Test of Active Carbon Adsorption from Cassava (*Manihot Utilissima*) Peels Against Dyes

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Abstract. *Cassava peel* is the leading waste generated by the cassava processing industry. One of the regulatory efforts is to use it as a raw material for activated Carbon to adsorb dyes. This study aims to determine the adsorption capacity of activated Carbon from cassava peel waste on yellow dye. Activated Carbon from cassava peel has been identified using FTIR. The results of FTIR characterization determined the absorption of functional groups O-H, C=C, C-H, and C-O, which indicated the presence of lignocellulose and hemicellulose content in the activated Carbon of cassava peel. The optimum mass measured in this study was 1 g with an adsorption percentage of 59.474%. The optimum contact time measured in this study was 60 min, with a percentage of adsorption power of 82.526%. The optimum concentration of yellow dye measured in this study was 200 ppm with an adsorption percentage of 94.000%.

Keywords: Cassava peel · Activated Carbon · Dyes · Power Adsorption

1 Introduction

Indonesia is known as an agrarian country, which means that most of Indonesia's population lives in rural areas with a livelihood as farmers [1] Indonesia are promoting cassava production as a catalyst for their food [2]. Cassava can produce 16% of cassava peel and Cassava peel waste can be used as a material for making activated carbon because cassava peels have a carbon content of around 59.31% [3].

Adsorption is one of the alternative methods that is highly regarded for the remediation of pharmaceuticals from wastewater. Most widely used adsorbent for wastewater treatment because of its extended surface area, microporous structure, high adsorption capacity, and high degree of surface reactivity. Activated carbon is a porous solid containing 85–95% carbon because it is made of materials containing carbon by going through a process of dehydration, carbonization, and activation. -95%, hydrogen 0.6–7.8%, organic compounds 0.04–0.45% and inorganic compounds (ash) 1.2–3.3%. Other properties of activated carbon include: black in color, odorless, tasteless, has a much greater absorption capacity than non-activated carbon, and has a large surface area between 300 to 2000 m2/gram. Because it has a very large surface area, activated carbon is very suitable

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for applications that require a large contact area such as in the adsorption and reaction, and catalysis fields [4].

Dye effluents released from numerous dye-utilizing industries are harmful towards the environment and living things [5]. The dyestuffs from the textile industry were made from organic compounds such as procion, erionyl, and auramine, which are known to be very difficult to degrade naturally. Dyestuffs that have been used around 10–15% cannot be used anymore, so they must be discarded [6]. Waste dyes generally have non-biodegradable properties because they contain complex aromatic compounds that are difficult to decompose by microbes. In addition, dye waste harms human health and the biota that live around polluted water bodies [7]. Therefore, the waste must be treated before being disposed of so as not to pollute the environment through biological, chemical, and physical methods. Enzyme degradation (biological) and adsorption (physical) dye removal as these are known as one of the most efficient dye removal techniques these days [5].

Adsorption is the process of changing the order of the gas layer on the surface of solid or liquid object. One of the materials used as an adsorbent is carbon elements that are copious within the universe. Carbon particles are also very broad because they have several advantages, such as being harmless, cheap, with high volumetric capacity, high reversible capacity, easy to assemble, and stability [8].

The adsorbent used in this study was obtained from activated charcoal from the utilization of cassava peel waste because the lignocellulose content of cassava peel has the potential to adsorb cationic waste, such as dye waste. So it is expected that activated carbon from cassava peel waste can be an excellent adsorbent to handle dye waste.

2 Method

The materials used in this study include cassava peel, yellow textile dye (wantex), NaOH crystals, and Aquades. Characterization of carbon compounds using FITR and the adsorption power test carried out with a spectrophotometer.

The manufacture of activated carbon begins with dehydrating the cassava peel to remove all water content. Cassava peel samples were cleaned using water and distilled water, cut into small pieces, and then dried in the sun until dehydrated (about 2–3 days). After that, the cassava peel was dried in an oven at 120 °C for 2 h. The second stage is carbonization (the incomplete combustion process of a material containing complex carbon compounds and not being oxidized to carbon dioxide). The solid material left after the carbonization process is carbon in the form of charcoal with narrow pores. Cassava peel was carbonized at 350 C in a furnace for 1 h. The formed charcoal is cooled, pulverized, then sifted with a size of 100 mesh. The third stage is activation (the process of changing the activated carbon surface to be much more expansive). The activator used was 10 g of NaOH crystals dissolved in 500 mL of distilled water, shaken until homogeneous to produce a 2% NaOH solution. The carbon powder was soaked in 2% NaOH solution for 1 h. Afterward, the soaked carbon was dried in an oven at a temperature of 26 h and produced a cassava peel-activated carbon.

FTIR characterizes activated carbon to determine functional groups and identify compounds based on the spectrum and wavelength of the sample. Testing the adsorption power of cassava peel-activated carbon on dyes was carried out using a visible spectrophotometer to obtain the absorbance value, which will use to find the solution's final concentration value using a standard solution calibration curve. In this test, three variations were carried out including variations in the mass of activated carbon, namely 0; 0.2; 0.4; 0.6; 0.8; 1 g, variations in activated carbon contact time are 10, 20, 30, 40, 50, 60 min, and variations in dye concentration are 50, 100, 150, 200 ppm.

3 Results

3.1 FTIR Analysis

The test is carried out on the FTIR wavenumber total of 4000 to 650 nm with the Y-axis function in the form of transmittance. The spectrum of the FTIR test results of activated carbon from cassava peel showed in Fig. 1.

The results of the FTIR spectra of activated carbon from cassava peel in Fig. 1 show absorption vibration peaks at specific wavelengths, Absorption in the wave number region of 3446, 993 cm^{-1} indicates hydroxyl groups (O-H) absorption. The absorption at a wave number of 1559.157 cm^{-1} indicates absorption of an alkene group (C=C) which is the skeleton of the hemicellulose builder in the cassava peel [9]. The absorption shown at wave number 1384,820 cm^{-1} indicates the presence of alkyl (C-H) absorption, which is the framework for building lignocellulose structures [10]. The absorption at the wave number of 1082.807 cm^{-1} indicates the absorption of the ether group (C-O), which is the linker of the carbon chain in lignocellulosic compounds on activated carbon of cassava peel [3].

3.2 Determination of the Maximum Wavelength of Yellow Dyes and Calibration Curve

Before testing the adsorption power of activated carbon from cassava peels, measurements were first made to determine the dye's maximum wavelength and the standard solution's calibration curve. Determination of the maximum wavelength aims to determine the maximum absorption of light from the dye. Because the textile dye (wantex) is yellow, the test is carried out in the visible wavelength range of 320–800 nm. This test

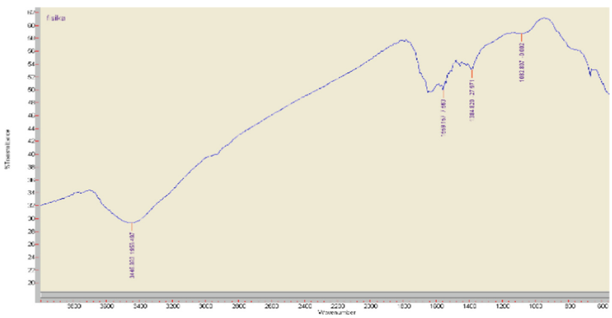

Fig. 1. FTIR spectra of activated carbon from cassava peel

was carried out with a dye solution with a concentration of 5 ppm, and the absorbance was tested with a visible spectrophotometer.

Based on the results of the visible spectrophotometer test, the optimum absorbance value data can be seen which can be seen in Table 1.

The maximum wavelength of yellow dye (wantex) was obtained at a wavelength of 395 nm with an absorbance of 0.52.

The purpose of making standard solutions is to obtain a calibration curve that determines the dye solution's final concentration after the adsorption process. In this study, standard solutions were made with 10, 20, 30, 40, and 50 ppm concentrations. They then tested the absorbance value of the standard solution using a visible spectrophotometer at a maximum wavelength of 395 nm.

The data on the absorbance value of the standard solution can be seen in Table 2. Based on this value, a calibration curve can be made between the concentration of the standard solution as a function of the (x) axis and the absorbance as a function of the (y) axis which can be seen in Fig. 2.

Table 1. Data Result of Determination of Maximum Wavelength

Wavelength (nm)	Absorbance
335	0,033
345	0,036
355	0,041
365	0,044
375	0,048
385	0,050
395	0,052
405	0,048
415	0,042
425	0,035

Table 2. Data of Standard Solution Measurement Results

Concentration (ppm)	Absorbance
1	0,069
20	0,159
30	0,253
40	0,339
50	0,456

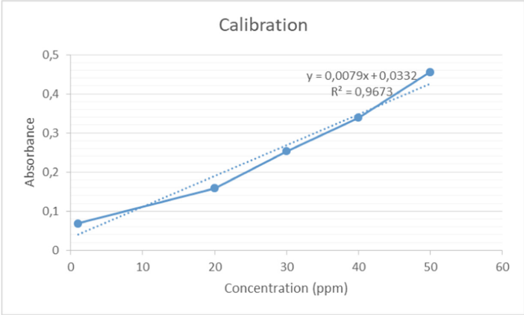

Fig. 2. Standard solution calibration curve.

Based on the calibration curve of the standard dye solution, a regression line of $R^2 = 0.9673$, the level of precision of the line means 96.73%. It was obtained with the equation $y = 0.0079x + 0.0332$.

3.3 Adsorption Power Test

3.3.1 Activated Carbon Mass Variation Test

This test aims to determine the effect of the mass variation of the adsorbent on the adsorption power. The mass variation of the adsorbent (activated carbon) is 0; 0.2; 0.4; 0.6; 0.8; 1 g. The adsorption test parameters were carried out at the initial conditions, where the dye concentration was 100 ppm. 100 ml of 100 ppm dye solution was put into an Erlenmeyer, added with a certain mass of adsorbent, then stirred using a magnetic sitter with a stirring time of 10 min. Then filtered using filter paper, the resulting filtrate was measured for its absorbance using a visible spectrophotometer at a maximum wavelength of 395 nm. Each variation was repeated three times.

The test results show the absorbance value data for mass variations which are presented in Table 3.

Table 3. Data on the Measurement of Activated Carbon Mass Variations and Adsorption Power

Mass (grams)	Average Absorbance	Adsorption Power (%)
0	0,705	22,526
0,2	0,650	28,316
0,4	0,555	38,316
0,6	0,511	42,947
0,8	0,385	56,211
1	0,354	59,474

Table 4. Data of Measurement Results of Contact Time Variations

Contact Time (minutes)	Average Absorbance
10	0.372
20	0.279
30	0.243
40	0.214
50	0.194
60	0.135

Table 5. Data of Measurement Results of Variations in Colour Substance Concentration

Concentration (ppm)	Average Absorbance	Adsorption Power (%)
50	0.208	49.684
100	0.174	78.421
150	0.124	89.123
200	0.083	94.000

3.3.2 Contact Time Variation Test

The test was conducted to determine the effect of adsorbent contact time variations on dyes' adsorption power, with variations in contact time of 10, 20, 30, 40, 50, and 60 min. The adsorption test parameters were carried out at the initial condition of the dye concentration of 100 ppm and the optimum mass of the adsorbent of 1 g. A 100 ml of 100 ppm dye solution was put into an Erlenmeyer then activated carbon adsorbent was added. The mixture was stirred using a magnetic sitter based on variations in contact time. Filtered by filter paper, the resulting filtrate was measured for its absorbance using a visible spectrophotometer at 395 nm. Each variation was repeated three times to strengthen the data obtained. The test results show the absorbance value data on contact time variations in Table 4.

3.3.3 Testing of Variations in Concentration of Dyes

This test was conducted to determine the effect of variations in dye concentration on adsorption power, with variations in dye concentration, namely 50, 100, 150, and 200 ppm with a solution volume of 100 ml. The mass of the adsorbent used is the optimum mass, 1 g. The mixture of adsorbent and dye was stirred using a magnetic sitter with an optimum contact time (60 min). Followed by filtering using filter paper, and the resulting filtrate was measured its absorbance using a visible spectrophotometer at a wavelength of 395 nm. Each variation was repeated three times to strengthen the data obtained. The test result data can be seen in Table 5.

4 Discussion

The optimum mass measured in this study was 1 g with an adsorption percentage of 59.474%. These results are from the research conducted by Eka [6], who used variations in the mass of the adsorbent to adsorb purple synthetic dye; the results of the study showed an increase in adsorption along with the addition of activated charcoal powder. One factor that affects the adsorption results is the mass of the adsorbent. The mass of the adsorbent affects the number of active groups [11]; the more the number of activated carbon adsorbents, the greater the surface area to adsorb the yellow dye.

The results of testing the adsorption power of activated carbon on variations in contact time indicate an effect of contact time on adsorption power. The optimum contact time measured in this study was 60 min, with a percentage of adsorption power of 82.526%. These results are consistent with a study by Nurlaili [12], who used variations in contact time to adsorb methyl orange dye, indicating that adsorption increased with increasing contact time. One of the factors that affect the adsorption power is contact time [13]. It is because of the more extended collision time during the moving process between the activated carbon of the cassava peel and the yellow dye. More reactions occur between the two, so the more yellow dye adsorb. However, the ability of activated carbon to adsorb is limited to a specific time, namely until equilibrium is reached because all activated carbon surfaces have been saturated and can no longer absorb crystal violet dye, even though the time continues to be increased.

The test results show the effect of dye concentration on the adsorption power. The optimum concentration of yellow dye measured in this study was 200 ppm with an adsorption percentage of 94,000%. The results from research conducted by Heni Irawati [7], used variations in the initial concentration of crystal violet dye, with the study's results showing that adsorption increased along with the increasing initial concentration of the dye.

Another factor that affects the adsorption power is the initial concentration of the yellow dye [14]. The increase of yellow dye adsorption was due to the greater concentration of yellow dye, the more yellow dye ions bound to the functional group of activated carbon of cassava peel so that more yellow dye was adsorbed by activated carbon of cassava peel [15]. However, the ability of activated carbon to adsorb is limited until the functional group equilibrium condition and surface area of activated carbon with yellow dye is reached. The activated carbon functional group can no longer absorb larger yellow dye ions, so there are still many remaining yellow dye ions that are not adsorbed.

5 Conclusion

Based on the results of research that was carried out, it can be concluded that activated carbon made from the raw material of cassava peel waste was identified as having functional groups O-H, C=C, C-H, and C-O, which indicates the presence of lignocellulose and hemicellulose content, adsorption power influences the mass of activated carbon, contact time activated carbon and concentration of yellow dye.

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References

1. A. Permatasari, … L. K.-J. T. H., and undefined 2014, "Karakterisasi karbon aktif kulit singkong (Manihot utilissima) dengan variasi jenis aktivator," *researchgate.net*, doi: https://doi.org/10.20961/jthp.v0i0.13004.
2. E. S. Ikuemonisan, T. E. Mafimisebi, I. Ajibefun, and K. Adenegan, "Cassava production in Nigeria: trends, instability and decomposition analysis (1970–2018)," *Heliyon*, vol. 6, no. 10, p. e05089, Oct. 2020, doi: https://doi.org/10.1016/J.HELIYON.2020.E05089.
3. D. Ocktafiani, I. Aziza, P. U. D. Cahya, H. Budiastuti, and Rispiandi, "Cassava Peels Waste Becomes Activated Carbon - A Literature Review," *Int. Conf. GREEN Technol. Des. 2020*, vol. 1, no. 1, pp. 92–97, 2020, doi: https://doi.org/10.26760/ICGTD2020.V1I1.15.
4. R. Kayiwa, P. Olupot, M. L.-J. of M. Science, and undefined 2019, "Production and potential of activated carbon from cassava peels for remediation of active pharmaceutical ingredients from wastewater: A review," *rif.mak.ac.ug*, vol. 4, no. 4, pp. 1–24, 2019, Accessed: Oct. 12, 2022. [Online]. Available: https://rif.mak.ac.ug/wp-content/uploads/2021/12/30122-Article-Text-56504-1-10-20200208.pdf.
5. V. Katheresan, J. Kansedo, and S. Y. Lau, "Efficiency of various recent wastewater dye removal methods: A review," *J. Environ. Chem. Eng.*, vol. 6, no. 4, pp. 4676–4697, Aug. 2018, doi: https://doi.org/10.1016/J.JECE.2018.06.060.
6. E. Purnamawati, R. R, and agrippina wiraningtyas, "PEMANFAATAN ARANG AKTIF DARI TONGKOL JAGUNG (Zea Mays L.) SEBAGAI ADSORBEN ZAT WARNA SINTETIS UNGU," *J. REDOKS J. Pendidik. Kim. DAN ILMU Kim.*, vol. 2, no. 2, pp. 43–48, Dec. 2019, doi: https://doi.org/10.33627/RE.V2I2.302.
7. H. Irawati *et al.*, "Adsorpsi Zat Warna Kristal Violet Menggunakan Limbah Kulit Singkong (Manihot esculenta)," *BIMIPA*, vol. 25, no. 1, pp. 17–31, Jan. 2018, Accessed: Oct. 12, 2022. [Online]. Available: https://journal.ugm.ac.id/bimipa/article/view/17940.
8. A. Bayu Nandiyanto, N. N. Azizah, R. Safitri, and R. Taufik, "Investigation of adsorption performance of calcium carbonate microparticles prepared from eggshells waste," *jestec.taylors.edu.my*, vol. 17, no. 3, pp. 1934–1943, 2022, Accessed: Oct. 12, 2022. [Online]. Available: https://jestec.taylors.edu.my/Vol17Issue3June2022/17_3_24.pdf.
9. L. Ituli *et al.*, "Synthesis and IR Characterization of Activated Carbon Acid Catalysts from Cassava Peels and their Use in Esterification of Free Fatty Acid in Palm Kernel oil," *researchgate.net*, no. 2, 2020, doi: https://doi.org/10.9734/irjpac/2020/v21i830186.
10. R. Kayiwa, H. Kasedde, M. Lubwama, and J. B. Kirabira, "Mesoporous activated carbon yielded from pre-leached cassava peels," *Bioresour. Bioprocess.*, vol. 8, no. 1, pp. 1–12, Dec. 2021, doi: https://doi.org/10.1186/S40643-021-00407-0/FIGURES/8.
11. J. Wang and X. Guo, "Adsorption kinetic models: Physical meanings, applications, and solving methods," *J. Hazard. Mater.*, vol. 390, p. 122156, May 2020, doi: https://doi.org/10.1016/J.JHAZMAT.2020.122156.
12. T. Nurlaili, L. Kurniasari, R. Dwi Ratnani Program Studi Teknik Kimia, U. Wahid Hasyim, and S. X. Jl Menoreh Tengah, "Pemanfaatan limbah cangkang telur ayam sebagai adsorben zat warna methyl orange dalam larutan," *publikasiilmiah.unwahas.ac.id*, vol. 2, no. 2, pp. 11–14, 2017, Accessed: Oct. 14, 2022. [Online]. Available: https://publikasiilmiah.unwahas.ac.id/index.php/inteka/article/view/1938.

13. R. Arora, "Adsorption of Heavy Metals–A Review," *Mater. Today Proc.*, vol. 18, pp. 4745–4750, Jan. 2019, doi: https://doi.org/10.1016/J.MATPR.2019.07.462.
14. L. Zhang *et al.*, "Coconut-based activated carbon fibers for efficient adsorption of various organic dyes," *RSC Adv.*, vol. 8, no. 74, pp. 42280–42291, Dec. 2018, doi: https://doi.org/10.1039/C8RA08990F.
15. A. salah omer *et al.*, "Adsorption of crystal violet and methylene blue dyes using a cellulose-based adsorbent from sugercane bagasse: characterization, kinetic and isotherm studies," *J. Mater. Res. Technol.*, vol. 19, pp. 3241–3254, Jul. 2022, doi: https://doi.org/10.1016/J.JMRT.2022.06.045.