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Absorption Time and Temperature Effects on The Physical Chemical Properties of Refined Used Cooking Oil Using Bentonite and Carbon Bagasse Adsorbents

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Abstract

Bentonite and carbon bagasse adsorbents are used to study the effects of temperature and absorption time on the physico-chemical properties of refined used cooking oil. Any extended use of outdated cooking oil will have an impact on the body's health since it causes fat cells to accumulate in various vital organs. Used cooking oil can be cleaned by using adsorbents like bentonite, bagasse, and activated carbon. This study investigated the effects of temperature and adsorption period on the purification results of used cooking oil using activated carbon adsorbents comprised of bagasse and bentonite. In this study, a factorial group randomised design was used. First, there is a 1:1 adsorbent to substrate ratio. Secondly, there are four adsorption temperature levels: 30°C, 60°C, 90°C, and 120°C. The third factor is adsorption time, which are: 30, 60, 90, and 120 minutes. Counting the quantity of acids, peroxides, and free fatty acids was one method of data analysis. The best results are obtained when used cooking oil is refined using activated carbon, bagasse, and bentonite at 120°C for 90 minutes of adsorption. The result is an acid number of 0.913, a peroxide number of 2.532, and a free fatty acid content of 0.459%.

Keywords: *absorption, duration, sugarcane bagasse activated carbon, temperature, used cooking oil.*

Abstrak

Pengaruh Temperature dan Waktu Absorpsi Terhadap Properti Fisik dan Kimia dari Minyak Goreng Bekas yang Dimurnikan Menggunakan Adsorben Bentonit dan Karbon Ampas Tebu. Minyak goreng bekas adalah minyak goreng yang sudah dipakai berulang-ulang. Penggunaan minyak goreng bekas dalam jangka waktu tertentu akan berdampak pada kesehatan tubuh akibat deposisi sel lemak diberbagai organ tubuh seperti hati, jantung, ginjal, dan arteri. Minyak goreng bekas dapat dimurnikan menggunakan adsorben yaitu karbon aktif ampas tebu dan bentonit. Penelitian ini bertujuan untuk untuk mengetahui pengaruh suhu dan waktu adsorpsi minyak goreng bekas hasil pemurnian menggunakan adsorben karbon aktif ampas tebu dan bentonit. Penelitian ini menggunakan rancangan acak kelompok faktorial. Faktor pertama rasio perbandingan adsorben 1:1 faktor kedua adalah suhu adsorpsi yang terdiri 4 taraf yaitu: 30°C, 60°C, 90°C dan 120°C. Faktor ketiga adalah waktu adsorpsi yang terdiri dari 4 taraf yaitu: 30, 60, 90, dan 120 menit. Data dianalisis dengan analisa bilangan asam, bilangan peroksida dan kadar asam lemak bebas. Perlakuan terbaik dari proses pemurnian minyak goreng bekas menggunakan karbon aktif ampas tebu dan bentonit adalah perlakuan suhu 120°C dan waktu adsorpsi 90 menit, yang memperoleh bilangan asam sebesar 0.913, bilangan peroksida sebesar 2.532 dan kadar asam lemak bebas sebesar 0.459%.

Kata kunci: adsorpsi, karbon aktif ampas tebu, minyak goreng bekas, suhu, waktu.

INTRODUCTION

Cooking oil is one of the requirements that is inextricably linked to human activity, including food consumption [1]. Various culinary oils, such as samin oil, palm oil, and corn oil, are the sources of the oil. The waste that arises from the community's use of cooking oil in both small and large scales companies and residences is referred to as used cooking oil [2].

Bentonite Clay

Clays are hydrous aluminosilicates made up of metal oxides, various mineral crystals, and combinations of finely grained clay minerals. Through ion exchange or adsorption, clays absorb cations and anions and play a significant function in the environment. According to [3], they are considered low-cost sorbents because price is a crucial factor. Their negative charge, which can be neutralized by the adsorption of positively charged anions, accounts for their high adsorption ability. Bentonite, which is a member of the 2: 1 clay family and is made up of an octahedral sheet of aluminum ions and two tetrahedrally coordinated sheets of silicon, is the term used to describe clays that yield montmorillonite. Clay can be altered to increase its capacity for sorption [4]. For example, bentonite coated with iron can be produced through the use of magnetic alteration [5]. In scientific literature, the group of iron compounds having hydroxide, oxyhydroxide, and oxide structures are referred to as "iron oxides." Their chemical, structural, and physical properties are greatly influenced by the method of chemical synthesis, and they are frequently employed in practice as pigments, catalysts, sorbents, and in ferrofluids [6], among other applications. The purpose of this work was to compare the adsorption capacity of magnetic composites with that of unmodified bentonite, and to investigate the sorption properties of these materials while eliminating heavy metals (Zn, Cd, and Ni) from model solutions [7].

Carbon Bagasse

A byproduct of the sugarcane industry, sugar cane bagasse is collected after the juice is extracted to produce sugar. Worldwide, an estimated 54 million dry tons of bagasse are produced each year [8]. 16.6 million tons are produced in Pakistan each year [9]. At the moment, it is supplied as a raw material for the production of pulp, paper and building boards or utilized as fuel for boilers. According to [10], sugarcane bagasse is not a very effective adsorbent for organic compounds like metal ions and sugar colorants in its natural condition. To improve bagasse's adsorptive qualities towards organic molecules or metal ions, which are frequently present in water and wastewater, physical and chemical modifications are required. Bagasse is efficiently transformed into activated carbon to do this. It has been observed that bagasse is a good resource for making activated carbon.

MATERIAL AND METHODS

Efforts to process used cooking oil can be done in various ways, one of which is through a purification process using the adsorption method. Adsorption was chosen because it is easy to implement and economical. In this study, bio-adsorbents from bagasse waste and bentonite were used by varying the adsorption temperature of 30°C, 60°C, 90°C, 120°C for 30, 60, 90, 120 minutes respectively, with the analysis used to determine the free fatty acid content, acid number, and peroxide number.

Preparation of Raw Materials

Cutting bagasse to a 20 mm size is the first step, followed by cleaning it with distilled water, letting it dry in the sun, and then crushing it in a blender.

Activating Bentonite

Prepare bentonite to a size of about 100 mesh, dissolve in 5 N HCl, and then heat for two hours while stirring at a temperature of 70°C. then drying bentonite at 105°C for 4 hours after filtering and washing bentonite with water till the pH of the washing water is > 4.

Production of Activated Carbon from Sugarcane Bagasse

Once activated carbon bagasse has been soaked for 24 hours in 5% H_3PO_4 and has been filtered and washed until the pH is neutral, it is heated in an oven for 2 hours at 105°C using sugarcane bagasse powder that has been ground into a powder and carbonized at a temperature of 500°C.

Process for Adsorption

In an Erlenmeyer, combine 100 milliliters of used cooking oil with 10 grams of a bagasse and bentonite combination. Stir for 30, 60, 90, and 120 minutes, respectively, at 30°C, 60°C, 90°C, and 120°C. The oil was then filtered, and samples were obtained for analysis of the amount of free fatty acids, the number of acids and the amounts of peroxides.

RESULT AND DISCUSSION

Table 1. Standard of Carbon Active

No.	Test Parameters	Results	SNI No. 06-3730-1995
1.	Moisture content (%)	16,70	Max. 15
2.	Ash content (%)	4,78	Max. 10
3.	Fly substance (%)	15,59	Max. 25
4.	Fixed Carbon (%)	65	Min. 65
5.	Iodic Absorbency (mg/g)	761,4	Min. 750

The water content, ash content, volatile matter, fixed carbon, and iodine absorption data were acquired from the findings of the proximate analysis that was performed in **Table 1**. The SNI 06 3730-1995 standard has been reached by the 16.70% moisture content, 4.78% ash content, 15.59% volatile matter, 65% fixed carbon, and iodine absorption capacity, however the moisture content analysis is still higher than the SNI standard (max. 15%), which is 16.70%. This is so that water can be caught in the coal pores, which will obstruct the adsorption process because the pores of the bagasse are filled with water, which should be able to absorb spent cooking oil. Bagasse possesses hydroscopic qualities that allow it to absorb water.

Using Bentonite to Treat Wasted Cooking Oil

Acid Number

According to **Figure 1**, the lowest acid number value was obtained at a temperature of 90°C at 2.8123 (mg KOH/g) with an absorption time of 90 minutes, and at a temperature of 120°C at 2.552 (mg KOH/g) with an absorption time of 120 minutes. It is obvious that 120°C and 120 minutes are the ideal temperature and duration. This demonstrates that by employing bentonite as an adsorbent, used cooking oil may be cleaned [11].

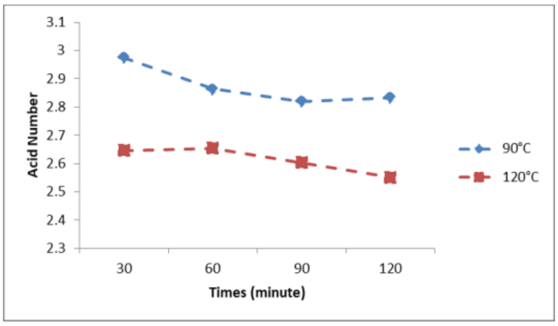

Figure 1. Acid Number of Using Bentonite with Used Cooking Oil

Peroxide Number

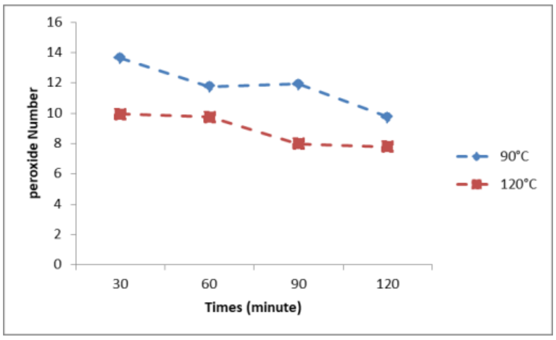

Figure 2. Peroxide Numbers of Using Bentonite with Used Cooking Oil

According to **Figure 2**, the lowest acid number value was obtained at 90°C 2.8123 ($MekO_2$/kg) and 120°C 2.552 ($MekO_2$/kg) with absorption times of 90°C and 120 minutes, respectively. It is obvious that the optimal temperature and time are 120°C for 120 minutes. This demonstrates that employing bentonite as a cooking oil adsorbent can lower the peroxide level. This is because during acid activation of the SiO2 molecule in bentonite, a silanol group (Si-OH) was produced [12].

Free Fatty Acid

According to **Figure 3**, the value of free fatty acids is 1.401% with an absorption time of 90 minutes at 90°C, and is 1.283% with an absorption time of 120 minutes at 120°C. It is obvious that the optimal temperature and time are 120°C for 120 minutes. This demonstrates that higher temperatures cause lower FFA content to develop. This is because, according to [13], raising the adsorption temperature might make the impurity molecules in used cooking oil have a higher kinetic energy, which permits them to enter the adsorbent's pores more quickly. The findings of this study indicate that 120°C is the optimum temperature for lowering the FFA content of used cooking oil. FFA levels often reduced following the adsorption procedure when adsorption duration and stirring were increased. After enough contact time, adsorption equilibrium will be attained. Because the adsorbate diffuses slowly over the adsorbent surface, adsorption will persist longer if the liquid phase containing the adsorbent remains stationary [14].

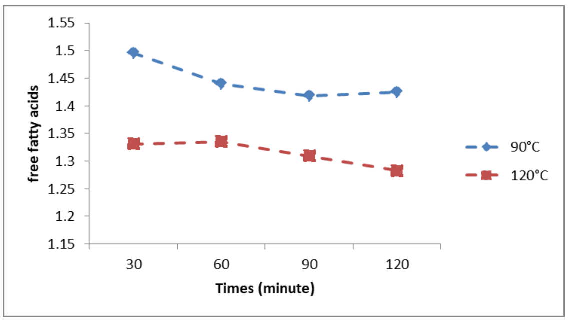

Figure 3. Free Fatty Acid Data of Using Bentonite with Used Cooking Oil

Using Activated Carbon to Treat Wasted Cooking Oil

Acid Number

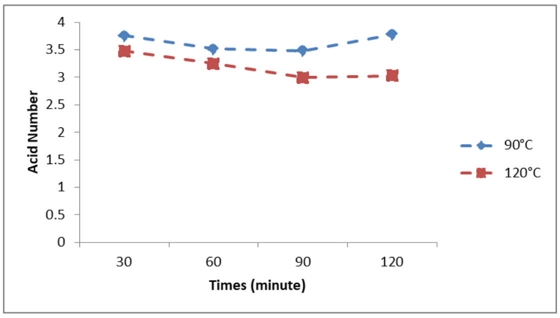

Figure 4. Acid Number of Using Activated Carbon with Used Cooking Oil

According to **Figure 4**, the acid number value was 3.263 (mg KOH/g) at 90°C and 3.027 (mg KOH/g) at 120°C with absorption times of 90 and 120 minutes, respectively. It is obvious that the optimal temperature and time are 120°C for 120 minutes. This demonstrates how cooking oil may lower its acid number by utilizing activated carbon as an adsorbent [15].

Peroxide Number

According to **Figure 5**, the acid number value was 5.781 ($MekO_2$/kg) at 90°C and 8.121 ($MekO_2$/kg) at 120°C with absorption times of 90 and 120 minutes, respectively. It is obvious that 90°C for 90 minutes is the optimal setting. This demonstrates that cooking oil may lower the peroxide level by employing activated carbon as an adsorbent. The reason is a phenomenon known as hydrolysis, in which water and water vapor combine at high temperatures to break down triglycerides into monoglycerides, diglycerides, glycerol, and Free Fatty Acids. Oils smell rotten due to hydrolysis processes, and the amounts of acids increases with production and storage.

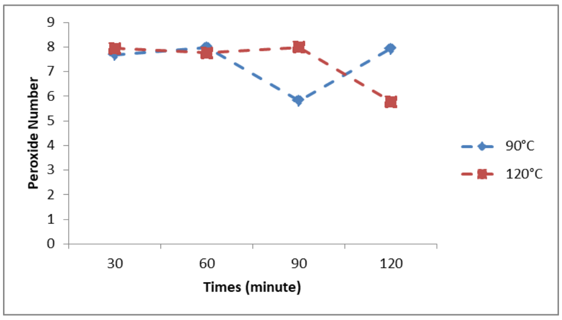

Figure 5. Peroxide Numbers of Using Activated Carbon with Used Cooking Oil

Free Fatty Acid

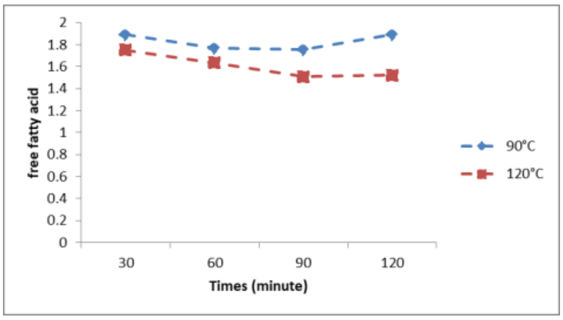

Figure 6. Free Fatty Acid Data of Using Activated Carbon with Used Cooking Oil

According to **Figure 6**, the graph demonstrates that free fatty acids grew at a temperature of 120°C after initially falling to 90°C for 90 minutes and then rising again at 120°C for the same temperature. This demonstrates how the temperature of adsorption influences the amount of Free Fatty Acids in oil after adsorption. In general, the lower the oil Free Fatty Acid concentration after adsorption, as higher temperatures result in molecules having more kinetic energy for collisions, which increases the capacity of adsorbents to adsorb free fatty acids. However, excessive temperatures also have a negative effect on Free Fatty Acid levels, which tend to rise as a result of cooking oil e xpe riencing degradation when heated above 100°C. The results of using activated carbon bagasse can lower levels of Free Fatty Acids by 1.522%.

Effect of Dissolving Time and Adsorption of Used Cooking Oil Using Sugarcane Bagasse Activated Carbon and Bentonite

In order to determine the best temperature and adsorption time conditions to enhance the quality of used cooking oil, this research was carried out to determine the quality of used cooking oil using the adsorption method and to study the effect of adsorption temperature and time in the refining process on the quality of used cooking oil. In this study, bentonite and bagasse were utilized as adsorbents. A number of variables, such as the peroxide number, acid number, and Free Fatty Acids, affect the quality of food oil.

Acid Number

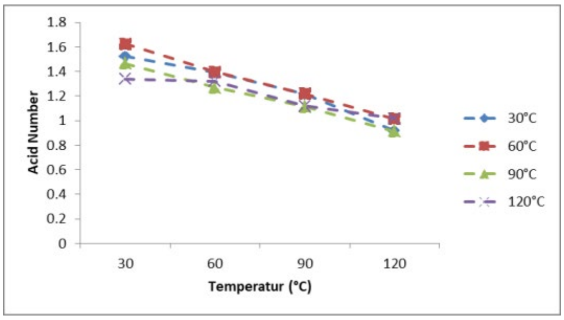

Figure 7. Effect of Solvent and Adsorption Time on Acid Number

According to **Figure 7**, the greater the adsorption temperature, the lower the acid number of used cooking oil is at all adsorption temperatures. Basically, the acid number in cooking oil after adsorption decreases the higher the adsorption temperature. This is due to the fact that at higher temperatures, molecules will collide with more energy, increasing the capacity of adsorbents to absorb acid quantities [16]. According to the contact time variation, the oil acid number drops with increasing adsorption time. This demonstrates how the acid number of the oil after adsorption depends on the adsorption time. In general, the adsorption process will be better optimized the longer the adsorption duration. Because bagasse contains cellulose, which is abundant in electronegative and polar hydroxyl groups that can interact with H^+ groups from Free Fatty Acids that are electropositive, activated carbon is able to adsorb Free Fatty Acid molecules**Error! Reference source not found.** [17].

Peroxide Number

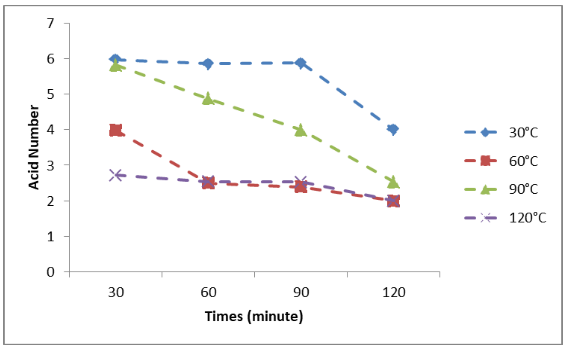

Figure 8. Effect of Solvent and Adsorption Time on Peroxide Number

The data in **Figure 8**, the peroxide number of the oil after adsorption initially reduces till the temperature of 60°C, then rises again at 90°C, the higher the temperature. Basically, the amount of peroxide left in cooking oil after adsorption decreases with increasing adsorption temperature. This is due to the fact that at higher temperatures, molecules will collide with more energy, increasing the capacity of adsorbents to adsorb peroxide chemicals. However, too high temperatures might also have a negative effect because they can hasten the synthesis of peroxide chemicals. A similar effect to that of oil acid number is demonstrated by the fluctuation of adsorption time on oil peroxide number. The synthesis of peroxide compounds back in used cooking oil can be triggered by processing oil at a high temperature of 120°C for an increasing period of time [18].

Free Fatty Acid Content

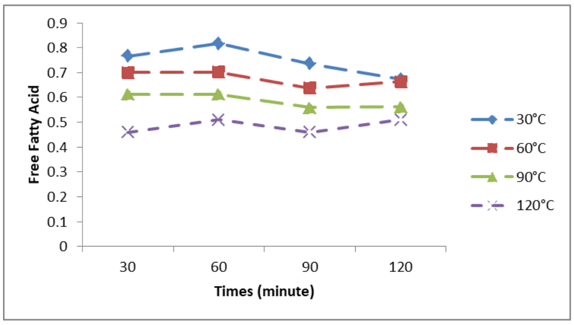

Figure 9. Effect of Solvent and Adsorption Time on Free Fatty Acid Content

A graph showing the relationship between temperature and time on the purification of used cooking oil is shown in **Figure 9**, the decrease in FFA likewise reduces the higher the operating temperature is. At a temperature of 120°C, the Free Fatty Acid value decreased by 0.459%, which was the least amount. A graph showing the association between adsorption time and oil FFA content shows that the initial sample's Free Fatty Acid value was 1.702%. FFA levels decreased from 30 to 90 minutes after adsorption. 0.459% was the lowest FFA content. The quantity of Free Fatty Acids slightly increased at 120 minutes.

CONCLUSION

According to this study, Free Fatty Acids, peroxides, and acid content can all be decreased by purifying used cooking oil utilizing the adsorption method and a combination of bentonite and bagasse activated carbon. The best temperature for reducing the amount of acid and peroxide in used cooking oil is 120°C for 90 minutes, which led to an acid number of 0.913 (mg KOH/g), peroxide number of 2.532 ($MekO_2$/kg), and free fatty acid content of 0.459% from an initial condition of 3.383 (mg KOH/g), 11.977 ($MekO_2$/kg), and 1.702% of Free Fatty Acids. Activated carbon bagasse and bentonite were utilized in this study's purification of used cooking oil, however they were unable to lower the acid number to meet SNI 3741:2013 cooking oils 0.6 mg KOH/g quality standards. As for the suggestion, the next research must be done on the use of the products of wasted cooking oil refining, such as biodiesel and soap production and more research is required to lower the acid number in order to achieve SNI 3741:2013 quality requirements.

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All authors contribute equally.

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Additional information

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