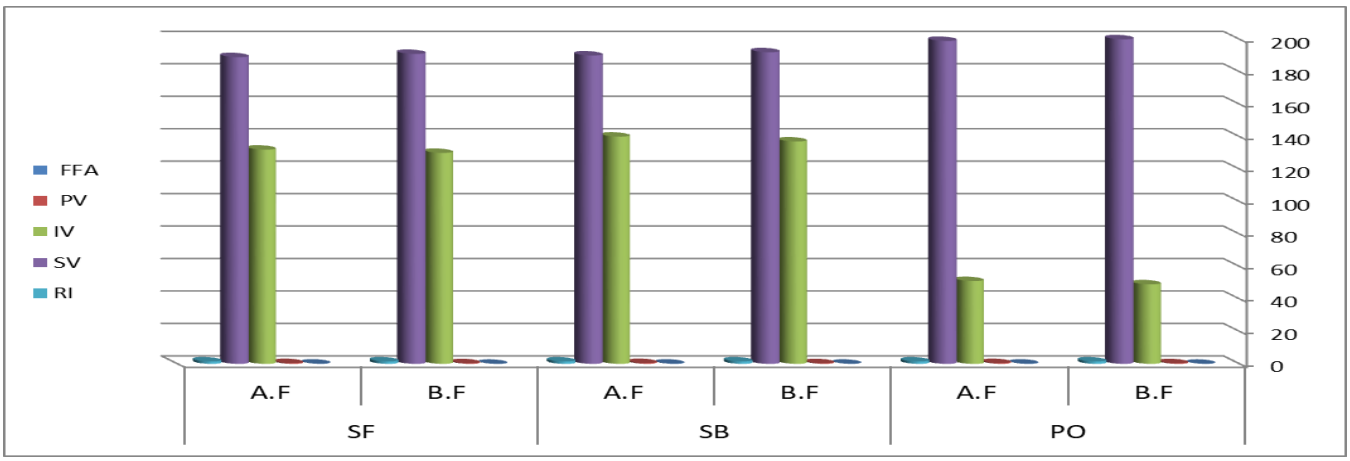

Figure 1: Physical and chemical properties of pure oils.

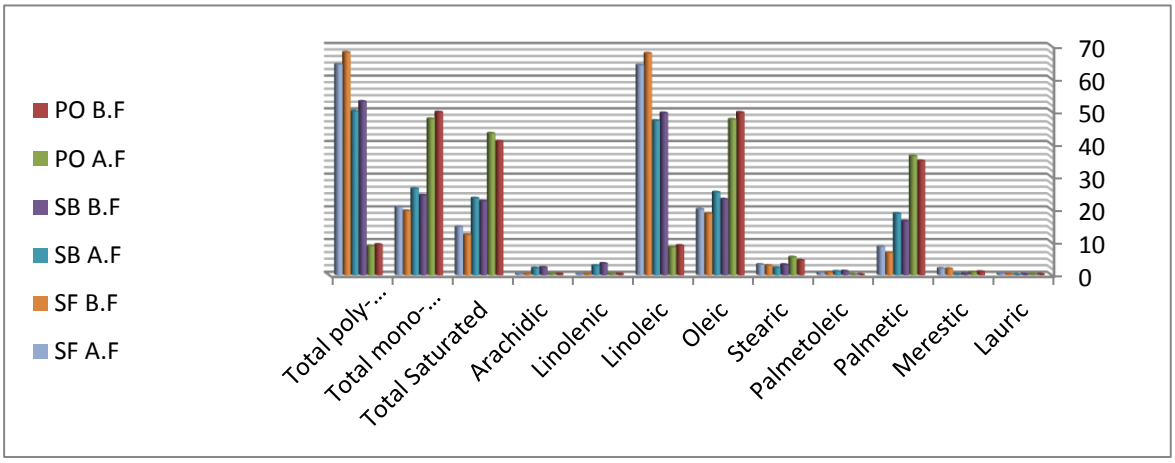

Figure 2: Fatty acids composition of pure oils.

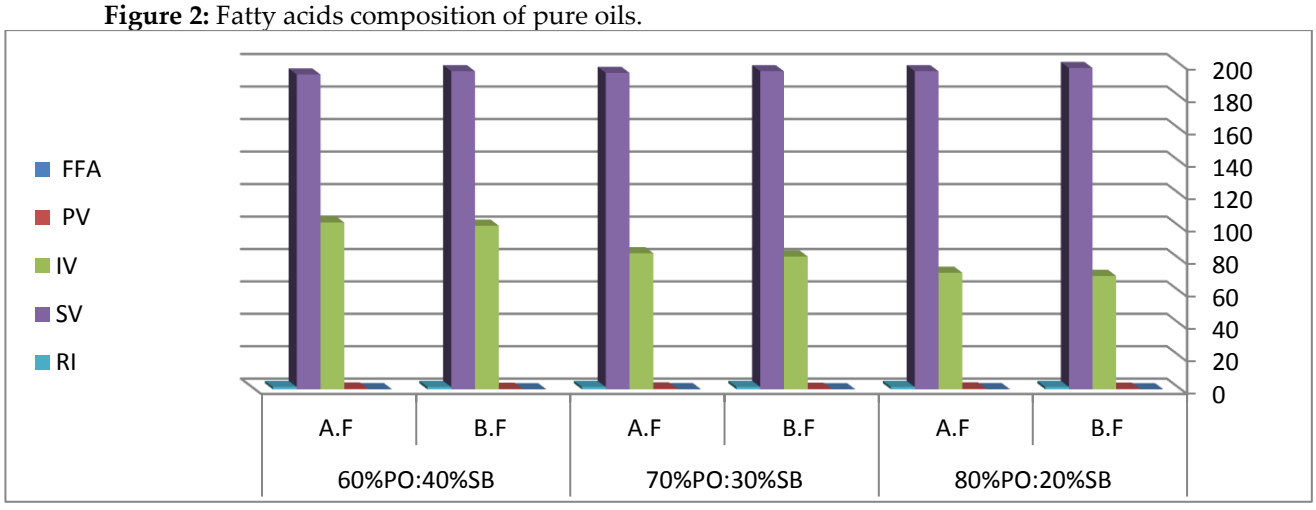

Figure 3: Physical and chemical properties of binary blended

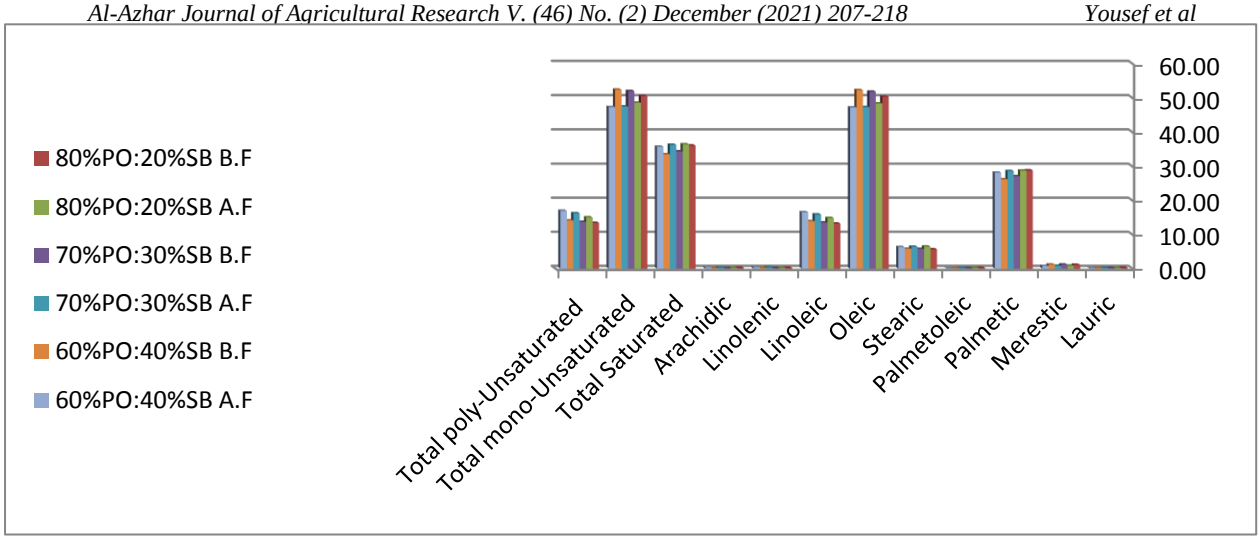

Figure 4: Fatty acids composition of Binary blended

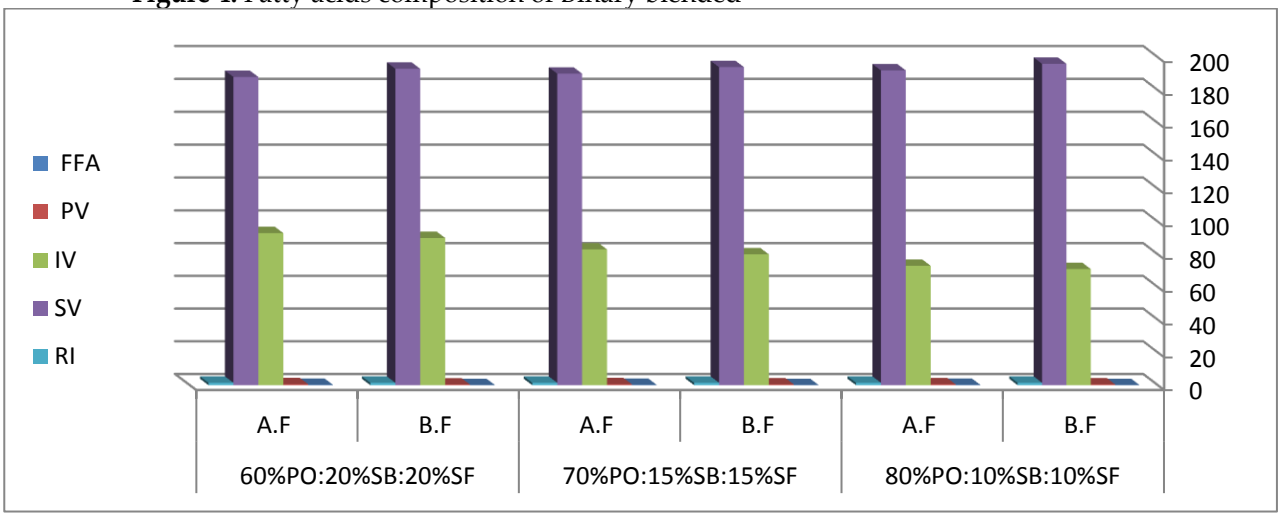

Figure 5: Physical and chemical properties of triple blended

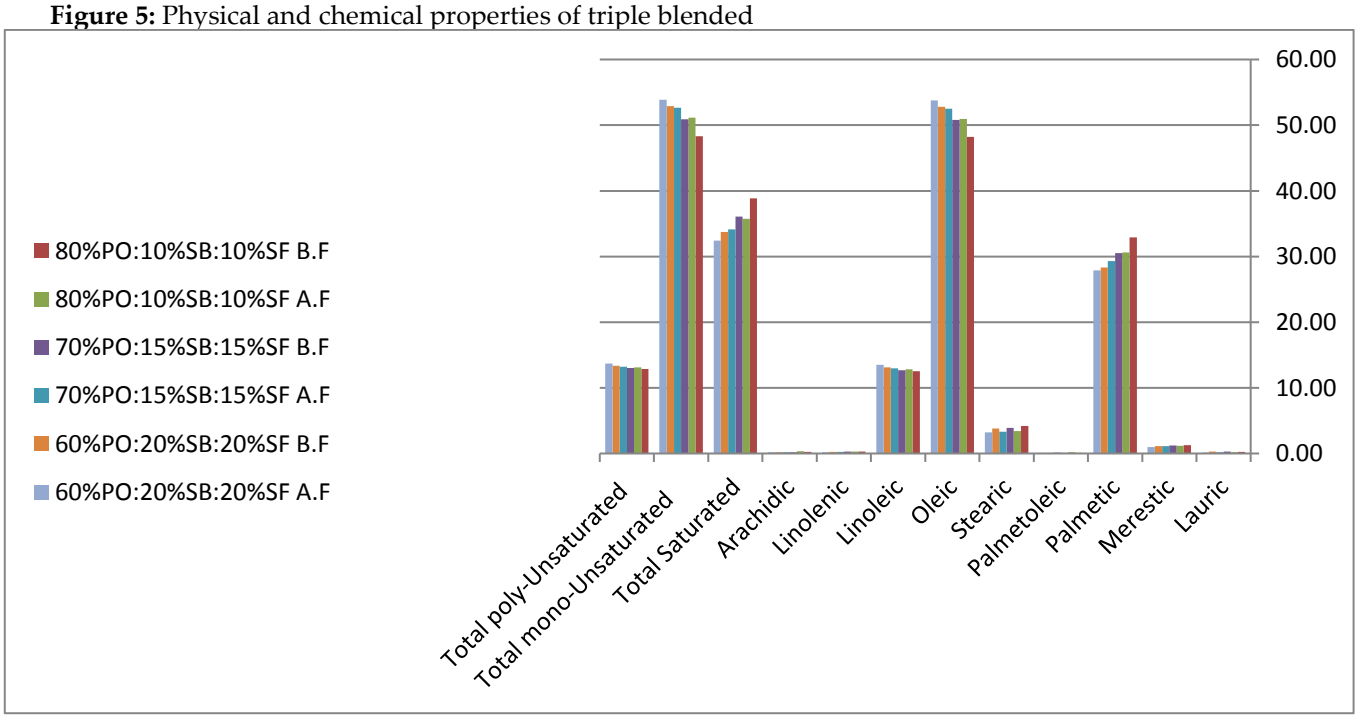

Figure 6: fatty acids composition of triple blended oils

الخصائص الفيزيائية والكيميائية لزيت النخيل المخلوط مع زيوت نباتية أخرى

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الملخص العربى

تم خلط زيت النخيل مع زيت فول الصويا وزيت زهرة الشمس لتحسين قابليته فى الأسواق من حيث نقطة الإنصار ومدة صلاحيته. وتم تحديد وتقيم الخصائص الفيزيائية والكيميائية (الأحماض الدهنية الحرة ، ورقم البيروكسيد، والرقم اليودى، ورقم التصبن، ومعامل الانكسار). والأحماض الدهنية لزيت الأولين وخلطاته مع زيت الصويا وزيت زهرة الشمس أظهرت النتائج أن زيت النخيل الخام كان الأفضل مقارنة بزيت الصويا وزيت زهرة الشمس، وخلط زيت النخيل مع زيت الصويا وزيت زهرة الشمس لتكوين خلطات ثنائية وثلاثية أدت إلى تعزيز الإستقرار التأكسدى لزيت الصويا وزيت زهرة الشمس. وكانت أفضل الخلطات الثنائية هى 60% زيت النخيل : 40%زيت الصويا، بينما أفضل الخلطات الثلاثية هى 60% زيت النخيل : 20% زيت الصويا : 20% زيت زهرة الشمس.

الكلمات الاسترشادية: زيت النخيل, زيت الصويا, زيت زهرة الشمس, الخلط, الحماض الدهنية الحرة,عملية القلى