







# Preparation and Quality Evaluation of Different Oil Blends

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**Abstract:** The aim of the study was to derive an oil composition with a balanced ratio of saturated, monounsaturated, and polyunsaturated fatty acids (SFA, MUFA, PUFA) along with improved properties and shelf life. The blends were prepared to consist of linseed oil (LO) with soybean (SBO), mustard (MO), coconut (CO), olive (OO), and sunflower oil (SFO) in various ratios, i.e., 20:80, 30:70, 40:60, 50:50, 60:40, 70:30 and 80:20 (v/v), respectively. Among all blends, fatty acid ratios (SFA:MUFA:PUFA) of 1:1.4:4.6 for LO and SBO (20:80), 1.5:1:3.1 for LO and CO (80:20), and 1:1.9:3.4 for LO and OO (80:20) were found close to the recommended intake (1:1.5:1) and showed better quality. The storage study revealed that a maximum of blends retained their quality and found fit for consumption except some of the blends (LO:SBO, LO:SFO & LO:MO), which could be because of their higher PUFA content. The present study provides the scope of blending using commonly consuming oils to balance the overall properties of the blend. Blending is one of the economical and simple processes used to improve the nutritional, physical, and sensory quality of any oil. Based on the compositional variation in oils, a better blend could be formulated with overall improved quality.

**Keywords:** vegetables oils; blending; fatty acid composition; shelf life; quality.

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## 1. Introduction

Fats and oils are essential nutrients in human and animal diets, being the richest source of energy and a carrier of fat-soluble vitamins. They also provide essential fatty acids and are precursors of different hormones [1]. Varieties of vegetable oil/fat have a unique composition and play a major role in the economic, sensory, and functional properties of food and food products [2]. The compositions of various commonly used vegetable oils indicate an imbalance in their fatty acid composition and are not in tune with the recommendations of an expert committee [3]. The right combination of fatty acid in triacylglycerol (TG) of oils and fats, as suggested by nutritionists, cannot always be met from single oil. A simple and alternative method to achieve this is to formulate a physical mixture of different oils in the right proportion or to develop structured lipids (SLs) from different oils. The blending of edible oils has now been accepted by the Government of India [4]. Manufacturers are permitted to blend any two

oils, where the proportion of one oil must be not less than 20% [4]. Nowadays, blends of few edible oils are available in the Indian market. However, it is not yet clear whether these blended oils are a physical mixture of two oils and can provide all the perceived benefits.

Mustard, soybean, sunflower, coconut, and olive oils are some of the common cooking oils in India [5]. MO is a highly consumed oil in India, containing a high amount of erucic acid (48.5-58.2%) [5]. Since erucic acid consumption has been associated with myocardial lipidosis in test animals; therefore, such oil is doubtful to be consumed by humans [6]. Nowadays, attempts have been made to regulate the content of erucic acid in edible oils. Hence, blending is a simple and cheap process to regulate erucic acid in vegetable oil. SBO is the second most consumed oil in India, which exhibits a good amount of linoleic acid and oleic acid along with small but significant amounts of  $\alpha$ -linolenic acid [7]. SFO accounts for 58% of the total edible oil produced in India. The use of SFO for frying can be considered as a healthy choice due to balanced amounts of saturated fatty acids (SFA, ca. 6%) and monounsaturated fatty acids (MUFA, ca. 20%), and a high content of polyunsaturated fatty acids (PUFA), which constitute 68–72% of total fatty acids [7] which have numerous positive health potentials [8]. Among edible oils, olive oil (OO) shows important and outstanding characteristics due to its distinctive sensorial qualities (taste and flavor) and high nutritional value that has been acknowledged across the world. Several health benefits associated with its consumption were initially observed among Mediterranean people, and its dietary consumption is nowadays considered highly beneficial to human health [9-11]. OO is rich in oleic acid, which helps to decrease the level of LDL cholesterol in blood plasma, which reduces the chances of coronary heart disease. Coconut oil is a clear liquid at ambient temperature and has a pleasant aroma. It mainly consists of saturated fatty acids (>91%), and the major portion of saturated fatty acids are medium-chain fatty acids (MCFA) (>51%) that are easily digestible and absorbed into the body through the portal vein and generate energy [12-14] along with antibacterial and antioxidant potentials [15]. Linseed or flaxseed has been extensively studied for its numerous health benefits [16-17] but has still not occupied a space in the cooking oil market. Recently, LO has been suggested for cooking by FSSAI and ICMR as it possesses a high amount of fiber lignin, which acts as antioxidants.

The blending of LO can be done to reduce the high content of  $\omega$ -3 fatty acid, and as it affects the stability of the oil. As per the World Health Organization (WHO), the proportions of SFA, MUFA, and PUFA in the dietary fats should be in the proportion of 1:1.5:1 [18]. According to various investigations, the above-mentioned ratios of fatty acids are highly recommended for maintaining good health, but no natural oil possesses such a balanced composition. Hence, an attempt was made to develop an oil/fat blend that could have better chemical properties with balanced fatty acid composition.

## 2. Materials and Methods

The present investigation was designed to evaluate the fatty acid composition, chemical properties, and stability of blends made from a variety of common edible vegetable oils with linseed oil.

## 2.1. Material.

### 2.1.1. Procurement of oils/fats.

Common oils were collected from Sadar Bazar, Ambala Cantt., India. Oils included coconut, olive, soybean, mustard, linseed, and sunflower oil. All oils/fats were freshly extracted from the nuts and seed using the cold-press process.

### 2.1.2. Reagents and chemicals.

The mixture of fatty acid standards was procured from Supelco (Sigma Aldrich, Germany). The other chemicals and reagents used for fatty acids methyl esters (FAME) synthesis were of HPLC grade, and the remaining chemicals were of AR grade purchased from Central Drug House (CDH), New Delhi, India.

## 2.2. Blending of oils/fats.

Generally, blending refers to the mixing of different types of substances having a similar composition to make a product of desirable quality. For blending different edible oils such as mustard oil, olive oil, coconut oil, sunflower oil, and soybean oils were taken in different ratios with linseed oil (Table 1). The mixtures of oils/fats were blended in conical flasks using a magnetic stirrer at a constant temperature of 40°C for about one hour.

**Table 1.** Different oils/fats blend with linseed oil in different proportions.

Oil	1	2	3	4	5
Blends (v/v)	20:80	20:80	20:80	20:80	20:80
	30:70	30:70	30:70	30:70	30:70
	40:60	40:60	40:60	40:60	40:60
	50:50	50:50	50:50	50:50	50:50
	60:40	60:40	60:40	60:40	60:40
	70:30	70:30	70:30	70:30	70:30
	80:20	80:20	80:20	80:20	80:20

1-LO:MO, 2-LO: SBO, 3-LO: SFO, 4-LO:CO, 5-LO: OO

LO: Linseed oil; MO: Mustard oil; SBO: Soybean oil; SFO: Sunflower oil; CO: Coconut oil; OO: Olive oil

### 2.3. Chemical properties of oils/fats.

Chemical properties (Acid value, peroxide value, and iodine value) of all the oils were studied before and after blending as per standard procedures given by FSSAI, 2011 regarding fats and oils [4].

### 2.4. Fatty acid composition.

FAME synthesis was carried out using the method of direct FAME synthesis by O'Fallon et al. (2007) [19]. Forty microliter oil sample was taken in a screw cap Pyrex culture tubes added with 0.7 ml of 10 N KOH followed by 5.3 ml of methanol. Tubes were placed in a hot water bath at 55 °C for 1.5 hours with vigorous handshaking for 5 seconds after every 20-minute intervals to dissolve and hydrolyze the sample. Tubes were cooled at room temperature, and 0.58 ml of 24N H<sub>2</sub>SO<sub>4</sub> was added and mixed properly. After the formation of K<sub>2</sub>SO<sub>4</sub> precipitates, tubes were again placed in a water bath at 55 °C for 1.5 hours with handshaking for 5 seconds each after 20-minute intervals as performed earlier. After that, these tubes were cooled at room temperature, and 3 ml hexane was added and vortexed for 5 minutes. Thereafter,

tubes were centrifuged for 5 minutes, and the top hexane layer containing FAMES were placed in GC vials and stored at -20 °C until GC analysis [19].

The prepared FAMES of individual and blended oil samples were injected into the Perkin Elmer, Clarus 680 gas chromatograph equipped with an FID detector. Zebron™ ZB-WAXplus™, Capillary Column (60 m x 0.32 mm x 0.25 μm), packed with Polyethylene Glycol (PEG) as stationary phase, was used for the separation and identification of fatty acids using the following instrumental conditions; injector temperature: 230 °C; detector temperature: 240 °C; carrier gas: nitrogen @ 1ml/min in splitless mode; oven program; starting at 100 °C (held for 3 minutes) to 150 °C @ 7 °C (held for 2 minutes) to 230 °C @ 7 °C (held for 5 minutes); injector volume: 1μL. The obtained fatty acids were quantified by calculating area percentage comparing Supelco 37 FAME mixture as the reference standard.

### *2.5. Storage study.*

All blended samples were stored at room temperature and analyzed for their quality as per the standards procedures given by FSSAI, 2011 [4]. Storage study was carried out for up to four months, and samples were drawn for analysis after one month of interval.

### *2.6. Data analysis.*

Each sample of the individual as well as a mixture of oils/fats (fresh and stored), was analyzed for chemical parameters (acid value, peroxide value, and iodine value), and one-way analysis of variance (ANOVA) was calculated and significant difference between the values was observed. All experiments were conducted in triplicates. Mean values with no common superscript are significantly different ( $p < 0.05$ ), according to Duncan's multiple range test. The data analysis was performed with the help of SPSS version 23. Whereas the fatty acid profile was taken in triplicates, and the mean values were reported with  $\pm$  standard deviation.

## **3. Results and Discussion**

The present investigation was carried out to prepare and study the storage stability of various oil blends, where linseed oil was taken as base oil, while other oils were added in different ratios.

### *3.1. Chemical properties of individual edible oils.*

As depicted in Table 2, acid values of linseed oil ( $1.07 \pm 0.34$ ) and sunflower oil ( $1.06 \pm 0.07$ ) were significantly higher than other oils, while the lowest value was observed in coconut oil ( $0.40 \pm 0.34\%$ ). The peroxide value of mustard oil ( $3.10 \pm 0.42$  meqO<sub>2</sub>/kg) was the highest among all oils. Because of the higher concentration of PUFA, iodine value was observed significantly high in linseed oil ( $176.32 \pm 7.04$ ). At the same time, coconut oil showed the lowest iodine value ( $10.14 \pm 1.12$ ) as it contains more of an SFA. The results obtained were found in accordance with the value given by different researchers for LO, CO, SBO, OO, and MO [20-25].

### *3.2. Chemical properties of oil blends.*

Analysis of blended samples (Table 3) showed that acid value existed under the standard limit ( $\leq 2$  for all edible oils) as prescribed by FSSR, 2011. Similarly, the peroxide

value (Table 4) was also found under the prescribed standard limit ( $\leq 10 \text{ meqO}_2/\text{kg}$ ). On the other hand, iodine value (Table 5) was affected significantly due to the specific properties and fatty acid profile of individual oils, i.e., linseed oil has the highest and coconut oil has the lowest iodine value. Therefore, when such types of oils were blended in different proportions, their degree of unsaturation, along with iodine value, was affected accordingly.

**Table 2.** Chemical properties of individual edible oils.

Sample	Acid Value	Peroxide Value	Iodine Value
Linseed Oil	1.07±0.34 <sup>f</sup>	1.40±0.20 <sup>e</sup>	176.32±7.04 <sup>f</sup>
Coconut Oil	0.40±0.34 <sup>a</sup>	0.61±0.64 <sup>a</sup>	010.14±1.12 <sup>a</sup>
Soybean Oil	0.80±0.11 <sup>c</sup>	1.06±1.86 <sup>d</sup>	120.38±6.42 <sup>d</sup>
Sunflower Oil	01.06±0.07 <sup>e</sup>	1.02±0.31 <sup>c</sup>	129.22±4.87 <sup>e</sup>
Olive Oil	00.49±0.10 <sup>b</sup>	0.81±0.25 <sup>b</sup>	086.01±3.06 <sup>b</sup>
Mustard Oil	01.00±0.17 <sup>d</sup>	3.10±0.42 <sup>f</sup>	099.52±4.33 <sup>c</sup>

Values are means of triplicate ± standard deviation

Within a column with the same lowercase letter are not significantly different at  $p < 0.05$

**Table 3.** Acid value of oils/fats blends.

Ratios	Acid Value of Different Blends				
	1	2	3	4	5
20:80	1.12±0.08 <sup>ij</sup>	1.06±0.11 <sup>g</sup>	1.12±0.10 <sup>ij</sup>	0.37±0.02 <sup>a</sup>	0.55±0.04 <sup>ef</sup>
30:70	1.10±0.11 <sup>i</sup>	1.10±0.20 <sup>i</sup>	1.10±0.09 <sup>j</sup>	0.39±0.03 <sup>b</sup>	0.55±0.08 <sup>ef</sup>
40:60	1.12±0.10 <sup>ij</sup>	1.12±0.18 <sup>j</sup>	1.07±0.10 <sup>g</sup>	0.38±0.07 <sup>a</sup>	0.54±0.03 <sup>e</sup>
50:50	1.12±0.09 <sup>ij</sup>	1.12±0.10 <sup>ij</sup>	1.12±0.12 <sup>j</sup>	0.40±0.09 <sup>b</sup>	0.55±0.09 <sup>ef</sup>
60:40	1.18±0.09 <sup>k</sup>	1.10±0.07 <sup>i</sup>	1.10±0.08 <sup>i</sup>	0.41±0.05 <sup>c</sup>	0.56±0.04 <sup>ef</sup>
70:30	1.12±0.10 <sup>j</sup>	1.08±0.11 <sup>h</sup>	1.10±0.12 <sup>i</sup>	0.40±0.03 <sup>b</sup>	0.55±0.07 <sup>ef</sup>
80:20	1.12±0.11 <sup>j</sup>	1.12±0.10 <sup>j</sup>	1.12±0.09 <sup>j</sup>	0.41±0.04 <sup>bc</sup>	0.56±0.08 <sup>ef</sup>

Values are means of triplicate ± standard deviation

Within a row with the same lowercase letter are not significantly different at  $p < 0.05$

**Table 4.** Peroxide value of oils/fats blends.

Ratios	Peroxide Value of Different Blends				
	1	2	3	4	5
20:80	2.40±0.88 <sup>i</sup>	1.20±0.34 <sup>d</sup>	1.00±0.78 <sup>c</sup>	1.11±0.32 <sup>c</sup>	1.60±0.75 <sup>e</sup>
30:70	2.20±0.95 <sup>h</sup>	1.12±0.16 <sup>c</sup>	0.82±0.91 <sup>a</sup>	0.81±0.21 <sup>a</sup>	0.80±0.09 <sup>a</sup>
40:60	1.80±0.38 <sup>f</sup>	0.81±0.27 <sup>a</sup>	1.00±1.03 <sup>b</sup>	1.19±0.68 <sup>d</sup>	1.11±0.62 <sup>c</sup>
50:50	1.60±0.90 <sup>e</sup>	0.81±0.60 <sup>a</sup>	0.81±0.88 <sup>a</sup>	1.10±0.78 <sup>c</sup>	1.11±0.69 <sup>c</sup>
60:40	1.81±0.66 <sup>f</sup>	1.20±0.55 <sup>d</sup>	1.21±0.82 <sup>d</sup>	0.81±0.06 <sup>a</sup>	1.12±0.90 <sup>c</sup>
70:30	2.20±0.10 <sup>h</sup>	1.00±0.42 <sup>b</sup>	0.81±0.40 <sup>a</sup>	0.82±0.10 <sup>a</sup>	1.20±0.10 <sup>d</sup>
80:20	2.11±0.09 <sup>g</sup>	1.00±0.48 <sup>b</sup>	1.00±0.95 <sup>b</sup>	1.11±0.10 <sup>c</sup>	1.12±0.10 <sup>c</sup>

Values are means of triplicate ± standard deviation

Within a row with the same lowercase letter are not significantly different at  $p < 0.05$

**Table 5.** Iodine value of oils/fats blends.

Ratios	Iodine Value of Different Blends				
	1	2	3	4	5
20:80	110.23±4.50 <sup>i</sup>	119.25±4.38 <sup>h</sup>	120.45±3.03 <sup>p</sup>	061.69±2.24 <sup>a</sup>	111.23±3.72 <sup>j</sup>
30:70	114.93±5.11 <sup>l</sup>	121.26±6.07 <sup>q</sup>	124.33±3.60 <sup>r</sup>	068.90±3.49 <sup>b</sup>	113.36±4.21 <sup>k</sup>
40:60	117.88±4.15 <sup>n</sup>	124.65±3.94 <sup>rs</sup>	129.78±2.90 <sup>w</sup>	076.55±4.72 <sup>c</sup>	116.82±3.27 <sup>m</sup>
50:50	125.87±3.55 <sup>t</sup>	130.92±4.34 <sup>s</sup>	138.45±3.05 <sup>al</sup>	082.38±3.47 <sup>d</sup>	118.57±5.45 <sup>o</sup>
60:40	129.63±5.44 <sup>vw</sup>	139.28±5.51 <sup>a2</sup>	140.35±4.92 <sup>a3</sup>	086.88±2.48 <sup>e</sup>	124.85±3.09 <sup>s</sup>
70:30	132.47±5.32 <sup>y</sup>	143.28±5.10 <sup>a5</sup>	141.92±4.50 <sup>a4</sup>	090.45±3.25 <sup>f</sup>	127.56±5.18 <sup>u</sup>
80:20	135.93±5.12 <sup>z</sup>	150.57±5.21 <sup>a7</sup>	146.47±3.11 <sup>a6</sup>	093.93±5.78 <sup>g</sup>	129.23±3.24 <sup>v</sup>

Values are means of triplicate ± standard deviation

Within a row with the same lowercase letter are not significantly different at  $p < 0.05$

### 3.3. Fatty acid composition of oils/fats before and after blending.

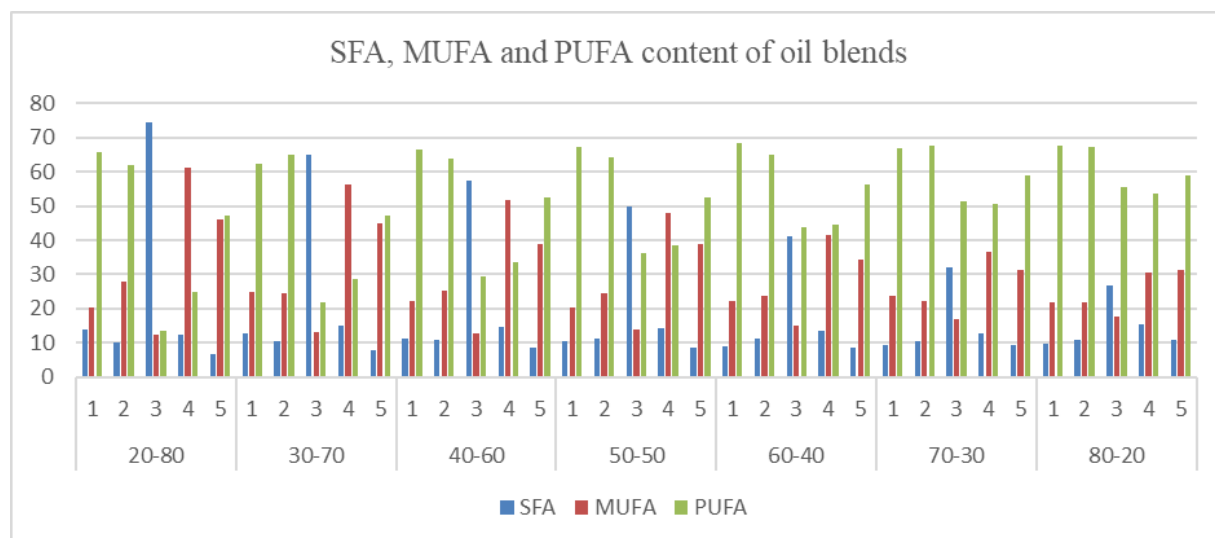
The FAMES of individual, as well as blended oil samples, were analyzed for the fatty acid profile using gas chromatography. The results obtained for fresh oils were illustrated in

Table 6, and, Figure 1 and 2 reveals the percentage and ratios of SFA, MUFA, and PUFA in blended samples.

**Table 6.**Fatty acid composition of common edible oils.

Fatty Acids	Oil Samples					
	Linseed	Coconut	Mustard	Soybean	Sunflower	Olive
C8:0	-	05.85±1.03	-	-	-	-
C10:0	-	04.86±0.76	-	-	-	-
C12:0	02.13±0.34	47.97±4.21	-	-	-	-
C14:0	00.99±0.04	19.35±2.33	-	-	-	-
C16:0	05.79±0.76	08.80±1.63	02.62±0.21	06.55±1.31	06.97±0.86	14.06±2.21
C16:1	-	-	-	00.07±0.00	-	01.11±0.32
C18:0	04.69±0.47	02.49±0.22	01.24±0.06	03.29±0.43	03.28±0.51	03.02±0.54
C18:1	19.29±1.23	08.11±1.243	11.70±1.12	26.90±3.54	26.21±2.34	71.15±5.74
C18:2	13.36±1.43	02.54±0.16	16.05±1.65	59.23±4.38	62.67±4.48	09.59±1.76
C18:3	51.95±3.72	-	12.47±2.36	03.00±0.38	00.29±0.01	00.99±0.24
C20:0	00.21±0.02	-	04.89±0.52	00.12±0.00	00.57±0.01	-
C20:1	-	-	01.05±0.04	00.07±0.01	-	-
C20:2	-	-	00.63±0.02	-	-	-
C22:0	01.56±0.22	-	01.11±0.24	00.62±0.02	-	-
C22:1	-	-	44.06±2.43	-	-	-
C23:0	-	-	-	00.17±0.00	-	-
C24:0	-	-	01.18±0.34	-	-	-
C24:1	-	-	02.04±0.41	-	-	-
SFA	<b>15.37</b>	<b>89.32</b>	<b>11.04</b>	<b>10.75</b>	<b>10.82</b>	<b>17.08</b>
MUFA	<b>19.29</b>	<b>08.11</b>	<b>58.85</b>	<b>27.04</b>	<b>26.21</b>	<b>72.26</b>
PUFA	<b>65.31</b>	<b>02.54</b>	<b>29.15</b>	<b>62.23</b>	<b>62.96</b>	<b>10.58</b>
SFA:MUFA:PUFA	<b>1:1.2:4.3</b>	<b>35.1:3.1:1</b>	<b>1:5.3:2.6</b>	<b>1:2.5:5.7</b>	<b>1:2.4:5.8</b>	<b>1.6:6.8:1</b>

Values are means of triplicate ± standard deviation

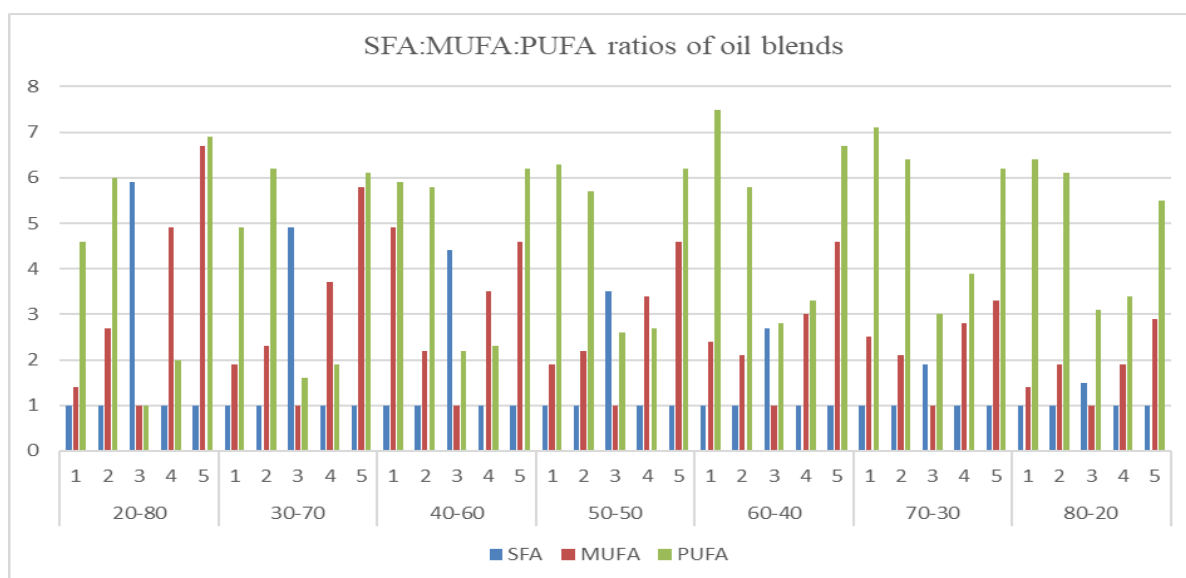


1-Linseed and Soybean oil blend, 2-Linseed and Sunflower oil blend, 3-Linseed and Coconut oil blend, 4-Linseed and Olive oil blend, 5-Linseed and Mustard oil blend

**Figure 1.** Percentage of SFA, MUFA, and PUFA in blended samples.

### 3.3.1. Fatty acid profile of individual oils/fats.

As revealed from the fatty acid profile of individual vegetable oils (Table 6), LO contained a high amount of ALA (51.95±3.72) followed by oleic acid (19.29±1.23) and linoleic acid (13.61±1.43). While coconut oil showed a very different fatty acid profile as it contained more amount of medium-chain fatty acids dominated by lauric acid (47.97±4.21) along with a significant amount of myristic acid (19.35±2.33) and have a very low level of MUFA and PUFA.



1-Linseed and Soybean oil blend, 2- Linseed and Sunflower oil blend, 3-Linseed and Coconut oil blend, 4-Linseed and Olive oil blend, 5- Linseed and Mustard oil blend

**Figure 2.** Ratio of SFA, MUFA, and PUFA content in blended samples.

Mustard oil has a unique composition because of high erucic acid ( $44.06 \pm 2.43$ ) content; other fatty acids such as oleic ( $11.70 \pm 1.12$ ), linoleic ( $16.05 \pm 1.65$ ), and linolenic acid ( $12.47 \pm 2.36$ ) were also present in significant amounts. In the fatty acid composition of soybean oil, linoleic acid ( $59.23 \pm 4.38$ ) was found predominating, which contributed to more than half the composition, followed by oleic acid ( $26.90 \pm 3.54$ ). The composition of sunflower oil was found close to soybean oil as it also contained a high amount of linoleic acid ( $62.67 \pm 4.48$ ), and the second dominating fatty acid was oleic acid ( $26.21 \pm 2.34$ ). Olive oil is well known for its better frying properties because of its high oleic acid content. The results showed the maximum content of oleic ( $71.15 \pm 5.74$ ) along with a significant amount of palmitic ( $14.06 \pm 2.21$ ) and linoleic acid ( $09.59 \pm 1.76$ ). A study conducted by various researchers reported a similar pattern of fatty acids profile of common edible vegetable oils [1-2, 5, 7, 10, 20, 21].

The ratio of total SFA:MUFA:PUFA in different oils greatly affects the stability, digestibility, and quality of the respective oil [26]. It was observed that the calculated value of SFA:MUFA:PUFA of each oil was significantly different from each other and were specific according to their respective composition. Linseed oil contained the maximum amount of PUFA (65.31) amongst selected oils samples, and the ratio of SFA:MUFA:PUFA was 1:1.2:4.3. Whereas coconut oil showed an opposite pattern in ratio, i.e., 35.1:3.1:1. In the case of mustard, soybean, and sunflower oil, the ratios were 1:5.3:2.6; 1:2.5:5.7, and 1:2.4:5.8, respectively. On the other hand, olive oil has the highest MUFA content, showed a ratio of SFA:MUFA:PUFA was 1.6:6.8:1. It was concluded from the compositional study that no individual oil has a composition that meets the recommendation given by WHO, 2008 [18]. Therefore, the blending of selected oils was performed to adjust composition in line with recommended levels of SFA, MUFA, and PUFA.

### 3.3.2. Fatty acid composition of oil blends.

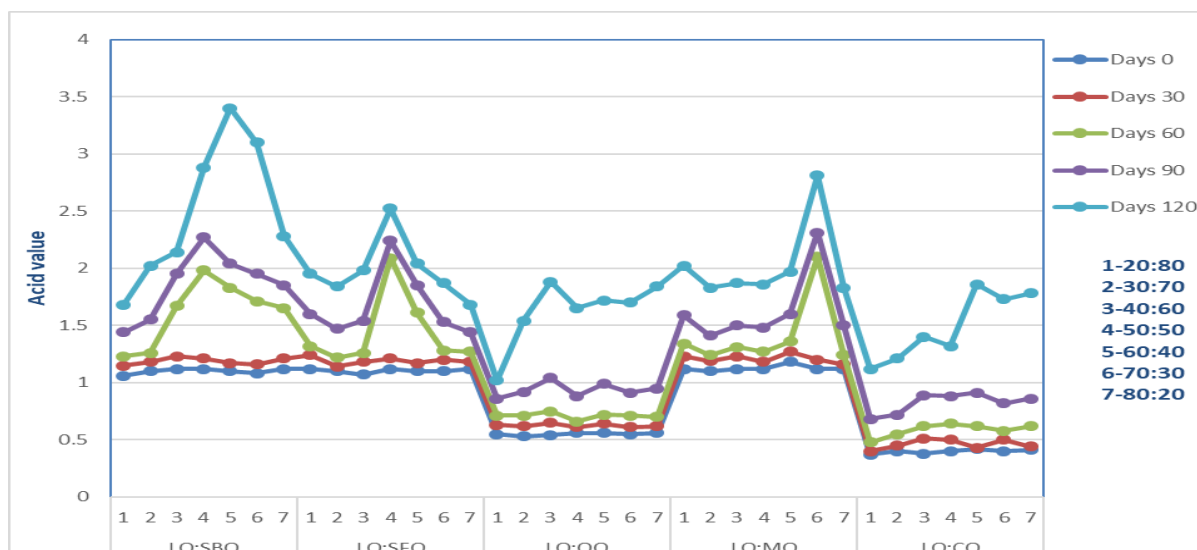
After analyzing the fatty acid composition of individual oil samples, the respective oil blends were also studied for their total SFA, MUFA, and PUFA content, which is shown in Figures 1 and 2.

As revealed in Figure 1, PUFA content of blends increased with an increasing proportion of linseed oil, while SFA and MUFA content varies according to the unique fatty acid composition of individual oil. In LO and SBO blend, the proportion of 20:80 showed SFA:MUFA:PUFA content in a ratio of 1:1.4:4.6, while the blend of 80:20 showed a ratio of 1:1.4:6.4 in which the former was observed close to recommended intake [18]. In a blend of LO and SFO, MUFA and PUFA content were noticed higher than the recommended level, as both oils have high PUFA content (linoleic and linolenic acids). In this set of blends, none of the blends were found suitable as per their fatty acid composition.

The blend of LO and CO was an interesting combination because both oils have opposite properties. LO is rich in PUFA content; on the other hand, CO contained a high amount of SFA. CO shows SFA:MUFA:PUFA ratio as 35.1:3.1:1, while LO has 1:1.2:4.3. When both the oils were blended, the fatty acid composition was affected drastically. In blend of 20:80, SFA:MUFA:PUFA ratio was 5.9:1:1 followed by 4.9:1:1.6, 4.4:1:2.2, 3.5:1:2.6, 2.7:1:2.8, 1.9:1:3 and 1.5:1:3.1 respectively for remaining blends (Figure 2). As mentioned above, a blend of 80:20 showed SFA:MUFA:PUFA content close to the recommended level. LO and OO blends also showed good compositional balance. Olive oil has a high smoke point, so it can be a good choice as a frying medium, but the economic value of this oil is comparatively high. Therefore, the blending of OO with any low-priced oil could be a better economical option. Blend of LO and OO in ratio 80:20 showed SFA:MUFA:PUFA content in ratio 1:1.9:3.4, which was found close to the suggested ratio. In a blend of LO and MO, none of the proportions were observed to be near the recommended level.

### 3.4. Storage study of oil blends.

The chemical properties of different oil blends stored at room temperature were studied up to 120 days. The samples were drawn to check their quality after one-month intervals. Acid, peroxide, and iodine values are depicted in Figure 3 to 5.

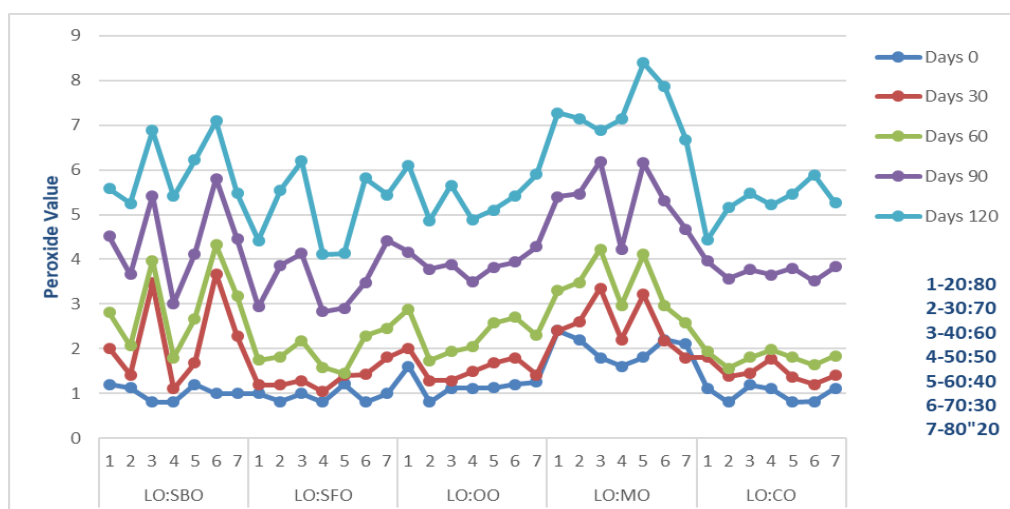


**Figure 3.** Acid value of oil blends at different storage times.

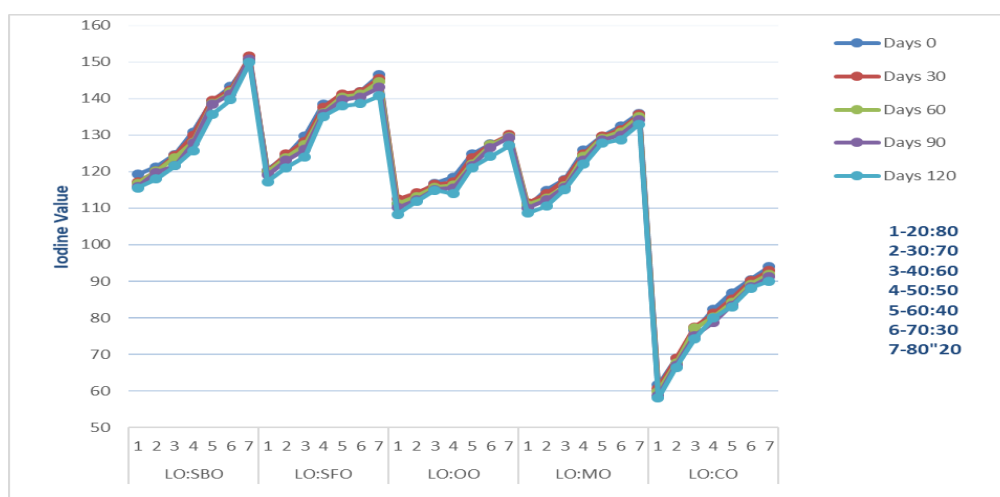
The acid value is mostly used to check the quality of oils and fats. The limits for acid value for individual oils/fats are already mentioned by FSSAI, 2011 [4]. As presented in Figure 3, acid values of different blends at zero days ranged from 1.06 to 1.12, 1.07 to 1.12, 0.53 to



0.56, 1.10 to 1.18, and 0.37 to 0.42 for LO:SBO, LO:SFO, LO:OO, LO:MO and LO:CO blends, respectively and were observed under the standard limit.



**Figure 4.** Peroxide value of oil blends at different storage times.



**Figure 5.** Iodine value of oil blends at different storage time.

With an increase in the storage period, the quality of oils was affected due to an increase in acid value [27]. Up to 60 days of storage, all the blended samples were found stable except blends of LO:SFO (50:50) and LO:MO (70:30). After 90 days, 0.2 to 0.3 percent increase was observed in acid value, and some of the samples such as LO:SBO (50:50), LO:SBO (60:40), LO:SFO (50:50), LO:MO (70:30) exceeded the standard limit possibly because of high concentration of PUFA in respective oil blends. Further, up to 120 days of storage, 8 samples out of 35 were degraded, and the maximum acid value was recorded in LO:SBO (60:40) blend. Results from different studies [28-29] revealed a similar pattern of increase in acid value, which is greatly affected by storage conditions and period.

Peroxide value represents the concentration of peroxides and hydroperoxides generated due to lipid oxidation. It is an important parameter to determine the oxidative stability of oils and fats [30]. FSSAI, 2011 has prescribed the standard for peroxide value, which should be below 10meq/Kg as the rancidity tolerance limit of fresh oils [4]. A noticeable rancid taste will appear as the value rises above 20meq/Kg (this is the standard limit for most industries). A continuous increase in peroxide value was observed with an increase in the storage period in all the samples (Figure 4). The samples were found fresh at the initial stage and up to 120 days

of storage. Hence, no rancid flavor was observed even in a single sample throughout the storage time.

Iodine value is used to check fat stability and resistance to oxidation by measuring the degree of unsaturation. It is significantly affected by storage conditions and time because of the formation of peroxides and hydroperoxides [31]. In the present investigation, it was observed that the iodine value decreased slightly with an increase in storage time. This may be due to the susceptibility of unsaturated bonds to oxidation (Figure 5). The maximum decrease (4.4 percent) in iodine value was observed in LO:SFO (40:60) blend, as the respective oils, have a high degree of unsaturation. While, in the remaining samples, a significant decrease was observed, compared to a lesser extent.

#### 4. Conclusions

The present study was designed to improve the quality of oils using a physical blending process, as no single conventional oil has the ideal fatty acid ratio. Various blends were prepared and studied for their quality. As per the recommended level of SFA:MUFA:PUFA, all samples were examined, and blends of LO:SBO (20:80), LO:CO (80:20), and LO:OO (80:20) were found close to the recommended intake (1:1.5:1). Keeping the quality of maximum samples was also improved and observed well, up to 120 days of storage at room temperature. These blends were nutritionally better as linseed oil contained  $\omega$ -3-fatty acid, which is well known for its anti-obesity, anti-carcinogenic, anti-diabetic properties, and prevents cardiovascular diseases. Blending has improved the nutritional quality of samples as each oil has its own specificity and composition. Like, coconut oil has a high amount of medium-chain glycerides, which shows anti-obesity properties because they are easily digestible in the body; olive oil has a high amount of MUFA and therefore possess good frying properties and stability. Similarly, soybean oil is considered good for balancing lipid profile as it reduces the total and LDL cholesterol. Based on specific properties, different oils can be utilized in blends of respective oils. Although, it is still a challenge to manage SFA:MUFA:PUFA ratio as per the recommendation. Therefore, more blends of oils with different ratios can be researched to achieve the ideal composition and to improve overall quality accordingly.

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#### Conflicts of Interest

The authors declare no conflict of interest.

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