Proceedings

International Conference on Sustainable Environment and Innovation(ICoSEI)2025

Sustainable Adsorbents from Snake Fruit (*Salacca zalacca* (Gaert) Voss) Peel Waste: Comparative Study of Powder and Activated Carbon for Paracetamol Removal

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Abstract. Contaminants of emerging concern (CEC) refer to chemical compounds that are increasingly identified in various environments but do not have established treatment guidelines. An example of this is paracetamol, a common pain relief medication seen in wastewater systems and even in drinking water supplies. Even in small amounts, paracetamol poses risks to aquatic life and may also have detrimental effects on human health. In Indonesia, it has been detected in areas like Jakarta Bay and the Citarum River. Traditional techniques used in Wastewater Treatment Plants (WWTPs) do not effectively eliminate paracetamol because of its polar characteristics and limited ability to break down biologically. Using adsorption represents a viable solution, as the peel of snake fruit (*Salacca zalacca*), which is high in cellulose and pectin, shows promise for creating porous activated carbon. This study aims to characterize snake fruit peel powder and activated carbon, evaluate their effectiveness in paracetamol removal, and determine optimal pH, contact time, and adsorbent mass using a factorial design with Design Expert. Characterization showed activated carbon had 3.22 percent moisture content, 891.4 milligrams per gram iodine number, and pore sizes of 2.11 to 5.93 micrometers. Optimal conditions were pH 8, 15 minutes contact time, and 125 milligrams adsorbent mass, achieving 97.5 percent removal efficiency, higher than snake fruit peel powder with 80.6 percent. In conclusion, snake fruit peel activated carbon demonstrates greater adsorption capacity for paracetamol compared to its powdered form.

Keywords: Adsorbent, Snake Fruit Peel, Activated Carbon, Parasetamol, UV-Visible Spectrophotometry

Introduction

Currently, pharmaceuticals have become an essential part of daily life due to their crucial role in detecting, preventing, and treating various diseases (Islami et al., 2024). Paracetamol is an analgesic and antipyretic drug that is widely available on the market at an affordable price, making it frequently used by the public to treat mild ailments such as fever and headaches. The annual production of paracetamol is estimated to reach approximately 145,000 tons. Along with the increase in paracetamol production, the amount of waste generated also continues to rise (Wardi, 2019).

Pharmaceutical waste is classified as hazardous and toxic material (B3) that must be handled carefully to prevent pollution, environmental damage, or threats to the health and survival of humans and other living organisms (Islami et al., 2024). Research by Koagouw et al. (2022) found high concentrations of paracetamol in two locations in Jakarta Bay—610 ng/L in Angke and 420 ng/L in Ancol.

Pharmaceutical waste is generally generated from drug manufacturing activities, including wastewater discharge into aquatic environments and equipment washing during production processes. Expired medicines that are disposed of into water bodies contribute to aquatic pollution. This results in a decline in water quality, potentially causing the death of aquatic organisms. Wastewater entering aquatic systems can reduce dissolved oxygen levels, leading to oxygen depletion and the death of aquatic biota. Therefore, special treatment of pharmaceutical wastewater is necessary before discharge to avoid harmful impacts on living organisms and the environment (Wardi, 2019).

Wastewater treatment is therefore essential and can be conducted using various methods such as precipitation, electrodialysis, coagulation, reverse osmosis, and ultrafiltration. However, these methods often have drawbacks, including high costs, long processing times, and limited efficiency. One promising treatment method is adsorption, which is considered simple, efficient, and cost-effective. A major advantage of adsorption is that it does not generate sludge and the adsorbent can be regenerated (Apecsiana et al., 2016).

Recently, adsorption processes have increasingly utilized agricultural waste as organic-based bioadsorbents. Bioadsorbents offer several advantages, including low cost, no regeneration requirement, high treatment efficiency, abundant raw material availability, and minimal sludge production (Hanifah et al., 2023).

According to Iwuozor et al. (2021), adsorbents are classified into seven groups based on their chemical composition or structure: biosorbents, activated carbon, biochar (solid carbon produced from carbonization, pyrolysis, or gasification of biomass, with or without oxygen), clays and minerals, polymers, resins, and nanoparticles. In this study, activated carbon was selected as the adsorbent because of its large surface area, high adsorption capacity, and suitability for optimal application (Hadisoebroto et al., 2023).

The bioadsorbent used in this study is derived from agricultural waste—specifically, salacca peel. Salacca peel contains 25.85% cellulose, which contributes to its porous structure, enabling it to trap heavy metal ions (pollutants) and making it a suitable adsorbent for wastewater contaminants. It also contains around 6.7% pectin, further enhancing its potential as activated carbon for bioadsorbent applications (Hanifah et al., 2023). Salacca peel is widely available and environmentally friendly, making it safe for use as an adsorbent (Fathanah & Lubis, 2022).

Research by Romdhani et al. (2023) demonstrated that activated carbon from sawdust achieved 85% adsorption efficiency for paracetamol at an optimal dose of 750 mg/L, with adsorption equilibrium reached within just 20 minutes. Similarly, Zuhier (2025) found that sulfuric-acid-activated carbon from guava leaves removed 93.5–94% of paracetamol across various pH levels. These findings indicate that biomass-derived activated carbon is highly effective for paracetamol adsorption in aqueous solutions. However, studies on the use of activated carbon from salacca peel for paracetamol adsorption remain very limited. To date, few studies have specifically explored the potential of salacca peel in this context, leaving significant opportunities for further research (Romdhani et al., 2023; Zuhier, 2025).

Adsorption efficiency depends on parameters such as pH, contact time, and adsorbent mass. pH affects the surface charge of the adsorbent, the degree of ionization, and the species involved in adsorption. Contact time influences diffusion and the attachment of adsorbate molecules to the adsorbent surface (Hanifah et al., 2023). Therefore, this study aims to analyze the effectiveness of activated carbon from salacca peel as a paracetamol adsorbent using a UV-Vis spectrophotometer, by first determining the optimal pH, contact time, and adsorbent mass to achieve maximum removal efficiency.

Methods

Equipment and Material

The equipment used in this study includes a UV-Vis Spectrophotometer (Shimadzu UV 1800), FTIR Spectroscopy (Fourier Transform Infrared), analytical balance, 100-mesh sieve, blender, Buchner funnel, porcelain crucible, measuring cylinder, beaker glass, knife/scissors, oven, stopwatch, furnace, desiccator, magnetic stirrer, microfilter, volumetric pipette, volumetric flask, pH meter, Erlenmeyer flask, burette, moisture analyzer, pestle, and mortar.

The materials used in this study include salacca peel, pure paracetamol, distilled water, Na_2CO_3 solution, methylene blue solution, 0.125 N iodine solution, $Na_2S_2O_3$ solution, starch indicator, HNO_3, NaOH, 96% ethanol, KIO_3, KI, H_2SO_4, and aluminum foil.

Procedure

Plant Material Collection

Snake Fruit peels were obtained from fruit and vegetable vendors at the Main Market of Bandung City. The selected peels were fresh and free from mold.

Plant Determination

Plant determination was carried out at the Biology Laboratory, Faculty of Mathematics and Natural Sciences, Tanjungpura University.

Carbonization

Snake Fruit peels were washed with clean running water and oven-dried at 100 °C for 1 hour. The dried peels were cut into small pieces using scissors for easier carbonization. The pieces were then ground using a blender and sieved with a 100-mesh sieve for uniform size. Carbonization was conducted in a furnace at 350 °C for 1 hour. The resulting charcoal was further ground with a blender, then refined using a mortar and pestle, and sieved again with a 100-mesh sieve to obtain uniform particle size (Hanifah, 2023).

Carbon Activation

Ten grams of snake fruit peel charcoal powder were soaked in 100 mL of 5% Na_2CO_3 solution, stirred for 5 minutes, and left for 24 hours. The mixture was then filtered and washed with distilled water until the pH reached 7 (neutral), confirmed with universal pH indicator paper. The activated carbon was then oven-dried at 105 °C for 2 hours (Hanifah et al., 2023).

Characterization of Snake Fruit Peel Activated Carbon

Characterization followed the Indonesian National Standard (SNI) 06-3730-1995, based on Sahara et al. (2019), including:

1. Moisture Content Analysis

One gram of sample was placed in an aluminum dish, leveled, and placed in a Moisture Analyzer at 100 °C for 5 minutes. Moisture content (%) was recorded. According to SNI 06-3730-1995, moisture content should not exceed 15%.

2. Methylene Blue Adsorption Analysis

One gram of sample was placed in a beaker, mixed with 25 mL of 10 ppm methylene blue, covered with aluminum foil, and stirred for 30 minutes. The sample was filtered and analyzed using a UV-Vis spectrophotometer at 664 nm. The minimum adsorption capacity per SNI is 120 mg/g.

3. Iodine Adsorption Analysis

One gram of sample was mixed with 25 mL of 0.125 N iodine, stirred for 15 minutes, kept in the dark for 2 hours, filtered, and titrated with $Na_2S_2O_3$ after adding starch indicator until the blue color disappeared. Results were expressed in mg/g (Sahara, 2017).

4. SEM-EDS Analysis

Samples were cleaned, coated, mounted on stubs with carbon tape, and analyzed to determine surface area (Wardi, 2019).

5. FTIR Analysis

Two milligrams of powdered activated carbon were analyzed for functional groups using FTIR in the range of 650–4000 cm^{-1}.

Preparation of Paracetamol Solutions

- **Stock Solution (1000 ppm)**: 100 mg of paracetamol dissolved in 96% ethanol in a 100 mL volumetric flask.
- **Working Solution (100 ppm)**: Dilution of the stock solution. Serial concentrations of 1–5 ppm prepared for calibration.

Determination of Maximum Wavelength
Absorbance of 1–5 ppm paracetamol solutions was scanned at 200–400 nm to determine λmax.

Calibration Curve Preparation
Absorbance of standard solutions was measured (triplicate) and a calibration curve was prepared to determine regression equation and correlation coefficient (r).

Optimization of pH, Contact Time, and Mass (Design Expert Application)
Factorial design testing pH (4–8), contact time (15–75 min), and adsorbent mass (25–125 mg). Data analyzed with Design Expert software, and results verified experimentally.

Data Analysis
Adsorption efficiency (%) calculated as:

$$Ef\ (\%) = \frac{(Yi - Yf)}{Yi} \times 100\% \qquad (1)$$

Where:
Ef = adsorption efficiency (%)
Yi = initial paracetamol concentration (mg/L)
Yf= final paracetamol concentration (mg/L)

Result and Discussion

Plant Determination
Plant determination was carried out at the Biology Laboratory, Faculty of Mathematics and Natural Sciences, Tanjungpura University. It was identified that the salak peel used was of the species *Salacca zalacca* (Gaertn.) Voss.

Carbonization
The snake plant peel samples were chopped into small pieces using scissors to facilitate the carbonization process. They were then ground using a blender and sieved through a No. 100 mesh to obtain a uniform size. Carbonization was subsequently carried out in a furnace at a temperature of 350°C for 1 hour. Carbonization is a combustion process that transforms a material into carbon.

The resulting charcoal was further refined using a mortar and pestle, then sieved again through a No. 100 mesh to achieve uniform particle size (Hanifah, 2023).

Carbon Activation
After the carbonization process, the salak peel carbon underwent several further steps to become activated carbon, which would then be characterized. In this study, a 5% Na_2CO_3 solution was used as the activating agent. An activator is a substance or chemical compound used to activate charcoal before it becomes activated carbon. The aim of this activation is to activate the salak peel carbon so that it can function as an adsorbent by adding or expanding pore volume and increasing pore diameter formed during carbonization (Meilianti, 2020).

The activation process was carried out by heating the salak peel charcoal in an oven at 105°C for 2 hours. The resulting activated carbon from salak peel was black in color.

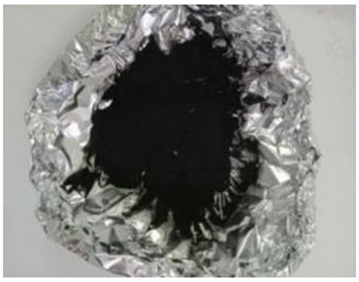


Figure 1. Snake Fruit Peel Activated Carbon

Characterization of Salak Peel Powder and Activated Carbon

The characterization data for snake fruit peel powder and activated carbon, including moisture content, iodine adsorption capacity, and methylene blue adsorption capacity, are presented in Table 1.

Table 1. Characterization of Snake Fruit Powder and Activated Carbon

Characterization	Snake Fruit Powder	Snake Fruit Activated Carbon
Water Content	5,20 %	3,22 %
Iodine Adsorption Capacity	862,6 mg/g	891,4 mg/g
Methylen Blue Adsorption	236 mg/g	237 mg/g

Table 1 showed that the moisture content in the salak peel powder meets the Indonesian Ministry of Health (2017) requirement that moisture content must be less than 10%. Meanwhile, the moisture content in activated salak peel carbon was 3.22%, which also meets the Indonesian National Standard (SNI) 06-3730-1995, requiring a maximum moisture content of 15%. Higher moisture content can reduce the adsorption capacity of the adsorbent toward the adsorbate because the pores contain more water, thus decreasing adsorption performance (Pradhana et al., 2021). Therefore, the lower the moisture content, the better the quality of activated carbon (Imani et al., 2021).

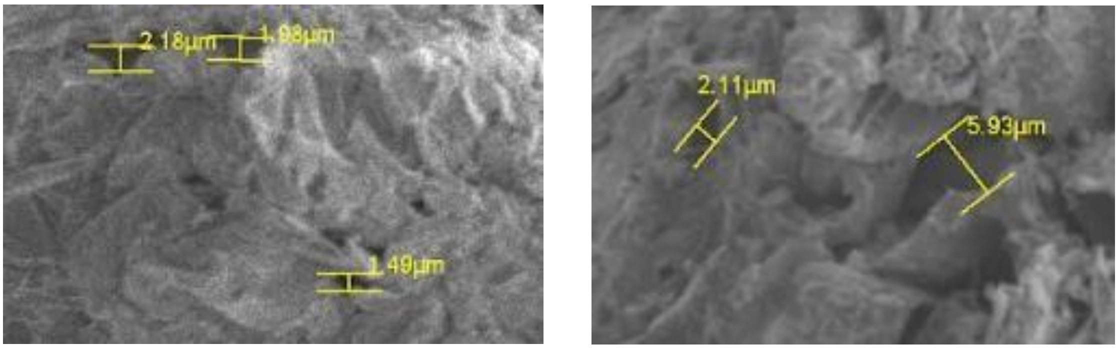
Iodine adsorption capacity testing was conducted using the iodometric titration method. The iodine adsorption capacity of the salak peel powder was 862.6 mg/g, and that of the activated salak peel carbon was 891.4 mg/g. These values meet the SNI 06-3730-1995 minimum standard of 750 mg/g.

Iodine adsorption capacity reflects the ability of the powder and activated carbon to adsorb molecules smaller than 10 Å, indicating the number of pores with diameters between 10–15 Å. The higher the iodine adsorption capacity, the better the quality of the powder and activated carbon (Andarista et al., 2023).

The adsorption of methylene blue by the powder and activated carbon can serve as an indicator of their adsorption performance. The adsorption performance was determined by measuring the methylene blue concentration before and after contact with the powder and activated carbon using a UV-Vis spectrophotometer (Dwityaningsih et al., 2023).

The adsorption capacity and efficiency of activated carbon toward methylene blue can be determined from these measurements (Dwityaningsih et al., 2023). The methylene blue adsorption capacity for salak peel powder was 236 mg/g, and for activated salak peel carbon it was 237 mg/g. These results meet the SNI 06-3730-1995 minimum requirement of 120 mg/g, indicating that both the powder and activated carbon from salak peel have good quality as adsorbents.

SEM (Scanning Electron Microscopy) is used to examine the microstructure of a material, including its texture, morphology, particle composition, and pore diameter of the salak peel powder and activated carbon (Ariyani, 2019). The SEM test results are shown in Figure 2.

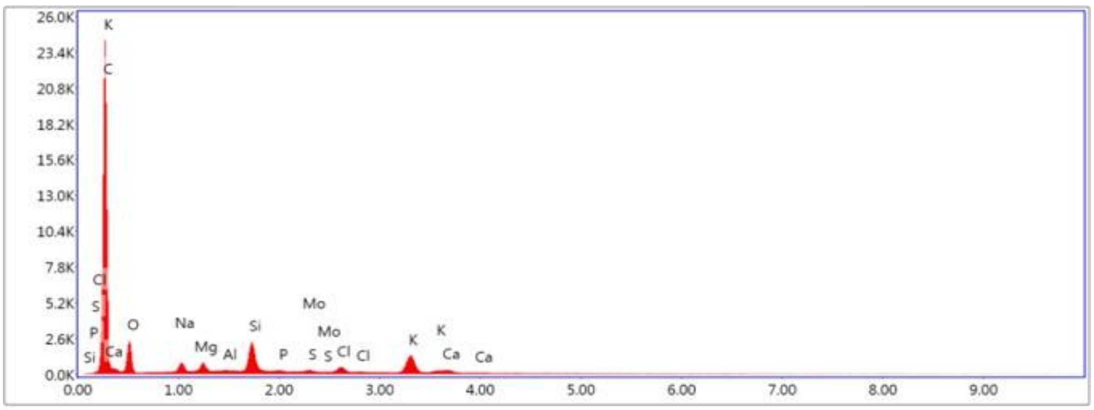


(A) **(B)**

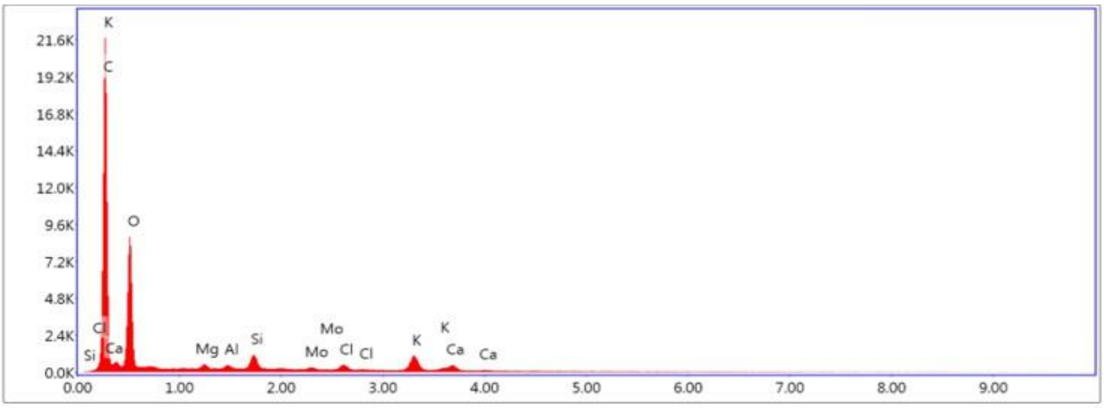
Figure 2. SEM Micrograph: A). Powder Snake Fruit, and B). Snake Fruit Peel Activated Carbon

Figure 2 shows the pore sizes of activated salak peel carbon at 2000× magnification. The pore sizes in salak peel powder ranged from 1.49–2.18 µm, while the activated carbon had larger pores, ranging from 2.11–5.93 µm. This indicates that the activation process increases pore size. Larger pores mean a greater surface area, which leads to increased adsorption rate and capacity. The surface area is also influenced by the concentration of the chemical activator, the carbonization temperature, the ratio of activator to carbon, and the soaking duration in the activator solution. Pore formation occurs due to etching from the reaction between the carbon surface and the activating agent (Na_2CO_3). Thus, pore size in activated salak peel carbon can significantly affect the adsorption process (Saban et al., 2023).

The EDS test aims to identify the elements forming the pores in the prepared samples. The EDS spectra results for the salak peel powder and activated carbon are shown in Figure 3. The EDS analysis identified several main elements: Carbon (C), Oxygen (O), Calcium (Ca), Potassium (K), Silicon (Si), Sodium (Na), and Magnesium (Mg).



(A)

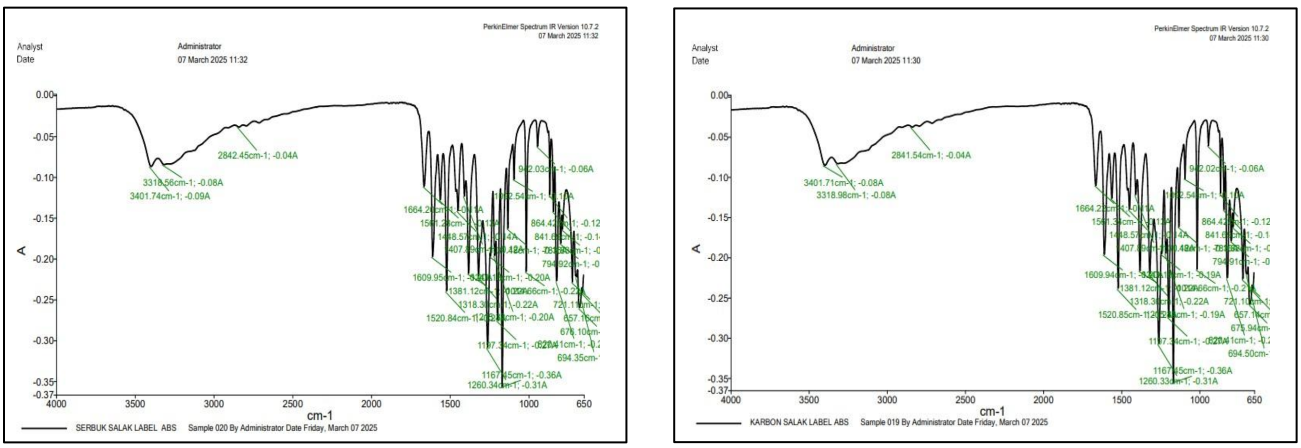


(B)

Figure 3. EDS Spektrum: A). Powder Snake Fruit, and B). Snake Fruit Peel Activated Carbon

Based on the analysis results, EDS successfully identified several main elements, namely Carbon (C), Oxygen (O), Calcium (Ca), Potassium (K), Silicon (Si), Sodium (Na), and Magnesium (Mg).

FTIR is a method for obtaining the infrared spectrum of absorption or emission from gaseous, solid, or liquid substances. This FTIR characterization is performed to identify a functional group in salak peel powder and activated carbon (Hartanto et al., 2023). The infrared spectrum is shown in the following figure.



(A) **(B)**

Figure 4. FTIR Graph: A). Powder Snake Fruit Peel, and B). Snake Fruit Peel Activated Carbon

The test results using an IR Spectrophotometer can be concluded that there are several functional group contents present in the powder and activated carbon of salak peel, indicating the presence of simple aromatic ring groups C=C, carbonyl C-O, and alkene C-H stretch, as shown in Figure 4.4. The presence of the C=C group indicates the characteristic aromatic structure of lignin and phenolic compounds in natural materials, which remains after the carbonization process (Hartanto et al., 2023).

The C=O or carbonyl group originates from compounds such as carboxylic acids, aldehydes, or ketones, which are also commonly found in biomass and can form or remain after the activated carbon process. Meanwhile, the C-H stretch from alkenes indicates the presence of unsaturated double bonds, which are also often found in complex organic structures in natural materials. This combination of groups gives activated carbon from salak peel good adsorption capabilities, as it can interact with various types of pollutants, including organic compounds like paracetamol (Hartanto et al., 2023).

Determination of Maximum Wavelength

The maximum wavelength is the wavelength that has the highest absorption compared to other wavelengths. Determining the maximum wavelength can be done by scanning to observe its absorption. The highest absorption region will provide the greatest absorbance value, resulting in high sensitivity (Emilia et al., 2021).

The standard solution was read for its maximum absorbance in the wavelength range of 200-400 nm in the UV region. Based on Figure 5, it can be seen that the maximum absorbance of paracetamol is 246.8 nm with an absorbance of 0.138.

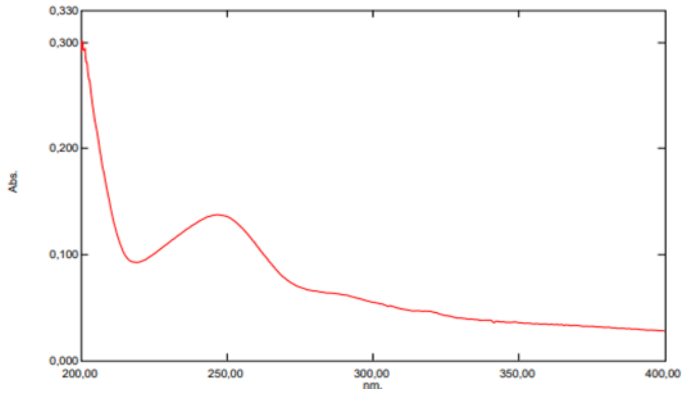


Figure 5. Maximum Wavelength Curve of Paracetamol

Standard Paracetamol Calibration Curve
The calibration curve is created based on standard solutions with the aim of obtaining a linear relationship between absorbance and solution concentration. The paracetamol standard curve was created with concentration variations of 1, 2, 3, 4, and 5 ppm using a UV-Vis Spectrophotometer at λ=246.8 nm.

Linearity is measured using a UV-Vis spectrophotometer. Measurements using this instrument can be performed because paracetamol has chromophore and auxochrome groups. The chromophore in paracetamol is a benzene ring, while the auxochromes are hydroxyl and amide groups (Nugraha et al., 2023).

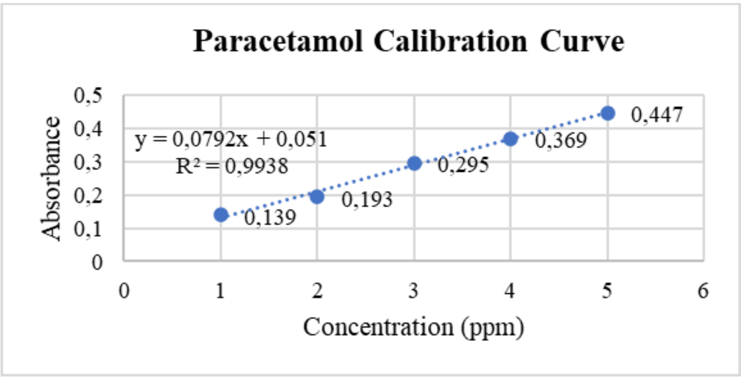


Figure 6. Paracetamol Calibration Curve

The linear regression equation obtained is y = 0.0792x + 0.051, with a correlation coefficient (r) value of 0.9938. The obtained correlation coefficient value indicates good linearity. This is because good linearity is shown by a correlation coefficient value close to 1. The correlation coefficient (r) can indicate the accuracy and precision in creating the standard series (Suryani et al., 2022).

Optimization of pH, Contact Time, Powder Mass, and Salak Skin Activated Carbon on Paracetamol Adsorption Using Design Expert Application

Testing with Design Expert was conducted at pH levels of 4, 5, 6, 7, and 8; contact times of 15, 30, 45, 60, and 75 minutes; and masses of 25, 50, 75, 100, and 125 mg. The lower limit and upper limit values for each factor are entered into the application, resulting in a total of 8 run formulas.

The formula was created according to the variations determined by the software, then testing was carried out using a UV-Vis spectrophotometer to obtain the percentage (%) effectiveness of the adsorbent as shown in Tables 2 and 3.

Table 2. Adsorption Effectiveness of Snake Fruit Powder

***Factor* 1** **pH**	***Factor* 2** **Contact time (menit)**	***Factor* 3** **Adsorben mass (mg)**	***Response* 1** **Adsorption effectiveness (%)**
4	75	125	37,4
8	75	125	75,3
8	15	125	66,7
4	75	25	76,8
8	15	25	80,6
4	15	125	46,7
4	15	25	77,3
8	75	25	79,5

As shown in table 2, the lowest adsorption effectiveness of snake fruit peel powder was 37.4% at pH 4, 75 minutes contact time, and 125 mg mass. The highest effectiveness was 80.6% at pH 8, 15 minutes contact time, and 25 mg mass.

Table 3. Adsorption Effectiveness of Snake Fruit Peel Activated Carbon

***Factor* 1** **pH**	***Factor* 2** **Contact time (menit)**	***Factor* 3** **Adsorben mass (mg)**	***Response* 1** **Adsorption effectiveness (%)**
4	75	125	36,9
8	75	125	57,1
8	15	125	96,2
4	75	25	70,5
8	15	25	97,5
4	15	125	85,9
4	15	25	60,1
8	75	25	76,3

In Table 3, snake fruit peel activated carbon shows the lowest adsorption effectiveness at 36.9% at pH 4, contact time of 75 minutes, and mass of 125 mg. Meanwhile, the highest adsorption effectiveness was 97.5% at pH 8, contact time of 15 minutes, and mass of 25 mg.

In statistical analysis using Design Expert, the "Prob > F" value is used to determine the significance of the model. This value indicates the probability of error in rejecting the null hypothesis that the model has no effect. If the value of "Prob > F" is less than 0.05, then the model is considered significant, meaning the statistically tested variable has a real influence on the observed response (Mustaqin, 2023).

Results of the ANOVA statistical analysis on the Design Expert application for adsorption paracetamol can be seen in the table below:

Table 4. ANOVA of Paracetamol Adsorption Using Design Expert Application for Snake Fruit Peel Powder Adsorbent

Source	*Sum of Squares*	*df*	*Mean Square*	*F Value*	*p-value Prob > F*	
Model	1898,16	6	316,36	3124,54	0,0137	
A-pH	510,40	1	510,40	5041,00	0,0090	
B-Time	0,66	1	0,66	6,53	0,2375	
C-adsorbent Massa	970,20	1	970,20	9582,23	0,0065	*significant*
AB	37,41	1	37,41	369,49	0,0331	
AC	336,70	1	336,70	3325,44	0,0110	
ABC	42,78	1	42,78	422,53	0,0309	
Residual	0,10	1	0,10			
Cor Total	1898,26	7				

Based on Table 4, the Prob > F values for snake fruit peel powder A-pH: 0.0090, C-Mass: 0.0065, AB-pH & Time: 0.0331, AC-pH & Mass: 0.0110, ABC-pH & Time & Mass: 0.0309 are significant influencing factors.

Table 5. ANOVA of Paracetamol Adsorption Using Design Expert Application for Snake Fruit Peel Activated Carbon Adsorbent

Source	*Sum of Squares*	*df*	*Mean Square*	*F Value*	*p-value Prob > F*	
Model	2863,81	4	715,95	11,99	0,0344	
A-pH	678,96	1	678,96	11,37	0,0433	*significant*
B-Waktu	1222,65	1	1222,65	20,48	0,0202	
BC	749,91	1	746,91	12,51	0,0385	
Residual	179,13	3	59,71			
Cor Total	3042,94	7				

Based on Table 5, the Prob > F values for activated carbon from salak peel at A-pH: 0.0433, B-Time: 0.0202, BC-Time & Mass: 0.0385 are significant factors in this test.

The results from the Design Expert application show that the most optimal adsorption of paracetamol occurs at pH 8. This is because at this pH, most paracetamol molecules are in a neutral form, which facilitates interaction with the activated carbon surface. Paracetamol has a pKa value of approximately 9.5, which means that at pH levels below 9.5, the compound tends to be non-ionized.

At pH 8, paracetamol can interact with the functional groups of activated carbon thru hydrogen bonding and van der Waals interactions. If the pH is too low, the surface of the powder and activated carbon will be positively charged, which reduces adsorption due to repulsion. Conversely, at high pH, paracetamol is ionized and negatively charged, which can also lead to repulsion. Therefore, a pH of 8 creates a balanced condition that supports optimal interaction between paracetamol and the powder and activated carbon, thus increasing adsorption efficiency (Ismadji et al., 2021).

Based on the analysis results, it was found that both the powder and activated carbon from snake fruit peel have the same optimal contact time, which is 15 minutes, for adsorbing the adsorbate paracetamol. Contact time is the time required for the snake fruit peel powder and activated carbon as adsorbents to interact with paracetamol as the adsorbate. The longer the interaction, the greater the number of adsorbate molecules successfully absorbed. However, contact times exceeding the optimum will cause desorption to occur. Desorption is the reverse of adsorption. The meaning of desorption itself is the release of the adsorbate from the surface of the adsorbent used (Fatriasari, 2018).

Beside pH and contact time, the mass of the adsorbent also plays an important role in determining the effectiveness of the adsorption process. Snake fruit peel powder and activated carbon shows maximum efficiency in absorbing paracetamol at an optimal mass of 25 mg. At this point, the powder has reached its maximum adsorption capacity, so further mass addition does not significantly improve efficiency.

The results obtained show that activated carbon from snake fruit peel is more effective as a paracetamol adsorbent compared to snake fruit peel powder. This is because the activation process transforms snake fruit peel powder into activated carbon by increasing the size and number of pores, expanding the surface area, and increasing the carbon content (Meilianti, 2020), all of which contribute to significantly improved adsorption capacity and efficiency. Therefore, the percentage (%) effectiveness for the salak activated carbon sample is greater, at 97.5%, compared to salak peel powder, which is 80.6%.

Conclucions

1. Snake fruit peel powder and activated carbon show optimal conditions at pH 8, contact time of 15 minutes, and a mass of 25 mg as a paracetamol adsorbent.
2. Activated carbon from salak skin is proven to be more effective as a paracetamol adsorbent compared to salak skin powder. This is evident from the activated carbon's ability to achieve higher adsorption efficiency, which is 97.5%, while salak skin powder only reaches 80.6%.

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