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The Effect of Surfactant, Time, and Speed of Stirring in The Emulsification Process of Soybeaan Oil in Water

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Abstract - *Homogenization is the process of uniform particle size in an effort to maintain the stability of a mixture which is formed from 2 incompatible phases or so-called emulsion.Emulsion is a complex system consisting of a liquid phase which is spread over another immiscible liquid phase which is usually through mechanical shear. All emulsions are thermodynamically unstable due to contact between oil and water molecules. However, emulsions can be stabilized rapidly in the presence of emulsifying or thickening agents such as Tween 20 and Tween 80. Apart from the addition of emulsion stabilizing surfactants, the speed of stirring also has an effect in stabilizing the emulsion. This research was conducted to determine the effect of stirring speed and addition of surfactants Tween 20 and Tween 80 on the stability of soybean oil emulsion. The results of density, viscosity, stability, and microscopic tests showed that the emulsion was treated with the addition of tween 80 with a stirring speed of 30.000 rpm*

Keywords *– emulsion, stability, surfactant, tween 20, tween 80*

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1. Introduction

Soybean oil is a vegetable oil that is produced from soybean seeds. Soybean oil consists of triglycerides of 90% - 95%, while the rest is phosphatides, free fatty acids, sterols and tocopherols. The amount of phosphatida in soybeans is about 2% consisting of lecithin and sephalin. Most of the fatty acids in soybean oil consist of essential fatty acids that are needed by the body [10]. Soybean oil can be used as cooking oil, salad dressings, mayonnaise, and other emulsion products.

Emulsion is a complex system consisting of a liquid phase which is dispersed in another immiscible liquid phase which is usually through mechanical shear [4]. Emulsions are typically produced in colloid plants, ultrasonication, rotor-stator systems, high-speed blenders or high-pressure homogenizers. High pressure homogenizers are well suited for the production of perfectly dispersed emulsions [2]. All emulsions are thermodynamically unstable systems, due to contact between oil and water molecules. However, emulsions can be stabilized quickly in the presence of an emulsifying or thickening agent [3].

Emulsifiers are additives in pharmaceutical and food products that act as stabilizers in emulsions. In food, emulsifiers act as additives to maintain the consistency and shape of food and as a developer, for example emulsifiers in cakes, ice cream, etc. Emulsifiers are of two types, namely natural and artificial. Examples of artificial emulsifiers include tween 20 and tween 80 [10]. Tween 20 is a hydrophilic non-ionic surfactant used to make stable water-based oil emulsions, as a solubilizing agent for various substances such as vitamins, and as a wetting agent in oral formulations, and as a parenteral suspension [9]. Tween 80 is a hydrophilic non-ionic surfactant which is widely used as an emulsifying agent in oil-in-water emulsions. In addition, tween 80 is also used as an ingredient to increase the solubility of essential oils and oil-soluble vitamins and is also used as a wetting agent in oral and parenteral suspensions. The level used as an emulsifying agent when combined with other hydrophilic emulsifiers in an oil-in-water emulsion is 1-10% [7].

This study focuses on the effect of adding soybean oil emulsifying surfactants using Tween 20 and Tween 80 and different stirring speeds to determine the level of emulsion stability produced. The parameters analyzed

included analysis of density, viscosity, emulsion stability, as well as microscopic on the variables of surfactant type, stirring speed, and stirring time.

2. Methodology

2.1. Materials

In this study, the equipment used for the process of making soybean oil emulsions includes a homogenizer, centrifuge, microscope, beaker, measuring cup, cuvette, pycnometer, oswald viscosimeter, stopwatch, digital balance, and a set of microscopes.

The materials used in the research include Soybean Oil, Tween 20, Tween 80, and Water.

2.2. Procedure

2.2.1 Soybean Oil Emulsification Process

The emulsification process of soybean oil is carried out by mixing 60 ml of water, 30 ml of soybean oil, 10 ml of tween 20 and 10 ml of tween 80 into a beaker. After all the ingredients are mixed into the beaker glass, the next step is the homogenization stage using a homogenizer. The homogenization process was carried out at a speed of 20,000 rpm and 30,000 rpm for 3 minutes and 6 minutes.

2.2.2. Density Analysis

Density analysis on the formed emulsion aims to measure the density of the emulsion formed [5]. The density test is carried out using a pycnometer and then the calculation is carried out using the formula :

$$\rho = \frac{mass\ pycnometer\ content - empty\ pycnometer}{pycnometer\ volume}$$

2.2.3 Viscosity Analysis

Viscosity analysis was carried out using Ostwald Viscometer then the sample viscosity was calculated using the formula:

$$\eta = \eta_o \frac{t.\rho}{t_o.\rho_o}$$

2.2.4 Stability Analysis

This emulsion stability analysis refers to the research conducted by [5] which has been adapted. In the emulsion that has been formed, each 10 mL of the emulsion sample is put into a bottle and allowed to stand at room temperature (25°C) for 24 hours then in a centrifuge for 15 minutes, then the separate volume of oil is measured and the calculation is carried out using the formula:

$$ES = \frac{High\ sedimentation}{Total\ Heigh\ Emulsion} \times 100\%$$

2.2.5 Microscopic Analysis

Microscopic analysis were performed to observe the size of the water particles and the distribution of water in the sample using a 10 times magnification microscope. Through testing using this microscope, it can be seen the level of stability of the emulsion produced. Where the emulsion is considered stable if the water particles and the distribution of water in the sample are uniform [6].

3. Results & Discussions

3.1. Effect of Stirring Speed, Time, amd Type of Surfactant Againts Density

The preparation of water emulsion on soybean oil was carried out according to the sample composition with 30 mL soybean oil, 60 mL water, and 10 mL tween 20 or tween 80.

Table 1. Density, Viscosity and Stability Analysis Results.

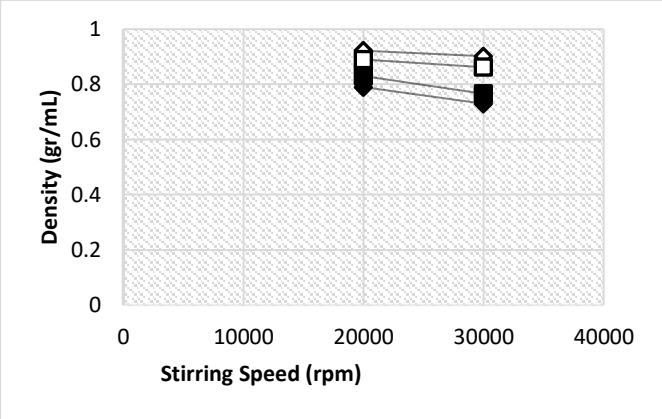


Figure 1. The Effect of Stirring Speed, Time, and Type of Surfactant (◇ Tween 20 (3 minutes); □ tween 80 (3 minutes); ◆ Tween 20 (3 x 2 minutes, interval 30" second); ■ Tween 80 (3 x 2 minutes, interval 30" second) Againts Density.

From Figure 1, it can be seen that it shows the relationship between the density of the eight emulsion samples and the stirring time and the relationship between the density of the eight emulsion samples and the stirring speed. According to [8]. The longer the homogenization time, the lower the density and viscosity of the material. Based on the analysis results shown in figure 1 and 2, it can be seen that the homogenization time and the stirring speed have an effect on the density of the soybean oil emulsion where the longer the stirring time and the higher the stirring speed, the smaller the emulsion density results. This is according to theory because the longer thestirring time and the increasing the stirring speed can reduce the viscosity of the emulsion but also increase the separation time of the oil emulsion in water. When the viscosity decreases, the density will also decrease because the density value is directly proportional to the viscosity.

3.2. Effect of Stirring Speed, Time, amd Type of Surfactant Againts Stability

After the emulsion is formed, the density and viscosity analysis is carried out and the sample will be observed for 24 hour for stability and microscopic analysis.

In the figure 2 it shows the relationship between the stability of the eight emulsion samples with the stirring time and the relationship between the stability of

the eight emulsion samples and the stirring speed. Based on the graph, it can be seen that the sample formulation that has the best level of stability is the sample using Tween 80.This is in accordance with the theory according to [1]. Tween 80 is more effective when compared to Tween 20, this is because the constituents of tween 80 hydrocarbons are oleic acid (C18: 1) and tween 20 hydrocarbons, namely lauric acid (C12: 0), where the presence of saturated hydrocarbons is more efficient in stabilizing the emulsion due to the dissolving phase dispersed in the dispersing phase can be inhibited by the presence of double bonds in unsaturated hydrocarbons.

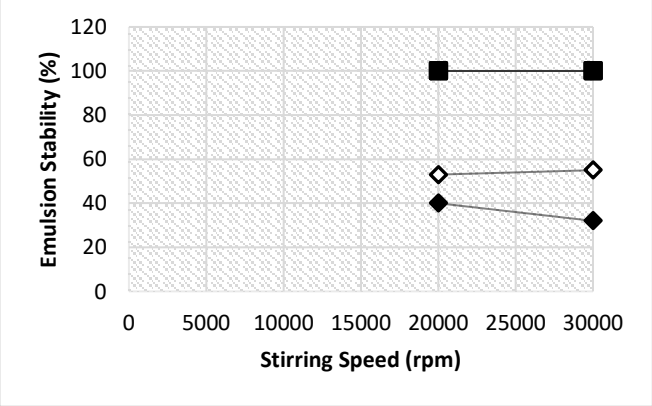


Figure 2. The Effect Stirring Speed, Time, and Type of Surfactant Surfactant (◇ Tween 20 (3 minutes); □ tween 80 (3 minutes); ◆Tween 20 (3 x 2 minutes, interval 30" second); ■Tween 80 (3 x 2 minutes, interval 30" second) Againts Stablity

In figure 1 and 2 there is a decrease in stability in the third and fourth samples, namely the sample with the Tween 20 formulation; stirring speed 20,000; and stirring time of 6 minutes. As well as tween 20; stirring speed of 30,000; and stirring time of 6 minutes. This is not in accordance with the theory according to [11]. The increase in homogenization speed and time had an effect on the formation of the emulsion and the stability of the emulsion. Stirring can expand the contact area. The faster the stirring cycle, the faster the contact between the particles. The circulation pattern will be formed due to the stirring process. The homogenization process of an emulsion is strongly influenced by this circulation pattern.

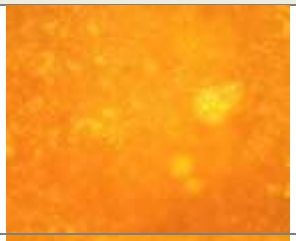
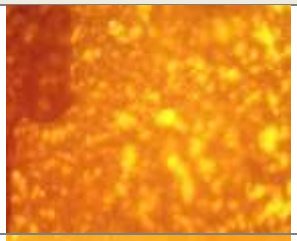
There are 3 main mechanisms that determine the emulsion to become unstable, namely creaming, flocculation and coalescence. The definition of creaming is a separation process due to the presence of gravitational force, namely the movement from up to down in the phases that form an emulsion of different density. Another factor that causes an unstable emulsion is the incorporation of a droplet with a fixed number and size which is often known as flocculation. Flocculation can also speed up the creaming process. In addition, the incorporation of globules into larger globules can also cause the emulsion process to be unstable. This process is called coalescence. Besides the stability and viscosity of the emulsion, other factors that influence the use of an emulsion are the number of peroxides and free fatty acids [11].

The emulsion stability analysing process is carried out by immersing it in room temperature for seven days to see if there is separation and phase change. The test at room temperature is carried out to avoid the stability influence factor in the form of temperature differences. Emulsion is said to be stable if after seven days and The droplet size is one of the factors that can determine the stability of the emulsion. The observation results of soybean oil emulsion droplets are shown in Figure 5. In the soybean oil emulsion, using the Tween 80 emulsifier, it can be seen that the resulting droplet size appears to be smaller, especially at the stirring time of 3x2.30 minutes and with a stirring speed of 30,000 rpm. Meanwhile, the emulsion using the Tween 20 emulsifier shows a large droplet. This is in accordance with the theory in research conducted by [10]. Viscosity is one of the factors that influence emulsion separation. Viscosity is inversely proportional to the emulsion separation rate.

Table 1. The Effect of Stirring Speed, Time, and Type of Surfactant Againts to Density, Viscosity, and Stability

Emulsion Composition	Analysis Density (gr/mL)	Viscosity (cP)	Stability (%)
Tween 20; 20,000 rpm; 3 minutes	0.922	3,443	53
Tween 20; 30,000 rpm; 3 minutes	0.902	3,378	55
Tween 20; 20,000 rpm; 3x2,30"second	0.79	2,895	40
Tween 20; 30,000 rpm; 3x2,30"second	0.73	2,682	32
Tween 80; 20,000 rpm; 3 minutes	0.89	3,448	100
Tween 80; 30,000 rpm; 3 minutes	0.862	3,030	100
Tween 80; 20,000 rpm; 3x2,30"second	0.83	2,653	100
Tween 80; 20,000 rpm; 3x2,30"second	0.766	2,326	100

Table 2. Miroscopic Analysis Test Results Using a Microsscope With 10 Times Menifications

	Tween 20	Tween 80
Mixing Speed 20,000 rpm		
3 minutes		
3 x 2 minutes, interval 30" second		
Mixing Speed 30,000 rpm		
3 minutes		
3 x 2 minutes, interval 30" second		

The higher the viscosity, the smaller the separation rate. This is because the viscosity of the continuous phase will prevent the flocculation and / or coalescence of the dispersion phase so that the emulsion separation speed is reduced.

However, in the results of microscopic test research, it is not very clear that the particles spread together or not because of the limitations of the tool when testing can only use 10X magnification.

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