INTERNATIONAL JOURNAL OF SOCIAL SCIENCE, EDUCATIONAL, ECONOMICS, AGRICULTURE RESEARCH AND TECHNOLOGY (IJSET) | ISSN (E): 2827-766X
Website:https://ijset.org/| Volumes 5 No. 8 (2026)

MAKING ADSORBENTS FROM ACTIVATED PALM SHELL CHARCOAL WITH THE ADDITION OF SODIUM ALGINATE POLYMER FOR CPO PURIFICATION

Krisalung Linliong Tampubolon [1*], Rafael Remit Winardi [1*], Zullham Effendi [1*]
[1]Program Studi Teknologi Pengolahan Hasil Perkebunan, Fakultas Vokasi,
Institut Teknologi Sawit Indonesia, Medan
*Email korespondensi : krisalung25@gmail.com

Received: 08/05/2026 | **Revised** : 15/05/2026 | **Accepted:** 04/06/2026 | **Published** :26/06/2026

Abstract

Crude Palm Oil (CPO) still contains various impurities that can lower the quality of the oil, thus requiring a refining process to improve its quality. This study aimed to evaluate the effectiveness of palm shell activated carbon modified with sodium alginate as an adsorbent in CPO refining. The study employed a non-factorial Completely Randomized Design (CRD) with five levels of sodium alginate concentration (0%, 1%, 2%, 3%, and 4%) and three replications. The observed parameters included water content, impurities, free fatty acids (FFA), and the Deterioration of Bleachability Index (DOBI) value. Data were analyzed using ANOVA at a 95% confidence level. The results showed that the treatment had a significant effect ($P<0.05$) on all parameters. The lowest moisture content was seen in treatment N3 at 0.085%, while the lowest impurity content was in treatment N1 at 0.384%. The lowest free fatty acid value was in treatment N0 at 45.590%, and the highest DOBI value was also in treatment N0 at 0.57. The study shows that activated carbon made from palm oil shells with added sodium alginate could be a good alternative adsorbent for the CPO purification process because it can really help improve the quality of crude palm oil.

Keywords: activated charcoal, palm kernel shell, sodium alginate.

INTRODUCTION

Palm oil (Elaeis guineensis Jacq.) is one of Indonesia's top plantation crops, producing crude palm oil (CPO) as its main product. But CPO still has different impurities like free fatty acids, pigments, metals, and oxidation compounds that can lower the quality of the oil, so it needs to be refined to meet quality standards. One method commonly used for refining oil is adsorption because it's great at getting rid of various impurities (Bansal and Goyal, 2005).

Palm oil shells are an abundant solid waste and have a high carbon content, making them potentially useful as raw material for activated charcoal. Activated charcoal has a large surface area and porous structure, so it can effectively adsorb various compounds (Bansal and Goyal, 2005). Research by Meisrilestari et al. (2013) also shows that activated charcoal made from palm oil shells has a high adsorption capacity and could potentially replace conventional adsorbents.

To boost the performance and stability of adsorbents, activated carbon can be modified using sodium alginate, which is a natural polymer that's biodegradable, non-toxic, and can form a supporting matrix that enhances the mechanical strength of the adsorbent (Draget et al., 2005). Using activated carbon adsorbents made from palm shell and modified with sodium alginate also offers a more economical and eco-friendly option for purifying CPO, especially for small- and medium-scale palm oil processing industries (Foo and Hameed, 2012; Basiron and Simeh, 2005). Based on this, this study aims to examine the effectiveness of palm shell activated carbon modified with sodium alginate as an adsorbent in the CPO refining process.

RESEARCH METHOD

This research design uses a Completely Randomized Design (CRD) Non-Factorial, with treatment concentrations consisting of 5 levels and 3 replications, symbolized as (N). N0 = 0%, N1 = 3%, N2 = 4%, N3 =

5%, N4 = 6%. Where, Number of Treatments: 5, Number of Replications: 3 and Total Number: 15. The observation parameters in this study are moisture content, impurity levels, free fatty acids, and DOBI.

Material

Oil Palm Shells, Sodium Alginate (Merck, pro analysis quality), CaCl2 (Merck, pro analysis quality), Crude Palm Oil and Distilled Water

.

Tool

Oven, Furnace, Blender, 100 mesh Sieve, Hotplate, Syringe, Measuring cup.

RESULTS AND DISCUSSION

Water Content

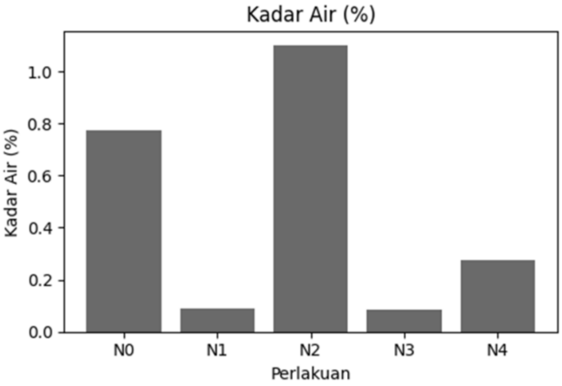

Figure 1. Results of the moisture content test

The moisture content of CPO after purification using activated carbon adsorbent from palm shell modified with sodium alginate ranged from 0.085% to 1.098%. The lowest moisture content was obtained in treatment N3 (0.085%), while the highest value was found in treatment N2 (1.098%). Analysis of variance showed that sodium alginate concentration had a significant effect ($P<0.05$) on moisture content. The lower moisture content observed in N3 indicates that the drying process was more effective and fewer water molecules were retained within the adsorbent matrix. Low moisture content is desirable because excessive water can occupy adsorption sites and reduce the effective surface area of the adsorbent. The porous structure of activated carbon combined with the optimized amount of sodium alginate contributes to improving adsorption performance. Similar findings were reported by Zhang et al. (2024), who stated that adsorbents possessing open pore structures and active functional groups exhibit higher adsorption capacity.

Impurity Content

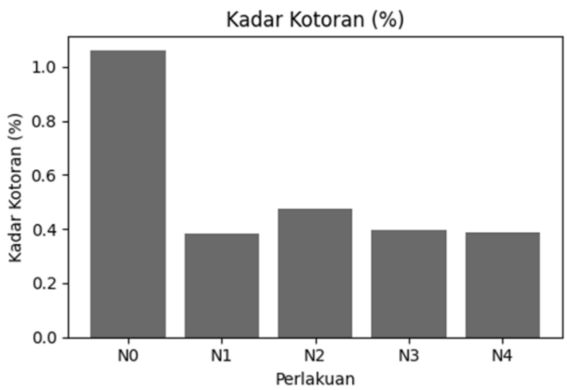

Figure 2. Results of the dirt content test

The impurity content after adsorption treatment ranged from 0.384% to 1.059%. Treatment N1 produced the lowest impurity content (0.384%), whereas N0 showed the highest value (1.059%).

ANOVA results indicated that the treatments significantly affected impurity removal ($P<0.05$). The reduction in impurity content demonstrates that activated carbon successfully adsorbed suspended particles and undesirable compounds present in CPO. The large surface area and pore structure of activated carbon enhance adsorption efficiency, while sodium alginate improves the structural stability of the adsorbent. According to Zhang et al. (2024), sodium alginate-based adsorbents contain abundant active sites that facilitate both physical and chemical adsorption mechanisms. Lower impurity levels indicate better oil quality because fewer foreign particles remain in the oil matrix.

Free Fatty Acid (FFA)

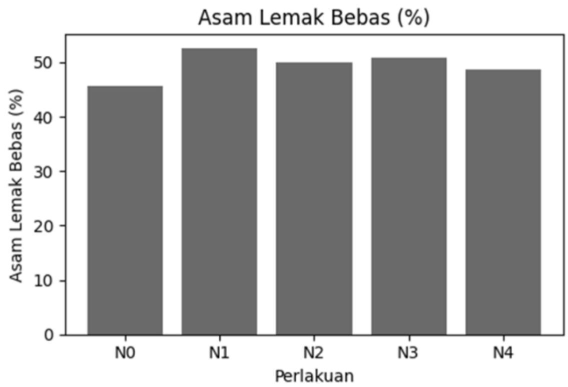

Figure 3. Results of free fatty acid test

The free fatty acid (FFA) values obtained in this study varied from 45.590% to 52.480%. The lowest FFA value was observed in treatment N0 (45.590%), whereas treatment N1 produced the highest value (52.480%). Statistical analysis revealed that sodium alginate concentration significantly influenced FFA values ($P<0.05$). Lower FFA values indicate better oil quality because free fatty acids are one of the primary indicators of oil deterioration. Excessive free fatty acids are formed due to hydrolysis and oxidation reactions occurring during storage and processing. Activated carbon possesses numerous pores that can adsorb polar compounds and degradation products, thereby improving oil stability. Tang et al. (2024) reported that porous carbon adsorbents are effective in reducing degradation compounds and enhancing oil quality. The lower FFA content obtained in treatment N0 suggests that the addition of sodium alginate beyond a certain level did not further improve FFA removal efficiency.

Deterioration of Bleachability Index (DOBI)

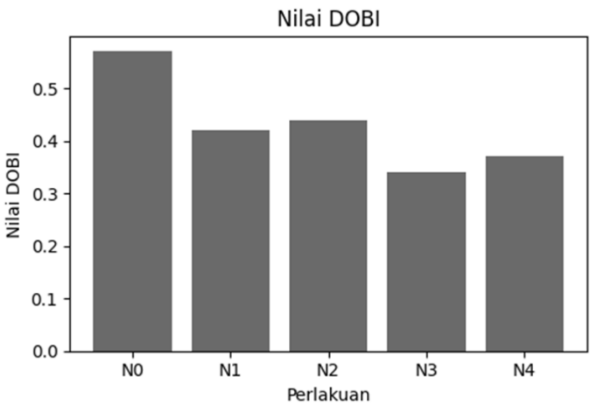

Figure 4. Results of Deterioration of Bleachability Index (DOBI)

The DOBI values ranged from 0.34 to 0.57. Treatment N0 resulted in the highest DOBI value (0.57), whereas the lowest value was obtained in treatment N3 (0.34). ANOVA showed that the treatments significantly affected DOBI values ($P<0.05$) . DOBI is an important indicator of crude palm oil quality and reflects the ease of bleaching during refining. Higher DOBI values indicate lower oxidation levels and better oil quality. The higher DOBI observed in treatment N0 suggests that excessive sodium alginate concentration may have reduced the effectiveness of maintaining carotenoid compounds relative to oxidation products. According to Aisyah et al. (2024), successful adsorption processes are characterized by reduced oxidation compounds and improved stability parameters, including DOBI values.

Table 1. Analysis of variance of CPO quality characteristics after purification using activated palm shell charcoal modified with sodium alginate

Variable	Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	Sig.
Moisture Content	Treatment	2.448	4	0.612	15.181	0.000*
	Error	0.403	10	0.040		
Impurity Content	Treatment	1.025	4	0.256	134.184	0.000*
	Error	0.019	10	0.002		
Free Fatty Acid (FFA)	Treatment	79.847	4	19.962	15.638	0.000*
	Error	12.765	10	1.277		
DOBI Value	Treatment	0.092	4	0.023	35.351	0.000*
	Error	0.007	10	0.001		

Note: *Significant at α = 0.05 (treatment significantly affected the observed response).*

CONCLUSION

The use of activated carbon derived from palm shell modified with sodium alginate significantly affected moisture content, impurity content, free fatty acid (FFA), and DOBI values of crude palm oil (CPO). The results indicate that this adsorbent has the potential to be used as an alternative material for improving CPO quality.

SUGGESTION

Further studies are recommended to optimize sodium alginate concentration and evaluate the adsorption performance under different processing conditions to obtain better CPO quality.

REFERENCES

Bansal, R. C., & Goyal, M. (2005). Activated Carbon Adsorption. Boca Raton, FL: Taylor & Francis Group.

Basiron, Y., & Simeh, M. A. (2005). Vision, challenges and opportunities in the Malaysian palm oil industry. Oil Palm Industry Economic Journal, 5(1), 1–16.

Draget, K. I., Smidsrød, O., & Skjåk-Bræk, G. (2005). Alginates from algae. In A. M. Stephen, G. O. Phillips, & P. A. Williams (Eds.), Polysaccharides and Polyamides in the Food Industry (pp. 1–30). Wiley-VCH.

Foo, K. Y., & Hameed, B. H. (2012). Preparation and characterization of activated carbon from agricultural wastes for adsorption applications: A review. Chemical Engineering Journal, 156(1), 2–10.

Gibon, V., De Greyt, W., & Kellens, M. (2007). Palm oil refining. European Journal of Lipid Science and Technology, 109(4), 315–335.

Ketaren, S. (2008). Pengantar Teknologi Minyak dan Lemak Pangan. Jakarta: UI Press.

Li, X., Wang, Y., Zhang, H., & Liu, J. (2024). Development of sodium alginate-based adsorbents for enhanced adsorption performance. International Journal of Biological Macromolecules, 276, 134986.

Mba, O. I., Dumont, M. J., & Ngadi, M. (2015). Palm oil: Processing, characterization and utilization in the food industry—A review. Food Bioscience, 10, 26–41.

Meisrilestari, Y., Khomaini, M., & Wijayanti, H. (2013). Pembuatan dan karakterisasi arang aktif dari cangkang kelapa sawit dengan aktivasi fisika dan kimia. Jurnal Teknik Kimia USU, 2(3), 1–6.

Tang, C., Liu, Y., Zhang, H., Wang, X., & Li, J. (2024). Porous activated carbon materials for adsorption and purification applications: Recent developments and future prospects. Journal of Environmental Chemical Engineering, 12(2), 112345.

Zhang, Y., Li, H., Wang, X., Liu, J., & Chen, Z. (2024). Adsorption behavior and mechanism of Cu(II) by sodium alginate/carboxymethylcellulose/magnesium hydroxide hydrogel. International Journal of Biological Macromolecules, 278, 135780.