Physical Blending Characteristic of Fish Oil and Sesame Oil

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Abstract: Fish oil is an animal oil which rich in unsaturated fatty acid such as omega 3, while the sesame oil is vegetable oil which rich in omega 6 and omega 9. The difference between unsaturated fatty acids content in each oil supposedly will produce different characteristics if being mixed. This study aimed to investigate the characteristics of the mixture by physical blending method. Both oils were mixed with proportion fish oil (F0) and sesame oil (S0) of 100:0 (F0), 90:10 (FS1), 80:20 (FS2), 70:30 (FS3), and 60:40 (FS4). Each oils were tested by its color, density, iodine value, saponification value and fatty acid composition. The results show that FS4 has the characteristics of mixed oil with the most yellow color with the value of density, iodine value, and saponification value respectively 0.94 g/cm³, 133.14 gI/100g and 170.01 mgKOH/g. Fish oil and sesame oil mixtures contained omega 3, omega 6, and omega 9 fatty acids that were higher than their original oils. Because of the benefit of the oil, the mixture of fish oil and sesame oil is suitable for application as edible oil or for industrial purposes.

1. Introduction
Cardiovascular disease such as coronary heart is a disease that affects many people in the world, especially in adults [1, 2]. Many factors cause cardiovascular disease to develop rapidly. The risk of coronary heart disease increased 1.3-fold in adults due to stress [3]. Cardiovascular disease could cause death. Therefore, precaution measure is needed to prevent the occurrence of the disease.

Omega 3 fatty acids could lower the risk of cardiovascular disease. Several studies have stated that cardiovascular disease could be reduced with unsaturated fatty acids [4], one of which is omega 3 fatty acids [5, 6, 7]. The mechanism of omega 3 fatty acids in cardiovascular disease is able to reduce blood pressure and improve arterial blood vessel function [8].

Omega 3 fatty acids could be found in fish and fish oil. Fish oil as a source of omega 3 is known to have been widely used as anti-inflammatory and nutraceutical needs to prevent various diseases [9, 10]. The presence of omega 3 fatty acids in fish oil ranges from 11-24% [11, 12] containing EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acids) [13]. Fish oil also contains other unsaturated fatty acids such omega 6 fatty acids mainly linoleic acid and arachidonic acid and omega 9 namely oleic acid [14, 15] which are also useful for health, however, this unsaturated fatty acid has a weakness, which is their susceptibility to oxidation because it contain a lot double bonds. Fish oil was hardly to apply in the food and beverage industry because fish oil is easily oxidized and form an undesirable flavor, thus, antioxidants are necessary to inhibit the oxidation [16].
Sesame oil is known its function as an anticancer, antioxidant, antiimmunoregulator, and anti-hypersensitive [17]. Sesame oil contains lignans and phenolic components that act as antioxidants [18, 19]. The fatty acids in sesame oil are omega 6 and omega 9 fatty acids, which are dominated by oleic and linoleic acids [20, 21]. Several studies of sesame oil have been carried out by adding sesame oil to vegetable oils such as soybean oil [22], palm oil [23], sunflower oil [24], and olive and linseed oil [25], while research on the addition of sesame oil to fish oil has never been done. The difference of fatty acid profiles in fish oil and sesame oil is presumably their effect on the characteristics of the mixed oil produced. The result of oil mixture is expected to have a complete fatty acid composition. Therefore, this study aims to determine the characteristics of fish oil mixed with sesame oil.

2. Research Methods

2.1. Materials

The materials used in this study were fish oil and sesame oil collected from the local market in Semarang, Central Java, Indonesia.

2.2. Methods

2.2.1. Fish Oil and Sesame Oil Mixture

Mixing oil was based on Roiai et al., [26] with modifications. Fish oil (F0) and sesame oil (S0) were physically blended with the proportion of fish oil:sesame oil (F0:S0) are 100:0 (F0), 90:10 (FS1), 80:20 (FS2), 70:30 (FS3), and 60:40 (FS4). Fish oil and sesame oil were mixed in Erlenmeyer then stirred using a magnetic stirrer at room temperature for 30 minutes at 400 rpm speed. The oil mixture of each formula was then stored in a dark bottle coated with aluminum foil and stored in a refrigerator with a temperature of 5°C.

2.2.2. Color

The oil color was analyzed by using the Minolta CR-200 Chromameter [27].

2.2.3. Density

Oil refraction index was measured with a refractometer while measuring oil density with a picnometer density bottle [28].

2.2.4. Iodine and Saponification Value

Iodine and oil saponification rates were measured according to AOCS [29].

2.2.5. Fatty Acid Composition

Within total of 0.1 g of oil were added with 5 ml of hexane and 0.25 ml of sodium methoxide solution. The mixture was then vented for 1 minute in a tightly closed condition. The mixture was then added with 5 ml of saturated NaCl and shaken for 15 seconds. The mixture was then allowed to stand for 10 minutes until a hexane layer was formed, which was the upper layer containing Fatty Acid Methyl Ester (FAMEs). FAMEs were then injected into a gas chromatography equipped with FID (HP 6890, G1530A model) and equipped with a Capillary Column BPX70 with 30 mm x 0.32 mm x 0.25 mm with a flow rate of 16 ml / minute [26].

2.2.6. Statistical Analysis

This study used a completely randomized design with 1 factor, namely the addition of sesame oil to fish oil. The data obtained were analyzed using one way ANOVA and if there were significant differences, further testing was carried out using the Tukey test.

3. Results and Discussion

Table 1. Color of Fish Oil and Sesame Oil Blends
A study was in line with Pandurang ining concentration of palm oil. The same results were also shown that sesame oil was more unsaturated than fish oil. Based on unsaturated fatty acid content, saturated with oil or fat.

The Iodine value expresses the degree of unsaturation of oil, which stated that density affected the quality of oil associated with the composition of fish oil. Fish oil with the addition of sesame oil had increased density along with the increasing concentration of sesame oil because sesame oil had density of 0.97. This result was higher than Singh et al., [32] which stated that sesame oil density was 0.95. The increase in the mixture oil density value in this study was in line with Pandurangan et al., [33] which stated that the value of density increased with increasing concentration of palm oil. The same results were also shown in the addition of rice bran oil. The amount of oil density was related to saponification and iodine value [33].

### 3.1. Color of Oil

The oil color is expressed as L (lightness), a (redness), and b (yellowish). Based on color measurements for fish oil samples have a bright yellow color which was indicated by the largest L value and the smallest b value compared to the other samples. The value of L, a, b for fish oil each was 20.40; 2.05 and 1.55 [30]. This showed that fish oil had a bright yellow color. While sesame oil had a reddish yellow color which was indicated by the smallest L value and the largest value of a. Sesame oil had a darker color with values L, a, b, each of which was 39.96; 24.86 and 28.94 [31]. The color of the mixture of fish oil and sesame oil produces an increasing intensity of reddish yellow color indicated by the decreasing value of L, while for the value of a and b increases with increasing concentration of sesame oil.

| No | Sample | L       | a       | b       |
|----|--------|---------|---------|---------|
| 1  | F0     | 62.57±0.05\(^a\) | 1.68±0.05\(^b\) | 3.87±0.09\(^c\) |
| 2  | FS1    | 61.24±0.17\(^a\) | 0.69±0.04\(^a\) | 9.92±0.04\(^b\) |
| 3  | FS2    | 60.02±0.21\(^d\) | 0.61±0.03\(^a\) | 15.09±0.02\(^c\) |
| 4  | FS3    | 58.32±0.21\(^c\) | 1.58±0.08\(^b\) | 33.71±0.23\(^d\) |
| 5  | FS4    | 55.54±0.22\(^b\) | 4.53±0.31\(^c\) | 39.77±0.61\(^e\) |
| 6  | S0     | 39.40±0.28\(^a\) | 15.94±0.07\(^d\) | 30.60±0.39\(^f\) |

Note:
The data ± standard deviation.
Different superscript on the same column indicates significantly different (α 0.05)

### Table 2. Characteristic of Fish Oil and Sesame Oil Blends

| No | Sample | Density (g/cm\(^3\)) | Iodine Value (gI/100g) | Saponification Value (mgKOH/g) |
|----|--------|-----------------------|------------------------|-------------------------------|
| 1  | F0     | 0.93±0.01\(^a\)       | 123.52±0.43\(^a\)      | 189.10±1.61\(^d\)            |
| 2  | FS1    | 0.93±0.01\(^a\)       | 129.37±0.25\(^b\)      | 183.37±1.95\(^d\)            |
| 3  | FS2    | 0.93±0.01\(^a\)       | 129.62±0.18\(^b\)      | 186.43±3.07\(^d\)            |
| 4  | FS3    | 0.94±0.01\(^b\)       | 129.68±0.08\(^b\)      | 177.47±2.16\(^c\)            |
| 5  | FS4    | 0.94±0.01\(^b\)       | 133.14±0.07\(^c\)      | 170.01±0.85\(^d\)            |
| 6  | S0     | 0.97±0.01\(^c\)       | 133.53±0.20\(^c\)      | 176.68±3.80\(^b\)            |

Note:
The data ± standard deviation.
Different superscript on the same column indicates significantly different at level (α 0.05)

### 3.2. Density

The result of fish oil density in this study was 0.93. This result was higher than Ospina et al., [28] which stated that density affected the quality of oil associated with the composition of fish oil. Fish oil density ranged from 0.85 – 0.88. Fish oil with the addition of sesame oil had increased density along with the increasing concentration of sesame oil because sesame oil had density of 0.97. This result was higher than Singh et al., [32] which stated that the sesame oil density was 0.95. The increase in the mixture oil density value in this study was in line with Pandurangan et al., [33] which stated that the value of density increased with increasing concentration of palm oil. The same results were also shown in the addition of rice bran oil. The amount of oil density was related to saponification and iodine value [33].

### 3.3. Iodine Value

The Iodine value expresses the degree of unsaturation of oil, which was associated with fatty acids not saturated with oil or fat [34]. The results of sesame oil iodine value were greater than fish oil. This showed that sesame oil was more unsaturated than fish oil. Based on unsaturated fatty acid content,
sesame oil contained greater unsaturated fatty acids compared to fish oil, especially in linoleic fatty acids. Iodine value of fish oil in this study amounted to 123.52 gI/100g. The iodine value of fish oil was around 119 - 129 gI/100g [15, 35], while iodine value of sesame oil ranged from 117 - 133 gI/100g [32, 36]. Iodine value in mixed oils increased with increasing concentration of sesame oil. This study is in accordance with Mostafa et al., [37] which stated that iodine value increases in a mixture of olive oil and canola oil.

3.4. Saponification Value
Saponification value states the amount of sodium hydroxide used to make 1 gram of fat or oil. Saponification value measured the amount of molecular weight of fatty acids that found in oil / fat [34]. Saponification value in fish oil decreased with increasing concentration of sesame oil. Sesame oil had a lower saponification rate than fish oil. Olasunkanmi et al., [36] stated that the amount of saponification value in sesame oil was 192.24 mgKOH/g, while fish oil was 199.27 mgKOH/g [35]. The ratio of long chain fatty acids and short chain fatty acids affects the level of saponification value. An amount of long chain fatty acids in oil can decreased saponification value [34]. This result related with fatty acid profile of sesame oil, where it contains of long chain fatty acids that higher than fish oil, so the increasing of sesame oil will decrease the saponification value.

### Table 3. Fatty Acid Composition

| No | Fatty Acid (%) | F0   | FS1  | FS2  | FS3  | FS4  | S0  |
|----|----------------|------|------|------|------|------|------|
| 1  | Lauric Acid    | 0.14 | 0.18 | nd   | 0.08 | 0.07 | nd   |
| 2  | Myristic Acid  | 8.58 | 11.25| 7.40 | 5.07 | 4.61 | 0.06 |
| 3  | Palmitic Acid  | 22.12| 9.10 | nd   | 18.47| 19.90| 24.21|
| 4  | Palmitoleic Acid| 6.97 | 9.15 | 6.15 | 4.17 | 5.62 | 3.03 |
| 5  | Stearic Acid   | 2.01 | nd   | 2.65 | 2.47 | 5.62 | 4.66 |
| 6  | Oleic Acid (ω=9)| 35.18| 35.11| 35.07| 29.28| 34.75| 34.84|
| 7  | Linoleic Acid (ω=6)| 16.83| 27.62| 22.16| 21.35| 20.82| 33.94|
| 8  | Linolenic Acid (ω=3)| 6.60 | 5.89 | 5.79 | 5.57 | 5.40 | 0.43 |
| 9  | Behenic Acid   | 0.06 | 0.14 | 0.10 | 0.06 | 0.08 | 0.09 |
| 10 | Erucic Acid (ω=9)| 0.48 | 0.66 | 0.87 | 0.99 | 0.38 | 0.02 |

Note: nd = non detected

3.5. Fatty Acid Composition
Fish oil and sesame oil have difference in the composition of fatty acids, especially omega 3 fatty acids. Based on Table 3, the dominant content of unsaturated fatty acid in F0 consists of oleic acid (ω = 9), linoleic (ω = 6), and linolenic (ω = 3) with the highest percentage of oleic acid. These results were similar to Choi & Lee [38] which stated that the unsaturated fatty acids of fish oil were oleic, linoleic and linolenic acids with the highest content of linoleic acid. Unsaturated fatty acid also found in S0, there were oleic and linoleic acid. Linolenic fatty acid in S0 was found in a small content namely 0.43%. These result was similar with Thakur et al., [39] which stated that the dominant fatty acids in sesame oil with various varieties were oleic and linoleic fatty acids, whereas linolenic fatty acid was in small amounts ranging from 0.26 – 0.50%.

The mixture of fish oil and sesame oil enhanced the distribution of fatty acids, especially omega 3 fatty acid. Within the addition of sesame oil to fish oil decreased the content of omega 3 in mixed oils. FS1, FS2, FS3, FS4 had the highest amount of omega 3, omega 6, and omega 9 fatty acids. This showed that the composition of fatty acids from fish oil and sesame oil can be distributed in the mixture of oil. The same result was shown by Ract et al., [40] that a mixture of sunflower-canola oil and canola-linseed oil produced fatty acid compositions accordance to the fatty acids of the original oil. Unsaturated fatty acids, especially omega 3, 6, and 9, are beneficial for health, so the mixture of fish oil and sesame oil is suitable for application as edible oil or for industrial purposes.
4. Conclusion

FS4 had the characteristics of mixed oil with the yellow color with density, iodine value, and saponification value respectively 0.94 g/cm³, 133.14 gI/100g and 170.01 mgKOH/g. The mixture of fish oil and sesame oil contained omega 3, omega 6, and omega 9 fatty acids that were higher than the origin.

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