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ENHANCEMENT OF COMPOSITION AND OXIDATIVE STABILITY OF SUNFLOWER AND SOYBEAN OIL BY BLENDING WITH PALM OIL

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ABSTRACT

The objective of this research was to create vegetable oil blends for food that had higher oxidative stability than pure sunflower and soybean oil. The following proportions of sunflower, soybean, and palm oil were evaluated when they were blended: 50:50 (v/v). A 45-day, 60 °C, accelerated storage test was performed. We calculated the free fatty acid level, fatty acid composition, induction time, and primary and secondary oxidation products. In comparison to sunflower 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.

1.Introduction

Edible oils may deteriorate as a result of lipid oxidation while being stored, handled, or prepared. Oil quality is primarily lost due to oxidation, which also reduces oil's nutritional content and produces unfavourable off-flavors that make oils containing food less appealing to customers. Additionally, the oxidation of lipids results in the production of some toxic by-products such reactive carbonyl compounds (RCCs), which have the potential to produce advanced lipid peroxidation end products (ALEs) that could be dangerous to human health (Guillén et al, 2005). The degree of lipid oxidation is determined by both the internal characteristics of the oil, such as its degree of unsaturation, the presence of antioxidant compounds or metals like copper and iron, and the exterior characteristics of the oil, such as the oxygen content and temperature. Oils that come into touch with oxygen trigger chain reactions that advance more quickly at higher temperatures and with higher lipid unsaturation levels (Fadda et al, 2022).

Due to the rising trend of replacing hydrogenated oils with saturated fatty acids (SFAs) with monounsaturated (MUFAs) and polyunsaturated fatty acids (PUFAs), which are regarded as healthier by consumers but are much more prone to oxidation than SFAs, lipid peroxidation is a major concern for the food industry. Additionally, when heated to deep-frying or cooking temperatures, oils high in MUFAs and PUFAs may produce RCCs, which give rise to ALEs, offering major health hazards. Even though it is highly recommended to consume MUFA and PUFA-rich oils, these oils must first be "preserved" before being used in cooking. Some oils, like olive oil, are inherently preserved by their high levels of endogenous antioxidants (polyphenols and tocopherols), but others, including soybean, sunflower, and peanut oils, must be fortified with exogenous antioxidants during manufacturing because of the refining process they go through (Viana da Silva et al, 2021). 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).

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). The fatty acid profile is altered by combining various vegetable oils, which may also increase their nutritional and practical usefulness. Because omega-3 and omega-9 fatty acids have anti-inflammatory characteristics, increasing consumption of MUFA and PUFA helps to lower the risk of coronary heart disease (Ramsden et al., 2013).The protection of cardiovascular illnesses, however, appears to be significantly influenced by merely ω -3, according to earlier research (Griffin, 2008). Additionally, high MUFA and PUFA content unsaturated oils are more susceptible to oxidation; hence, appropriately balancing MUFA and PUFA may result in oil blends with greater nutritional value, high storage stability, and even suitability for frying (Adhvaryu et al., 2000; Ramsden et al., 2013).

Fundamental yet distinct functions are played by the omega-3 and omega-6 fatty acids in the development of the cell membrane. The relationship between -3:-6 fatty acids in the diet is crucial because the varied numbers and positions of double bonds in the chain provide the fatty acids various physiological qualities. Since eicosapentaenoic acid and docosahexaenoic acid use the same metabolic pathways and compete for the same elongase and desaturase enzymes, the -3:-6 balances in the diet is crucial (Huerta-Yépez et al., 2016). Linoleic acid is converted to arachidonic acid, while -linolenic acid produces eicosapenta. Saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) should make up an even 1:1:1 ratio of the calories consumed by adults, according to the international nutrition and food committees established by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) (FAO, 2012). Simopoulos (2002) suggested a 3:1:6 ratio that was less than 1:4 to lower the risk of chronic diseases. When Gomes et al. (2019) examined the relationships between erythrocyte and plasma n-3:n-6 fatty acids and a variety of oxidative stress biomarkers in breast cancer patients, they discovered that plasma n-3:n-6 ratio was related to the anti-inflammatory factor.

Tallow, lard, fish oil, and milk fat are examples of animal-derived fats and oils (butter). Oils of vegetable origin are often made from plant seeds or beans (Oils and Fats in the Market Place, 2021). The most popular major vegetable oils are palm oil, soybean oil, rapeseed oil, and sunflower oil (Woodgate et al, 2014: The Four Major Vegetable Oils, 2021).Less than 25% of the total fatty acids in the majority of vegetable oils are saturated fatty acids (Kim et al, 2010). However, it's been noted that the saturated fatty acid content of palm, palm kernel, and coconut oils is higher, at 49%, 80%, and 90%, respectively. Mono- and poly-unsaturated fatty acids, predominantly oleic (18:1) and linoleic (18:2), make up the remaining portion of the fatty acid makeup (Kim et al, 2010). The most widely used edible oil worldwide is palm oil (Akoh, 2017). Palm oil and palm kernel oil, which have differing fatty acid contents, can be extracted from palm fruit (Li et al, 2012). Both are extracted, with the former coming from the mesocarp (which is high in Palmitic and oleic acids) and the latter coming from the kernel (which is high in Lauric acid) (Akoh, 2017).

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 favour 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 highly polyunsaturated oil. Because the body is unable to produce these fatty acids, they are vital to life (Gunstone, 2002). The widely used Rancimat method is an international standard that is carried out under accelerated storage circumstances at high temperatures (AOCS, 1998) and is accurate, repeatable, doesn't require the use of reagents, and its readings may be easily automated (Heidarpour and Farhoosh, 2018). The main objective of this works to study and evaluate the physico-chemical properties of blended palm oil with soybean and sunflower oils. Additionally, shelf life of the blends was computed using the oxidative stability index (OSI) values and extrapolating the results to standard storage temperatures.

2. Materials and methods

2.1. Materials and reagents

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

2.2. Preparation of oil and its blends containing antioxidants

2.2.1. 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.

2.2.2. Samples preparation

Three blends of palm oil, soybean oil and sunflower oil were prepared using a mechanical stirrer at 180 rpm for 15min (**Kumar *et al.* 2009**). These blends were prepared in the ratio of 50:50. These three blends named as:

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

2.2.3. Oxidative stability test:

2.2.3.1. Free fatty acid

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

2.2.3.2. Peroxide value (PV)

The peroxide value (PV) was conducted by referring to the AOAC method 965.33 described by (**AOAC, 2011)**. 5.00 g of oil samples were dissolved in 30 mL of a 3:2 acetic acid to chloroform solution 1mL of saturated KI was

then added after that. The mixture was maintained in the dark for five minutes after being allowed to stand for a minute with intermittent shaking. Following this, 30 mL of distilled water was added. Sodium thiosulfate (0.002 M) was used to titrate the mixture until the yellow color practically vanished. Then a 0.5mL solution of 1% starch was added. The titration was carried out until the blue color vanished. The identical conditions were used for the analysis of a blank. The following equation was used to get the peroxide value:

Peroxide value (PV) = (S × M × 1000)/sample weight (g)

Where, S is the value of Na2S2O3 used (blank corrected); M is the molarity of Na2S2O3.

2.2.4. Fatty acid composition

2.2.4.1. Methyl Esterification

Prepared fatty acid methyl esters (FAME**)** 100µl of fat in 10ml tube with Teflon cap and 200µl methanolic KOH (11.2g KOH in 100ml methanol HPLC grade) Then vortex (witag, Germany) for 1 min and add10 ml hexane HPLC grade Close tube and centrifuge by(Bouch,R144.Italy) for 10 min 2500 rpm .

2.2.4.2. GC/MS Measurements

Thermo Ultra Trace GC series gas chromatography and Thermo DSQ mass spectrometer from Thermo Fisher Scientific were used to analyse the fatty acid methyl esters (Waltham, MA, USA) .Used was an SGE BP x 70 column with a 25 m x 0.25 mm, 0.25 m film thickness and a 65% methyl, 35% phenyl silicone composition. Helium (99.999%) was used as the carrier gas at a flow rate of 1 mL/min. The oven temperature programme was modified as follows while the injection block temperature was maintained at 250 °C: Initial temperature ramping from 60 °C to 180 °C at 10 °C/min for 2 min, then ramping from 240 °C to 5 °C/min for 10 min. The source temperature was 220°C, while the injection temperature was 250°C. The MS interface was 240°C in temperature. The split ratio for the 0.5 L injection was 1:30. Ionization energy for the EI-MS measurements was 70 eV. The mass range was between 50 and 650 amu.With 0.1 interscan delays, the scan time is 0.5 seconds. NIST and Wiley (Gas Chromatography-Mass Spectrometry) GC-MS libraries were used for the library search (Sathianathan et al., 2014**).** The discovered fatty acids were quantified by comparing the area beneath each fatty acid peak to the sum of all fatty acid peaks.Results are given as grams of fatty acids per 100 grams of total fatty acids (**Lutterodt et al., 2011**). Each sample was examined three times.

2.2.5. Shelf-Life Testing

A forced-draft air oven with a temperature setting of 60 °C was used to speed up the oxidation of oil samples (30 g) in a series of 100 mL glass bottles. Over the course of the storage period, oxidation was observed every two weeks, and changes in PV and FFA were studied.

2.2.6. 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 3 g 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).

2.3. 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.

3.Results and discussions

3.1. Fatty acid 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 (1). 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 the Table (3) it noted that samples of soybean oil content of Linolenic acid (6.26 %), while this fatty acid no detect 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.

Table (1): Fatty acid composition for RBD sunflower oil, palm oil and Soya bean oil

Fatty acid composition		**Sunflower oil**	**Palm 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**	0.00 ± 0.00^{b}	0.31 ± 0.02^{a}	0.00 ± 0.00^{b}
Myristic	**C14:0**	0.00 ± 0.00^{b}	0.92 ± 0.05^{a}	0.00 ± 0.00^{b}
Palmitic	**C16:0**	5.30 ± 0.9^{c}	46.08 ± 2.3^{a}	10.29 ± 1.12^{b}
Stearic	**C18:0**	2.70 ± 0.1^{b}	3.5 ± 0.06^{ab}	3.65 ± 0.04^{a}
Arachidic	**C20:0**	0.10 ± 0.01^{b}	0.2 ± 0.02^{a}	0.10 ± 0.01^{b}
SFA		8.10 ± 0.85^{c}	51.00 ± 1.2^{a}	14.04 ± 1.05^{b}
Oleic	**C18:1**	23.11 ± 1.5^{b}	40.0 ± 2.4^{a}	20.70 ± 1.3^{c}
Linoleic	**C18:2**	67.79 ± 2.6^{a}	9.00 ± 1.2^{c}	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		91.40 ± 3.4^{a}	49.0 ± 1.8^{c}	85.96 ± 3.6^{b}

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

Table (2). Fatty acid composition for RBD sunflower oil, palm oil and Soya bean blends

Fatty acid composition		50% sunflower oil 50% palm 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 ($P \leq 0.05$).**

Table (3). Shelf life for sunflower oil, palm oil and Soybean oils (by antioxidants and without antioxidant) After 45 days

par		sunflower oil By anti +ve	sunflower oil without anti -ve	palm oil By anti +ve	palm oil without anti -ve	soybean oil By anti +ve	soybean without anti -ve
15 days	**FFA**	0.04 ± 0.00^{d}	0.06 ± 0.00^{b}	0.07 ± 0.00^{a}	0.058 ± 0.002^{b}	0.048 ± 0.001^{c}	0.04 ± 0.00^{d}
	PV	0.8 ± 0.05^{f}	3.5 ± 0.14^{a}	1 ± 0.04^{e}	3 ± 0.22^{b}	1.5 ± 0.18^{d}	1.6 ± 0.20^{c}
30 days	**FFA**	0.03 ± 0.02^{e}	0.055 ± 0.00^{c}	0.095 ± 0.002^{b}	0.1 ± 0.001^{a}	0.035 ± 0.002^{e}	0.048 ± 0.001^{d}
	PV	2.2 ± 0.05^{b}	2.6 ± 0.08^{a}	0.6 ± 0.03^{f}	0.89 ± 0.05^{e}	1.4 ± 0.04^{d}	1.9 ± 0.08^{c}
45 days	**FFA**	0.038 ± 0.00^{d}	0.06 ± 0.002^{b}	0.12 ± 0.001^{a}	0.1 ± 0.002^{a}	0.04 ± 0.00^{c}	0.038 ± 0.001^{c}
	PV	1.2 ± 0.05^{e}	3.3 ± 0.12^{a}	0.8 ± 0.04^{f}	2 ± 0.08^{c}	1.3 ± 0.06^{d}	3.2 ± 0.08^{b}

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

Table (4). shelf life for sunflower oil, palm oil and Soybean blends (by antioxidants and without antioxidant)

par		50% sunflower oil 50% palm oil By anti +ve	50% sunflower oil 50% palm oil without anti -ve	50 %palm oil 50% soybean By anti +ve	50 %palm oil 50% soybean without anti -ve	50% soybean 50% sunflower oil By anti +ve	50% soybean 50% sunflower oil without anti -ve
15 days	FFA	0.05±0.001^{b}	0.06±0.00^{a}	0.06±0.001^{a}	0.065±0.002^{a}	0.016±0.001^{c}	0.05±0.00^{b}
	PV	0.6±0.03^{c}	0. 16±0.01^{e}	0. 7±0.02^{b}	1. 2±0.05^{a}	0. 16±0.01^{e}	0. 5±0.02^{d}
30 days	FFA	0.058±0.00^{d}	0.09±0.002^{a}	0.065±0.001^{c}	0.076±0.002^{b}	0.03±0.00^{e}	0.052±0.00^{d}
	PV	0.25±0.03^{f}	1.6±0.08^{b}	0.65±0.03^{e}	2±0.04^{a}	1±0.01^{d}	1.4±0.02^{c}
45 days	FFA	0.06±0.001^{b}	0.074±0.002^{a}	0.074±0.002^{a}	0.078±0.001^{a}	0.039±0.00^{d}	0.052±0.002^{c}
	PV	0.75±0.05^{f}	1.7±0.09^{b}	1.0±0.05^{e}	1.5±0.07^{c}	1.3±0.04^{d}	3.2±0.12^{a}

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

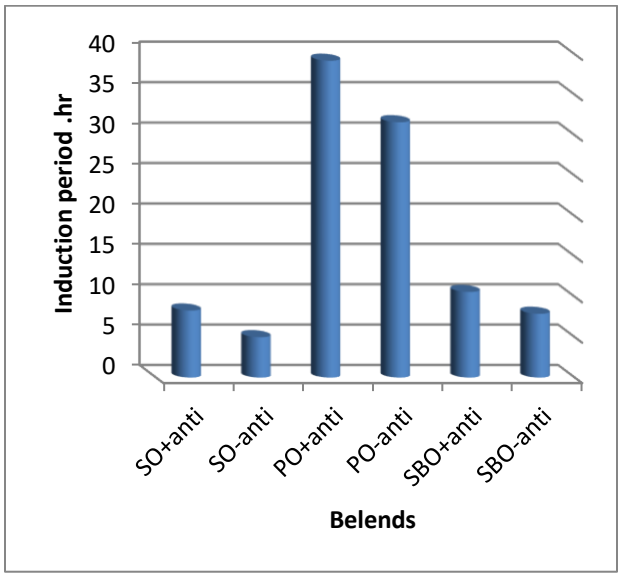

Figure 1. Thermophilic stability (Rancimat) for sunflower oil, palm oil and Soya bean oils (by antioxidants and without antioxidant) at 110˚c.

3.2. Thermophilic stability for sunflower oil, palm oil and Soya bean oils (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 hydro peroxides affects the oxidative stability of a substance (Madhujith & Sivakanthan ,2019: Cai et al, 2021). The results of induction periods at 11^{0}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 (figure 1). 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/discoloration (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).

3.3. Thermophilic stability for sunflower oil, palm oil and Soybean blends

The results of induction periods at 11°C for 50% sunflower oil 50% palm oil by antioxidant, 50% sunflower oil 50% palm 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. (Figure 2).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.

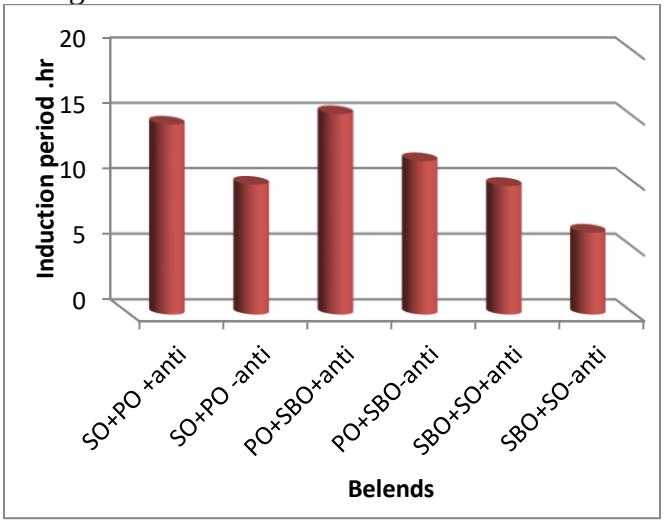

Figure (2). Thermophilic stability (Rancimat) for sunflower oil, palm oil and Soya bean blends oils (by antioxidants and without antioxidant) at 110 ˚C

3.4. Shelf life for sunflower oil, palm oil and soybean oils

The assessment of oxidative oxidation in oils and fats is frequently done using the PV test. Since the main byproduct of lipid oxidation is hydrogen peroxide, measuring PV or FFA can be utilized as an oxidative index in the early stages or lipid oxidation (Ramadan and Moersel 2004; Mohdaly et al. 2010).Table 3 presents the PV changes in oils and blends during storage for 45 days at 60°C. The final PV of sunflower oil had the highest value with 3.3 meq O2/kg among oils followed by soybean oil and finally sunflower oil. While the initial FFA of palm oil had the highest value with0.12 followed by soybean oil and finally sunflower oil. Addition of Antioxidants decreased the PV and FFA contents of oils ,which preserve fats and oils from deterioration, rancidity/discoloration (Mujeeda and Prasad, 2016) by acting as chain-breaking radical scavengers and peroxide decomposers (De Souza et al, 2011: Mujeeda and Prasad, 2016).

3.5. Shelf life for sunflower oil, palm oil and Soybean blends

PUFA concentration is a significant element determining the oxidative stability of particular oils and oil blends, in addition to the inherent natural antioxidants in oil

The oxidative stability of high PUFA oil can be increased by blending with high MUFA oil because the oxidative stability index (OSI) is inversely proportional to PUFA concentration (Chu et al., 1998; Kumar et al., 2009**)**. In other words, if oil's PUFA concentration is decreased by blending it with MUFA, MCFA, or SFA, the blend's oxidative stability will rise. The similar idea has been tried with the addition of palm oil to other vegetable oils. . The oxidative stability of palm oil and its blends is shown in Table (4). In the order of sunflower, soybean, and palm oil, peroxide generation rates were higher in sunflower oil and soybean than in palm oil. The peroxide values of the sunflower: palm oil and soybean: palm oil blends, on the other hand, dropped when palm oil was added to the blends, demonstrating that palm oil contributed to the

oxidative stability of the blends. In the oil mixes, palm oil partially prevented peroxide production. In contrast to the individual soybean oil, the soybean: palm oil blends significantly reduced the development of peroxide by 46.87% over a 45-day period, while the sunflower oil: palm oil blends significantly reduced the formation of peroxide by 51.1% over the same period

Compared to palm oil, TBHQ showed a stronger inhibitory effect on the production of peroxide. Therefore, it can be said that the lower rate of peroxide generation was caused by the inclusion of palm oil in the oil blends. FFA Follow the peroxide number in the same direction BO stabilized the similar behavior seen in SO and SBO (Kumar et al., 2009).

4. Conclusions

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

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Availability of data and materials

The current manuscript includes all of the data produced and examined for the study, and the associated authors have no objections regarding the data's and materials' accessibility.

Competing interests (Conflict of interest)

The authors assert that they have no competing interests.

Authors' contributions

N.A. R.: analyzed and interpreted the data of the work; **M. A. E.:** performed lab experiments, analyzed and interpreted the data of the work, and prepared the original manuscript; **S. M. A** supervised and reviewed the manuscript; **A. A. E.:** performed lab experiments, analyzed and interpreted the data of the work, and prepared the original manuscript; **M. F. A.:** performed lab experiments, analyzed and interpreted the data of the work, and prepared the original manuscript.

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