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The Value of Viscosity Coefficient Of Cooking Oil Resulted By Purification Based On Active Charcoal Temperature With The Falling Ball Method

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ABSTRACT

A change in viscosity indicates the damage to cooking oil. The value of the viscosity coefficient indicates the level of viscosity. This value describes the drag caused by friction between the cooking oil molecules to block the flow. The adhesive property of used cooking oil with a high viscosity value is that it is easy to stick to foodstuffs processed with this oil. Used cooking oil is cooking oil with a high viscosity coefficient value. This oil contains free fatty acids that are harmful to the body. Reuse of used cooking oil for frying foodstuffs is not recommended. Purifying used cooking oil is one way to make cooking oil safe to consume again. The surface adsorption capacity of activated charcoal is increased by heating. Activated charcoal activation temperatures are 27^{o}C, 40^{o}C, 50^{o}C, 70^{o}C, and 90^{o}C.The value of the viscosity coefficient of the purified cooking oil is interesting to study for the activation temperature of the activated charcoal used. The falling ball method was chosen to determine the value of the viscosity coefficient. This method measured the time the ball fell in the oil. Data were analyzed quantitatively descriptively and presented in graphical form. The results show that the value of the viscosity coefficient of the purified cooking oil decreases with the increase in the activated charcoal temperature. The value of the viscosity coefficient of cooking oil as a result of purification using activated charcoal at 90^{o}C is (0.854 ±0.004) *Pa. s*

Introduction

The reuse of used cooking oil in the community cannot be avoided. Cooking oil three times or more use is not recommended for use. Repeated heating of cooking oil can change the physics-chemical properties [1]. One of the physical properties that change is viscosity. Thick cooking oil is adhesive. In addition, used cooking oil is rich in free fatty acids. Consuming it in the long term can cause cancer [2].

The use of activated charcoal is an alternative method in purifying used cooking oil. Besides being inexpensive and straightforward, this method effectively reduces volatile substances, impurities, metal elements, and free fatty acids in the oil. Research by S. Oko [3] showed that the use of activated charcoal in the purification of used cooking oil reduced water content, free fatty acids, and peroxide numbers. H.N. Muhammad [4], A.A. El-R. Mohdaly [5] and T. Ariani [6], in their research, showed that the quality of used cooking oil increased after being purified with activated charcoal.

The high adsorption capacity of charcoal is due to its large porosity. The pores on the surface of the charcoal with an area of (3000 - 3500) m^2/gram can adsorb unwanted substances, such as odor substances, dyestuffs, water content, free fatty acids, and metal contamination. The porosity of the charcoal can be increased by physically activating the charcoal.

Figure 1. Coconut shell active charcoal

The surface area and volume of the charcoal pores become large. Physical activation of charcoal can be done by heating. Activation of charcoal by heating has higher effectiveness than NaOH [7].

Generally, cooking oil purification aims at producing used cooking oil that is safe for reuse. Passing the test on the standard criteria for cooking oil quality can be used to measure whether or not used cooking oil can be consumed again. Referring to the test criteria according to SNI: 3741-2013 [8], the value of the viscosity coefficient of cooking oil is not stated explicitly in terms of quantity. Although the amount is not expressly stated, the value of the viscosity coefficient is a physical parameter of the quality of cooking oil. The repeated use of cooking oil increases density, refractive index, free fatty acids, and oil viscosity [9]. Used cooking oil with high viscosity has higher adhesive properties. This cooking oil will easily stick to food ingredients.

Viscosity is a measure of the viscosity of a fluid that describes the fluid's resistance as it flows. This resistance is caused by the friction between the moving fluid molecules. The cohesive force between fluid particles causes shear stress between moving molecules [10]. The magnitude of the frictional force experienced by a particle of size r moving in a fluid with velocity v represents the magnitude of the viscosity coefficient. The greater the value of the viscosity coefficient, the thicker the liquid and the greater the fluid's resistance to flow. Temperature affects the viscosity of a fluid. The higher the temperature of the fluid, the less viscous the fluid is. In his research, K. Shoaliha [11] showed a decrease in the value of the viscosity coefficient in various heated cooking oils. The same study results were also shown by B. Esteban [12].

The manual viscometer with the falling ball method is a simple method, and it is pretty precise to determine the value of the viscosity coefficient. This method is used to determine the viscosity of various fluids. Y. Eguchi, [13] used this method to determine the Rheological Property of Blood. E. Yusibani and K. Shoaliha [9,11] used it to determine the viscosity of various types of cooking oil. The principle of this method is to measure the time it takes the ball to fall through the fluid a certain distance. The velocity of a falling ball in a fluid is affected by the size, density of the ball, and the fluid's viscosity. Based on Stokes principle, the viscosity coefficient is determined by the equation:

$$\eta = \frac{2r^2 g}{9\upsilon_T}\left(\rho_b - \rho_f\right), \quad (1)$$

where η is the coefficient of viscosity (Ns/s^2), r is the radius of the sphere (m), g is the acceleration due to gravity (m/s^2), ρ_b and ρ_f are the density of the ball and fluid (kg/m^3) and υ_T is the terminal velocity (m/s).

The difference between this study and previous studies is that the coefficient value of used cooking oil is obtained from the purification of activated charcoal activated by the heating method. The activation temperatures of activated charcoal are 40^{o}C, 50^{o}C, 70^{o}C, and 90^{o}C. This research was conducted to describe the value of the viscosity coefficient of cooking oil that has been purified with activated charcoal. The results of this study can educate the public that the viscosity coefficient value of used cooking oil from high purification results is adhesive easy to stick to food ingredients treated with this oil.

Methods

The sample of this research used cooking oil which was purified with activated charcoal. Used cooking oil was obtained with three times of discontinuous use. The purification was done by using the adsorbent method. Activated charcoal from coconut shell was used as an adsorbent. Activated charcoal pores were activated by heating. Activated charcoal activation temperatures were 40^{o}C, 50^{o}C, 70^{o}C, and 90^{o}C for 30 minutes in the oven. The mass of activated charcoal used in the purification process is 30% of the mass of used cooking oil. Stirring was carried out and continued with precipitation for 5 hours in the purification process. The final process is a filtering step using filter paper.

The sample measured was used oil resulting from 3 times of discontinuously using after being purified with activated charcoal as an adsorbent at room temperature and activated at 40^{o}C, 50^{o}C, 70^{o}C, and 90^{o}C. The measurement of the viscosity coefficient of the sample was carried out by using the falling ball method. This method measured the time a ball takes to fall in a sample at a distance of 20 cm at room temperature and a pressure of 1 atm. The measurement of the falling ball time was repeated 15 times to determine the terminal velocity. The mass of the ball used was 19.58 grams with a diameter of 2.92 cm. The density of the ball was 1.502 g/cm^3. Sample density was obtained from mass and volume measurements. The repetition of mass and volume measurements was carried out five times. The value of the viscosity coefficient was calculated by equation (1). This data was analyzed by descriptive quantitative techniques and expressed in graphical form.

Result and Discussions

When dropped in the sample, initially, the ball moved rapidly and then slowed down until it moved in a uniform, straight line. Due to the viscous nature of the sample, the magnitude of the acceleration of the ball decreased and eventually became zero. The ball was moving at a constant velocity (terminal velocity). The terminal velocity of the ball in used cooking oil which was purified by using activated charcoal at room temperature and activated at temperatures of 40°C, 50°C, 70°C, and 90°C is presented in Table 1.

Table 1.The terminal velocity of a ball in used cooking oil

Terminal velocity (m/s)	The temperature of active charcoal				
	Sample 1 :T_{room}	Sample 2: $T = 40^oC$	Sampele3: $T = 50^oC$	Sample 4 :$T = 70^oC$	Sample 5: $T = 90^oC$
v_T	0.328 ±0.095	0.331 ±0.096	0.332 ±0.097	0.336 ±0.097	0.339 ±0.099

The ball moved faster in sample 5 than in sample 1 (used cooking oil purified with activat

ed charcoal at room temperature). Referring to the results in Table 1, the ball terminal velocity increases with increased activated charcoal temperature. This shows that the resistance of the sample decreases with increasing the temperature of the activated charcoal used in the purification of used cooking oil. The increase in the temperature of activated charcoal shows that the travel time for the falling ball is getting smaller. The terminal velocity of the ball increased.

The velocity of the ball falling in the used cooking oil was influenced by the density factor of the oil. The ball moved slowly in sample 1, which had a high density, and moved fast in sample 5, which had low density. Sample 1 was a sample with a density of 883.2 kg/m³. Sample 5 was a sample with a density of 876.3 kg/m³. In sample 5, the friction between the molecules in the oil layer with the surface of the ball moving was smaller than in samples 1,2,3 and 4.

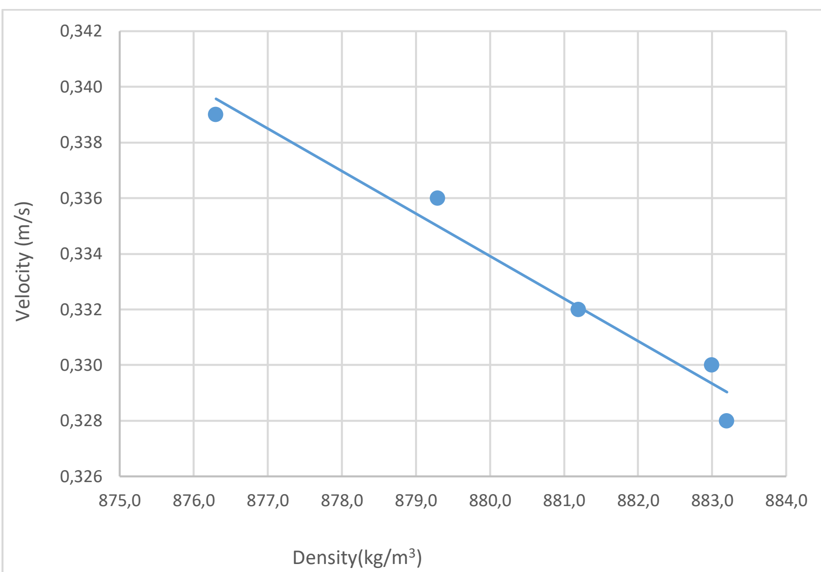

Figure 2. Graph of velocity versus density

The graph in Figure 2 shows a slowdown in the motion of the ball falling on a sample with a high density. The speed of the ball becomes smaller. The value of the viscosity coefficient of cooking oil that was purified with activated charcoal at room temperature and activated is presented in Table 2.

Table 2. The value of viscosity coefficient of used cooking oil

Viscosity coefficient value (Pa. s)	The temperature of active charcoal				
	Sample 1 :T_{room}	Sample 2: $T = 40^oC$	Sample 3: $T = 50^oC$	Sample 4 :$T = 70^oC$	Sample 5: $T = 90^oC$
η	0.877 ±0.004	0.868 ±0.004	0.869 ±0.002	0.860 ±0.007	0.854 ±0.004

The value of the viscosity coefficient of used cooking oil as a result of purification with activated charcoal at room temperature was higher than that of purification with heated activated charcoal. The use of activated charcoal with a temperature of 90^{o}C in the purification of used cooking oil had the smallest viscosity coefficient value (0.854 ±0.004) Pa. s. Increasing the temperature of activated charcoal tended to reduce the oil's viscosity. At the temperature of activated charcoal, which was 90^{o}C, the cohesion force between the molecules of used cooking oil was the smallest. The cohesion force increased with decreasing activated charcoal temperature. This cohesive force inhibited the movement of the ball falling. The friction between the molecules in the oil layer and the ball's surface became larger. The ball moved slower. The greater the cohesive force, the higher the viscosity. The ball moved fast in sample 5 with a low viscosity coefficient value and moved slowly in sample 1 with a high viscosity coefficient value.

One of the factors that affect the oil's viscosity is the concentration of solutes. If the amount of solute in used cooking oil is large, then the concentration in the oil is high, and the density of the oil is also high. Physically, the purification results of used cooking oil have a different viscosity than before. Increasing the activation temperature of activated charcoal can increase the adsorption power. The surface area and volume of activated charcoal pores becomes larger. The solute particles in the used cooking oil are drawn into the pores and accumulate there. The density of used cooking oil becomes small.

Referring to the graph in Figure 3, the higher the density value of the sample (used cooking oil clarified with activated charcoal), the greater the resistance of the oil film molecules to the ball moving. Its viscosity coefficient value became higher. This value was lower than sample 1. The ball falls in sample 1 with a speed of (0.328±0.095) m/s, slowing down its movement.

Besides the density, the oil's viscosity affects the terminal velocity of the falling ball. Referring to the data in table 1 and table 2, the terminal velocity of the falling ball can be analyzed in various values of the viscosity coefficient of used cooking oil. The graph of the falling ball terminal velocity versus the viscosity coefficient value is presented in Figure 4.

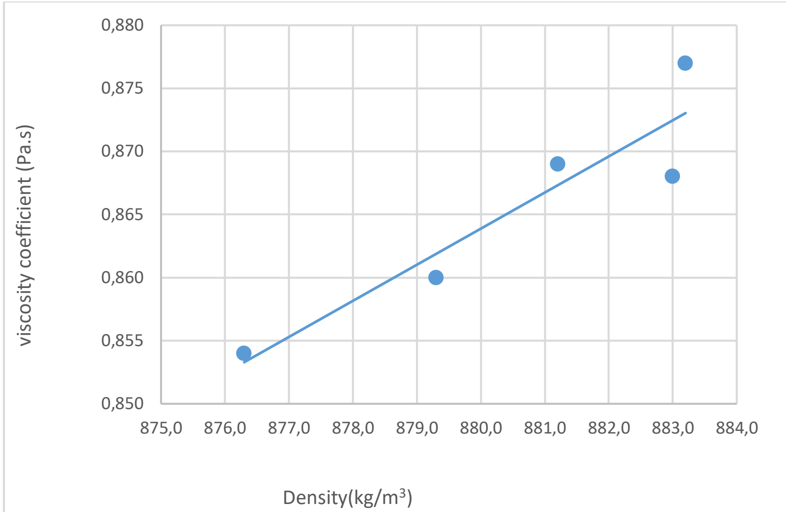

Figure 3. Graph of the viscosity coefficient versus density

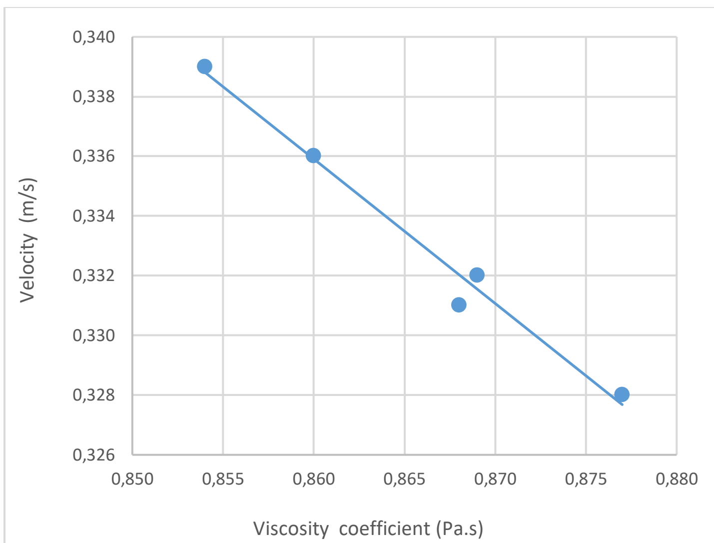

Figure 4. Graph of viscosity coefficient versus velocity

The ball moving in a sample with a viscosity coefficient of (0.854 ±0.004) Pa.s had a speed of (0.339±0.099) m/s. This value was lower when the ball was dropped on a sample purified with activated charcoal at room temperature. The terminal velocity of the falling ball in the sample was inversely proportional to the value of the viscosity coefficient [10]. These results indicated that used cooking oil with a high viscosity coefficient value had a large resistance to flow.

Conclusion

The value of the viscosity coefficient of used cooking oil due to purification decreases with increasing activated charcoal temperature. At a temperature of 90^{o}C activated charcoal, the value of the viscosity coefficient of used cooking oil reaches (0.854 ±0.004) Pa. s. Used cooking oil from purification with a high viscosity coefficient value is adhesive.

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