The effects of types and concentrations of adsorbents on aloe vera gel opacity

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Abstract. Aloe vera is one of the medicinal plants that are frequently used in the pharmaceutical industry, especially in cosmetic products. The type of Aloe vera that is commonly cultivated in Pontianak, Indonesia, is that of Aloe Chinensis Baker. The part of Aloe vera that is commonly used is its gel, which is an opaque mucilaginous gel. The objective of this research is to determine the effects of the addition of adsorbents on the Aloe vera gel opacity. Using Aloe vera as the main ingredient of aloe vera gel, gel is obtained by peeling off the green skin of the Aloe vera leaves that have been washed. A gel is then pureed and filtered to reduce dregs. The purified gel is added with adsorbents. This research employs two factorials, those are adsorbent types (Zeolite and Bentonite) and concentrations (0 %, 2.5 %, 5 %, 7.5 % and 10 %). The parameters used for analyses are refractive index, pH, Vitamin C content, density, and viscosity. Regression analyses are performed on the concentrations and yields. Results show that addition of Zeolite produces better clearance on Aloe vera gel than that of Bentonite, with the concentration of Zeolite at 2.5 %. The analyses further produce a refractive index of 1.332 for Zeolite treated gel. This value is close to the water refractive index of 1.3325.

1. Introduction
Aloe vera is one of the medicinal plants that are frequently used in the pharmaceutical industry, especially in the cosmetic industry. This is because Aloe vera’s pharmacological properties make it one of the important raw materials for cosmetics products [1]. Aloe vera belongs to the family of Liliaceae [2]. The most commonly cultivated type of Aloe vera in Asia, including Indonesia is Aloe chinensis Baker, from China, although it is not native there. This type has been commercially cultivated in Indonesia in Kalimantan Barat (West Kalimantan) province and is commonly known as Aloe vera Pontianak, as described by Baker 1877 [3].

The parts of Aloe vera plants that are generally utilized are its leaves that can be directly used in the forms of extract, leaf sap, gel (the mucilaginous part inside the leaves after separating it from the skin), and consisting of 96 % water and 4 % solids containing 75 beneficial compounds. Aloe vera gel also contains 17 amino acids important for our bodies. Its contents make this plant multifunctional. These constituents include aloin, emodin, resin, lignin, saponin, anthraquinone, vitamins, minerals, and so on. Aloe vera is used in the industry in the form of gel, powder, and extract [3], [4], [5]. To produce Aloe vera Powder by microencapsulation, The optimal drying inlet temperature was found at
120°C, which the active compounds of Aloe vera powder (aloenin (B), aloesin A and chrysophanol) can be maintained [3]. Microencapsulation is a technology coating solids, liquids and gases by the capsule in the form of a small capsule that can release contents under specific conditions [6].

Adsorption is a process in which a substance adheres to the surface of a solid caused by atomic or molecular attraction forces without being integrated [7]. A couple of adsorbents that are generally used in the adsorption process are Zeolites and Bentonites. The types of Zeolites commonly found in Indonesia are clinoptilolite and mordenite [8]. Mordenite can be used in the adsorption of H₂O, CO, CO₂, and CH₄ gases, while clinoptilolite can be used for CO, CO₂, and NO gases [9].

The typical structure of Zeolite is marked by a large number canals and pores that result in a large surface area. This condition can be further explained that each pore and canal inside as well as between crystals is considered in cylindrical form, thus the total surface area of Zeolite is the accumulated sum of the wall area of the pores and canals that make up Zeolite. The larger number of pores and canals, the larger surface area of Zeolite [10]. Based on this characteristic, Zeolite can be used as an adsorbent, ion exchanger, and catalyst.

Bentonite is an aluminium silicate hydrate mineral that is classified as a phyllosilicate or sheet silicate consisting of (SiO₂)₄ tetrahedral network built in an infinite space forming anionic (SiO₃)²⁻ network with Si/O ratio of 2/5. The general chemical formula of Bentonite is Al₂O₃.4SiO₂.2H₂O. The montmorillonite content in Bentonite is 85 % [11].

In a research conducted by Rajeswari (2012), on Aloe vera as a medicinal plant in India, the extract of Aloe vera is proven to heal many skin conditions. Aloe vera helps alleviate skin wounds caused by a burn, irritation, cut, and insect bite. Its antibacterial property can eliminate itch and reduce skin swelling [12]. Firdaus (2009) conducted an experiment on the applications of Bentonite and Zeolite to increase the quality of distilled vetiver oil in Garut regency, West Java. His result showed that the addition of Zeolites as adsorbent yielded a better result than that of Bentonite. The gel extracted from Aloe vera leaves usually has high opacity (cloudy), thus the objective of this research is to determine the effects of adsorbent additions on the opacity of Aloe vera gel.

2. Method

The research is conducted in the Applied Chemistry Laboratorium, Chemical Engineering Department, Faculty of Engineering, Universitas Muhammadiyah Jakarta (UMJ – University of Muhammadiyah Jakarta). The materials used in the research are Aloe vera (Aloe Chinesisis Baker), distilled water, Bentonite, Zeolite, amyllum/starch, concentrated HCl, Sodium Thiosulfate standard solution, and Iodine standard solution. The equipment used is beakers, graduated cylinders, volumetric flasks, measuring pipettes, drip pipettes, bulb, Erlenmeyer flasks, burette, funnels, filter papers, clamps and stands, analytical scale, pH meter, pycnometer, Brookfield viscometer, refractometer, blender, and centrifuge.

This research consists of two stages; making Aloe vera gel and the addition of adsorbents. It also contains two factorials; adsorbent types (Zeolites and Bentonites) and adsorbent concentrations (0 %, 2.5 %, 5 %, 7.5 % and 10 % m/v).

The Aloe vera gel extraction starts with washing the harvested leaves. Peeling separates the green skin from the colorless mucilaginous gel, which the latter then placed in a blender for pureeing. The pureed gel is filtered to reduce dregs. The filtered gel is used in the research [3].

The amount of Aloe vera gel per sample is 200 ml. Zeolite and Bentonite at the concentrations of 0 %, 2.5 %, 5 %, 7.5 % and 10 % (m/v) are added in the gel and homogenized with a magnetic stirrer for one hour. After settling for two days, the Aloe vera gel is separated from the adsorbents by centrifugation. The resulting supernatant undergoes absorbancy and other analyses. The following flow chart (Figure 1) describes the procedure.
3. Results and Discussion

3.1. The effects of adsorbent types and concentrations on yields

This research is conducted with two types of variables; those are the types of adsorbents (Zeolite and Bentonite) and the concentrations of adsorbents (0 %, 2.5 %, 5 %, 7.5 %, and 10 %) with the sample volume of Aloe vera gel at 200 ml. The Aloe vera gel obtained from the adsorption process is differentiated between the adsorbent and Aloe vera gel. The yield is calculated from comparing the volume of gel from the adsorption to that of pure Aloe vera gel. Adsorption process takes place for 48 hours and at a maintained temperature of 14 °C.

The complete result of yields from different types and concentrations of adsorbents is presented in Table 1.
Table 1. The yield of Aloe vera gel at different adsorbent types and concentrations

| No. | Sample      | Final Yield (%) |
|-----|-------------|-----------------|
| 1   | Zeolite 0 % | 100             |
| 2   | Zeolite 2.5 % | 80             |
| 3   | Zeolite 5 %  | 78.5            |
| 4   | Zeolite 7.5 % | 77             |
| 5   | Zeolite 10 % | 75              |
| 6   | Bentonite 0 % | 100            |
| 7   | Bentonite 2.5 % | 76            |
| 8   | Bentonite 5 %  | 75             |
| 9   | Bentonite 7.5 % | 74.5          |
| 10  | Bentonite 10 % | 73.5          |

The data analyses of the effects of adsorbent types and concentrations on Aloe vera gel yield are presented in a graphic form shown in Figure 2.

Figure 2. The effects of adsorbent types and concentrations on yields of Aloe vera gel from adsorption processes

The data are analyzed using Polynomial Order 2 to obtain the correlations between adsorbent concentrations and yields. The result is presented in Figure 2. Addition of Zeolite produces $y = 0.4114x^2 - 6.2343x + 97.843$ with $R^2 = 0.9017$, while addition of Bentonite produces $y = 0.5314x^2 - 7.4943x + 97.343$ with $R^2 = 0.8795$, with $y$ representing yields and $x$ representing concentrations. The above figure shows that the more adsorbent is added, the less yield is produced. These results are caused by the greater amount of adsorbent, the more molecules of Aloe vera gel are adsorbed thus reducing the volumes of Aloe vera gel yields.

3.2. The effects of adsorbent types and concentrations on densities

The density testings are performed by measuring the weight of an empty 25-ml pycnometer, then the empty pycnometer is filled with Aloe vera gel and weighted. The empty and filled pycnometer weights are used in the density formula to obtain results, which are presented in table 2.
### Table 2. Results of Density Testing from different adsorbent types and concentrations

| No. | Sample     | Density  |
|-----|------------|----------|
| 1   | Zeolite 0% | 1.0024   |
| 2   | Zeolite 2.5% | 0.9213  |
| 3   | Zeolite 5%  | 1.0028   |
| 4   | Zeolite 7.5% | 1.0032  |
| 5   | Zeolite 10% | 1.0036   |
| 6   | Bentonite 0% | 1.0024  |
| 7   | Bentonite 2.5% | 1.0024  |
| 8   | Bentonite 5%  | 1.0028   |
| 9   | Bentonite 7.5% | 1.0028  |
| 10  | Bentonite 10% | 1.0032  |

The effects of adsorbent types and concentrations on the densities of Aloe vera gel are presented in a graphic form shown in Figure 3.

![Figure 3. The effects of adsorbent types and concentrations on densities of Aloe vera gel from adsorption processes](image)

The data are analyzed with Polynomial Order 3 on Zeolite and Linear on Bentonite, which produces the following formulas. Addition of Zeolite produces $y = -0.0009x^3 + 0.0139x^2 - 0.0526x + 0.9698$ with $R^2 = 0.7178$, while addition of Bentonite produces $y = 8E-05x + 1.0023$ with $R^2 = 0.8929$, in which $y$ represents densities and $x$ represents adsorbent concentrations.

The measurement of Aloe vera gel densities is to determine the weight of Aloe vera gel per unit volume.

#### 3.3. The effects of adsorbent types and concentrations on refractive indices

The measurement of the refractive index by utilizing light refraction. In the refractometer, measurements are read at the point where prism and solution meet. With a low concentration solution, the refractive index of the prism is much greater than that of the sample, creating a large refraction angle and a low reading. The reverse would happen with a high concentration solution. However, before reading takes place, the temperature of Aloe vera gel has to be the same as that of measurement process. Reading is taken when a stable temperature is achieved (Badan Standarisasi Nasional/National Standard Bureau, 2006). The refractive indices of Aloe vera gel from different adsorbent types and concentrations are presented in Table 3.
Table 3. Results of Refractive Index Testing from different adsorbent types and concentrations.

| No. | Sample    | Bias Index |
|-----|-----------|------------|
| 1   | Zeolite 0 % | 1.3342     |
| 2   | Zeolite 2.5 % | 1.3332    |
| 3   | Zeolite 5 %  | 1.3335     |
| 4   | Zeolite 7.5 % | 1.3330    |
| 5   | Zeolite 10 % | 1.3325     |
| 6   | Bentonite 0 % | 1.3342    |
| 7   | Bentonite 2.5 % | 1.335     |
| 8   | Bentonite 5 %  | 1.335      |
| 9   | Bentonite 7.5 % | 1.334      |
| 10  | Bentonite 10 % | 1.333      |

The refractive index of a material is the ratio between the speed of light in air and that in the tested material. Measurement of refractive index is used to evaluate the characters and purity of a medium, determine solute concentrations, compare the components between two solutions, and determine the yield of material extraction of a solution. The effects of adsorbent types and concentrations on the refractive index are presented in a graphic form shown in Figure 4.

![Figure 4. The effects of adsorbent types and concentrations on refractive indices of Aloe vera gel from adsorption processes](image)

Polynomial Order 3 is used to analyse the addition of Zeolite, whereas Polynomial Order 2 is used to analyse the addition of Bentonite. Zeolite addition produces $y = -5E-05x^3 + 0.0004x + 1.3343$ with $R^2 = 0.9693$, while Bentonite addition produces $y = -5E-05x^2 + 0.0003x^2 - 0.0013x + 1.3341$ with $R^2 = 0.7111$, in which $y$ represents refractive index and $x$ represents adsorbent concentrations. The results show that the refractory indices that are close to that of water (at 1.3325) occur at 2.5 % Zeolite and 10 % Bentonite.

3.4. The effects of adsorbent types and concentrations on pH

The measurement of pH is performed with a pH-meter by placing the probe inside the Aloe vera gel. The results of pH testing are presented in Table 4.
Table 4. Results of pH Testing from different adsorbent types and concentrations

| No. | Sample      | pH  |
|-----|-------------|-----|
| 1   | Zeolite 0%  | 5   |
| 2   | Zeolite 2.5%| 5.6 |
| 3   | Zeolite 5%  | 5.8 |
| 4   | Zeolite 7.5%| 5.98|
| 5   | Zeolite 10% | 6   |
| 6   | Bentonite 0%| 5   |
| 7   | Bentonite 2.5%| 5.4 |
| 8   | Bentonite 5% | 5.5 |
| 9   | Bentonite 7.5%| 5.7 |
| 10  | Bentonite 10%| 5.9 |

The effects of adsorbent types and concentrations on the pH of Aloe vera gel is presented in a graphic form shown in Figure 5.

![Figure 5](image.png)

Figure 5. The effects of adsorbent types and concentrations on pH values of Aloe vera gel from adsorption processes

The results of pH testings are analyzed using a linear correlation between the adsorbent concentrations and pH values. The addition of Zeolite produces $y = -0.092x + 5.2$ with $R^2 = 0.837$, while that of Bentonite produces $y = 0.084x + 5.08$ with $R^2 = 0.9587$, with $y$ representing pH and $x$ representing adsorbent concentrations.

Figure 5 shows that the higher adsorbent concentrations, the higher pH values. These resulting pH values are in accordance with the standard in SNI 16-4399-1996 (SNI = Standar Nasional Indonesia/Indonesia National Standard). pH would influence adsorbent surface charge, degree of ionization, and the species that are adsorbed in the adsorption process. The values of pH also influence the chemical equilibrium of the adsorbates as well as adsorbents. In these pH variations, the possibility of chemical bonding between adsorbent and adsorbate may occur.

3.5. The effects of adsorbent types and concentrations on viscosities

The equipment used to measure the viscosity is the Brookfield Viscometer and takes place at the Testing Center of Jakarta Custom office. The working principle of a viscometer is to measure the torque needed to initiate the spinning motion of the spindle inside a solution. The spindle is activated by a motor synchronized with a calibrated springs; spring reflection is shown with a needle or digital gauge. Viscosity has a linear correlation with the spindle rotational speed, which is related to the size and geometrical form of the spindle [13]. The results of the viscosity testing on the adsorbent types and concentrations are presented in Table 5.
Table 5. Results of Viscosity Testing from different adsorbent types and concentrations

| No. | Sample  | Viscosity (cP) |
|-----|---------|----------------|
| 1   | Zeolite 0 % | 117.6 |
| 2   | Zeolite 2.5 % | 18.9 |
| 3   | Zeolite 5 % | 11.4 |
| 4   | Zeolite 7.5 % | 10.8 |
| 5   | Zeolite 10 % | 11.1 |
| 6   | Bentonite 0 % | 117.6 |
| 7   | Bentonite 2.5 % | 24.6 |
| 8   | Bentonite 5 % | 12.6 |
| 9   | Bentonite 7.5 % | 13.5 |
| 10  | Bentonite 10 % | 20.4 |

The effects of adsorbent types and concentrations on viscosities are presented in the graphic form as shown in figure 6.

3.6. The effects of adsorbent types and concentrations on Vitamin C contents

Vitamin C in Aloe vera gel is beneficial as a free radical inhibitor inside the body. Vitamin C contents are tested using Iodometric titration methods. Iodometric titration is a type of titration utilizing redox reactions by measuring the amount of Iodine left from redox reactions between Vitamin C and a reactant. The indicator used is amylum (starch) that is added at nearing the titration endpoint. This is to prevent the starch from enveloping the Iodine so that end reading is quickly achieved. These titration processes utilize standard Iodine (I₂), which is used for compounds with a strong reductor characteristic like Vitamin C [14].

The testing of Vitamin C is performed by obtaining 20 grams of Aloe vera gel that has gone through the adsorption process. The gel is dissolved in a 100 ml graduated flask, and the resulting slurry is centrifuged to facilitate filtration. Twenty milliliters of filtrate is placed inside an Erlenmeyer flask, added with two milliliters of 1% starch and 20 ml of distilled water. Titration is performed with

The viscosity data are analyzed using Polynomial Order 2 for both adsorbents. The addition of Zeolite produces

\[ y = 2.3409x^2 - 32.529x + 109.23 \]

\[ R^2 = 0.9237 \]

whereas Bentonite addition produces

\[ y = 2.3417x^2 - 32.261x + 107.45 \]

\[ R^2 = 0.8973 \]

in which y is the viscosity and x is the adsorbent concentrations. Figure 6 shows that adsorbent additions reduce the viscosity values of Aloe vera gel. The viscosity values determine the rheological values of gel usage on skin.

Figure 6. The effects of adsorbent types and concentrations on viscosities of Aloe vera gel from adsorption processes
0.01N standard Iodine, with the calculation of one milliliter of 0.01N Iodine representing 0.88 mg of Ascorbic acid. The results of Vitamin C content testing from different adsorbent types and concentrations are presented in Table 6.

| No. | Sample          | Vitamin C (mg/L) |
|-----|-----------------|------------------|
| 1   | Zeolite 0 %     | 0.2650           |
| 2   | Zeolite 2.5 %   | 0.38345          |
| 3   | Zeolite 5 %     | 0.3652           |
| 4   | Zeolite 7.5 %   | 0.3287           |
| 5   | Zeolite 10 %    | 0.3287           |
| 6   | Bentonite 0 %   | 0.265            |
| 7   | Bentonite 2.5 % | 0.3652           |
| 8   | Bentonite 5 %   | 0.3287           |
| 9   | Bentonite 7.5 % | 0.29215          |
| 10  | Bentonite 10 %  | 0.3287           |

The effects of adsorbent types and concentrations on Vitamin C contents are presented in the graphic form as shown in figure 7.

The titration results are analyzed with Polynomial Order 2 to determine the correlation between adsorbent concentrations and Vitamin C contents. The addition of Zeolite produces $y = 0.0009x^3 - 0.0168x^2 + 0.0817x + 0.2659$ with $R^2 = 0.993$, while the addition of Bentonite produces $y = 0.0011x^3 - 0.0182x^2 + 0.0769x + 0.2659$ with $R^2 = 0.9903$, in which $y$ represents the Vitamin C contents (mg/L) and $x$ represents the adsorbent concentrations. Figure 7 shows that the highest Vitamin C contents are found at adsorbent concentrations of 2.5 %. Vitamin C content in Aloe vera gel functions as an antioxidant and inhibitor of free radicals.

4. Conclusions
The conclusions of this research are:
1. The absorbance processes for 48 hours at 14 °C produce the highest yield with Zeolite at the concentration of 2.5 % with 80 % yield and formula of $y = -2.12x + 92.7$ with $R^2 = 0.6782$. This research shows that the higher the concentration of Zeolite, the lower the yield.
2. This research yields a refractive index close to that of water (1.3325) from addition of Zeolite at 2.5% with refractive index value of 1.332. The formula for this refractory indeces for Zeolite is 
\[ y = -2E-05x^3 + 0.0003x^2 - 0.0013x + 1.3341 \] with 
\[ R^2 = 0.7111. \]

3. The optimal result from this research is from the addition of Zeolite at the concentration of 2.5%; with the yield of 80% (\( y = -2.12x + 92.7 \) with 
\[ R^2 = 0.6782 \]), Vitamin C content of 0.38345 mg/L (\( y = -0.0029x^2 + 0.321x + 0.2832 \) with 
\[ R^2 = 0.6287 \]), refractive index of 1.332 (\( y = -2E-05x^3 + 0.0003x^2 - 0.0013x + 1.3341 \) with 
\[ R^2 = 0.7111 \]), density of 0.9213 (\( y = -0.0009x^3 + 0.0139x^2 - 0.0526x + 0.9698 \) with 
\[ R^2 = 0.7178 \]), viscosity of 18.9 cP (\( y = 2.3417x^3 - 32.261x + 107.45 \) with 
\[ R^2 = 0.8973 \]), and pH value of 5.6 (\( y = -0.092x + 5.2 \) with 
\[ R^2 = 0.837 \]).

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