

ACTIVE CHARCOAL FROM WASTE OF AVOCADO SEEDS AS A CHROMIC (Cr) METAL ADSORBENT USING CHLORIDE ACID (HCl) AND SULFURIC ACID (H₂SO₄) ACTIVATOR

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Abstract

Avocado seeds are one of the wastes generated from restaurants that serve avocado juice. This avocado seed waste can be used as activated charcoal by carbonization at high temperatures and chemical activation using HCl and H₂SO₄ activators. The results showed that the optimum concentration of HCl and H₂SO₄ activator was 5%, which at a concentration of 5% produced the smallest water content values, namely 0.5825% and 0.6763%, the lowest ash content was 0.2993% and 0.2296%, while the adsorption to iodine amounted to 252.2419 mg/g and 279.8959 mg/g. The charcoal from avocado seeds has the potential to absorb chromium metal, which at optimum conditions can absorb 0.1673 mg/L and 0.1535 mg/L.

Keywords: *Activated carbon, avocado seed, H₂SO₄, HCl, adsorption*

Introduction

Avocado or *Persea americana* is a fruit-producing plant with the same name. Historically, the avocado plant came from the tropics of America. Nikolai Ivanovich Vavilov, a Soviet botanist, confirmed that the genetic source of the avocado plant came from southern Mexico and Central America, and then spread to various countries with tropical climates (Rukmana, 1997). Avocado is only taken from the fruit, while avocado seeds only become waste which is thrown away and is still underutilized. Avocado seeds contain starch, reducing sugars, fiber, arabinose, pentose, and protein (Weatherby, 1934). Starch and cellulose are high molecular mass polysaccharides consisting of carbon, hydrogen, and oxygen compounds. One of the

efforts that can be done to increase the benefits of avocado seeds is to process them into activated carbon. The avocado seed is quite easy to be used by local community.

Avocado seeds have a water content of 12.67%, an ash content of 2.78%, mineral content of 0.54% higher than other fruit seeds (Alsuhendra, 2007). The chemical composition and properties of avocado seed starch can be seen in Table 1.

Table 1. Chemical composition and properties of avocado seed starch (Winarti and Purnomo, 2006)

Component	Percentage (%)	Component	Percentage (%)
Water content	10.2	Fat	tn
starch content	80.1	Crude fiber	1.21
*amylose	43.3	Color	brown is white
* amylopectin	37.7	Granule fineness	fine
Protein	tn	yield of starch	21.3

tn = not analyzed

*amylose + *amylopectin = starch

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Avocado seeds contain high starch, indicating that their carbon content is high (Kahn, 1987) (Maryam et.al, 2016). The results of the ultimate analysis and proximate analysis of avocado seeds can be seen in Table 2 and Table 3.

Table 2. Ultimate Analysis of Avocado Seeds (Environment, Energy and Climate Change II, 2015)

Element	Rate (%)
Carbon	48.3
Hydrogen	7.5
Nitrogen	<0.5
Oxygen	43.4

Table 3. Proximate Analysis of Avocado Seeds (Environment, Energy and Climate Change II, 2015)

Analysis results	Rate (%)
Humidity ^(a)	45.3
Dry Matter ^(a)	54.7
Volatile Solids ^(b)	78.7
Ash ^(b)	2.6
Fixed Carbon ^(b)	18.7

(a) wet basis

(b) dry basis

Activated carbon is amorphous carbon, which can be produced from materials containing carbon which are treated in a special way to obtain a wider surface (Tada et.al, 2016). The usage of carbon active as water treatment media is very popular (Jiang et.al, 2018). Activated carbon can be made from corn cobs, sugarcane dregs, coconut shells, rice husks, sawdust, hardwood and cassava peels because they contain lots of carbon compounds.

The process of making activated carbon goes through a process of carbonization, activation,

and washing. The activation method commonly used in the manufacture of activated carbon can be carried out by physical activation and chemical activation. Physical activation is usually carried out by heating the carbon at a temperature of 500-600°C or by steam and CO₂. While chemical activation uses chemical materials such as H₂SO₄, NaCl, HCl, NaOH, KOH, and H₃PO₄ (Sembiring and Sinaga, 2003). Ida Rahayu (2011) conducted a study on the manufacture of activated carbon from avocado seeds which is used as an adsorbent for residual chlorine in the water. Avocado seeds were carbonized at a temperature of 300°C using a 4% ZnCl₂ activator and the activation time was 4 hours. Obtained by the percentage reduction in chlorine of 81.03%.

Meylinda Putri Nur Fadillah (2015), conducted activated carbon from avocado seeds which is used as dye adsorbent in batik liquid waste. The carbonization temperature used was 700 C using a 30% H₃PO₄ activator and 60 minutes of activation time resulted in 6.17% moisture content, 10.62% ash content, 8.12% flying substance content and 81.26% carbon content.

Based on the description above, the authors conducted research on the manufacture of activated carbon from avocado seeds and tested its effectiveness on chromium (Cr) adsorption in wastewater, using process variables, namely the type and concentration of activator so that its effect on the quality of activated carbon would be known. In this study, industrial waste was used and measured using an Inductively Coupled Plasma (ICP) tool to determine the adsorption capacity of activated carbon to absorb As and Cr metals.

Research Methodology

Fig 1 shows the flowchart of this research, starting with sample preparation up to analysis.

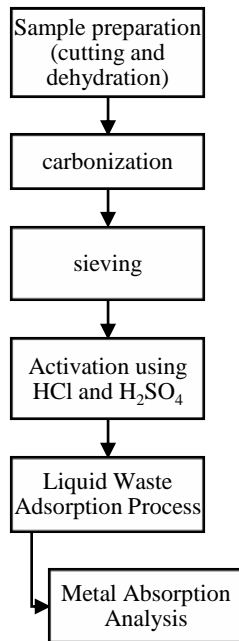


Figure 1. Research flow chart

- a. **Sampling**
The sample used in this study is avocado butter, avocado butter, which is obtained from waste or waste from selling juice in a restaurant in Depok City, West Java Province.
- b. **Sample Preparation**
The avocado seed sample was separated from the husk then washed with tap water then with aquadest then cut into small pieces. Avocado seeds that have been cut are then dried in the sun for \pm 2-3 days.
- c. **Carbonization Process**
The dried avocado seeds are then carbonated using a furnace at a temperature of $400\text{ }^{\circ}\text{C}$ for \pm 1 hour. Then the charcoal from the avocado seeds is cooled in a desiccator.
- d. **Avocado Seed Activated Charcoal Preparation**
The avocado seed charcoal obtained through the carbonization process is then crushed until smooth and sieved using a

mesh. The charcoal used is charcoal that passes at 100 mesh size and is retained at 200 mesh size. The charcoal obtained was washed with 1% NaHCO_3 and dried in an oven at $\pm 105\text{ }^{\circ}\text{C}$. Furthermore, every 10 grams of charcoal is activated using 100 mL of HCl and H_2SO_4 solutions with various concentrations of 2.5%, 5%, 7.5% and 10.0% then stirred for 5 minutes and let stand for 24 hours. HCl and H_2SO_4 solutions are common activators for this purpose (Sirimuangjinda et.al, 2012). The mixture is filtered and washed again with aquadest. The filtrate is tested with universal indicators until it reaches a pH of 5.0. Furthermore, the charcoal was dried in an oven at $105\text{ }^{\circ}\text{C}$ for 1 hour and cooled in a desiccator.

- e. **Chromium Metal Absorption Analysis**
A total of \pm 1 gram of activated charcoal is used to absorb liquid waste containing chromium. Then the filtrate obtained by setting the adsorption process is measured again using the ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometry) tool.

Result and Discussion

Carbonation and Activation

Making activated charcoal from avocado seeds has been done by carbonating dry avocado seeds using a furnace at a temperature of $400\text{ }^{\circ}\text{C}$ for \pm 1 hour. This process is carried out without direct contact and the burning of carbon-containing materials (Marsh and Francisco, 2006). The carbonation process aims to obtain high purity and to evaporate the compounds in carbon. During the carbonation process, several compounds such as tar and various metal oxides are formed.

The fat content contained in avocado seeds is very large so that the avocado seed charcoal is washed first using 1% NaHCO_3 so that the fat that is still contained in the avocado seed charcoal is lost. According to Shreve (1997) in Kurniati (2008) states that activation is a physical change in which the surface area of carbon increases sharply due to the removal of tar compounds and charcoal residue compounds. The use of HCL and H_2SO_4 is due to the fact that these two acids are activators that are in accordance with the impurities found in avocado seeds. The activator concentration used was 2.5%; 5.0%; 7.5%; and 10%. This aims to obtain the optimum concentration.

Characteristics of Charcoal

The results of the characteristics of the charcoal can be seen in Table 4 and Table 5. The characteristics of the avocado seed charcoal consist of measuring the moisture content, ash content and adsorption of iodine in order to obtain the optimum solution and concentration of the activator used.

Table 4. Characteristics of avocado seed charcoal with HCL activator

Concentration	Water content	Ash content	Iodine Adsorption
2.5%	0.9740	0.5886	204.1348
5.0%	0.5825	0.2993	252.2419
7.5%	0.6165	0.5495	238.0992
10.0%	0.6152	0.4779	197.2527

Table 5. Characteristics of avocado seed charcoal with H_2SO_4 activator

Concentration	Water content	Ash content	Iodine Adsorption
2.5%	0.9260	0.5791	258.7936
5.0%	0.6754	0.2296	279.8959
7.5%	0.7972	0.6684	266.1465
10.0%	0.8670	0.4584	279.8147

The hygro-tropical properties of activated charcoal can be seen when determining water content. Because water content is one of the chemical properties that affect activated charcoal. According to Rahmawati (2006), the high water content will reduce the quality of activated carbon because water adsorbed on activated carbon will reduce the capacity and adsorption power of liquids and gases.

In a study using an activator of HCl (seen in table 4), the lowest water content was obtained at a concentration of 5%. So it can be concluded that the activator is at the optimum condition when the HCl concentration is 5%. Whereas the activator that uses H_2SO_4 (Table 5) can be seen that the optimum conditions are when the concentration is 5%.

This optimum condition means that only a few water molecules are bound to the charcoal so that these water molecules will be released more easily during the heating process. The more water molecules bound by the activator cause the pores in activated charcoal to get bigger. In the adsorption process, the larger the pores, the larger the surface area of the activated charcoal, so that the adsorption capacity of activated charcoal is greater.

The quality of activated charcoal, apart from being influenced by water content, is also influenced by ash content. In activated charcoal, the higher the ash content will reduce the adsorption power of activated charcoal. In Table 4 and Table 5, it can be seen that both with the HCl or H_2SO_4 activator the lowest ash content is at the 5% concentration.

Activated charcoal with high iodine adsorption ability means that it has a larger surface area and has a larger micro and mesoporous structure (Jankowska et al., 1991). It can be seen in Table 4 and Table 5, the highest iodine adsorption

value is when the HCL and H₂SO₄ concentrations are 5%.

From the activation of the activated charcoal from the avocado seeds, chromium is absorbed. By using the absorption at optimum conditions activated charcoal obtained absorption of 0.1673 mg / L and 0.1535 mg / L.

Conclusion

Activated charcoal from avocado seeds can be used as an adsorbent in the absorption of chromium metal with absorption values of 0.1673 mg / L and 0.1535 mg / L. The adsorbent used was adsorbent at optimum conditions, namely when the activator concentration of HCL and H₂SO₄ was 5%.

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