SALAGA Journal
Vol. 03, No. 01, June 2025, pp. 1~5
ISSN: 3032-2677
DOI: 10.70124/salaga.v3i1.1809

Production of Biochar from Sago Dregs Using NaOH Pretreatment and Microwave Pyrolysis

Syam Djabal Nur[1], Diyah Yumeina*[1] and Salengke[1]
[1]Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia

Article Info

Article history:

Received 04 15, 2025
Revised 05 05, 2025
Accepted 05 11, 2025

Keywords:

Biochar
Microwave pyrolysis
NaOH Pretreatment
Sago dregs

ABSTRACT

The waste from sago dregs generated during the starch extraction process has not been optimally utilized and has the potential to cause environmental pollution. This study aimed to process sago dregs into biochar through chemical pretreatment (NaOH soaking) and physical pretreatment (microwave pyrolysis) and applied it as raw material for briquettes. The research methods consisted of (1) Pretreatment of sago dregs with 10% and 30% NaOH for 6 hours, (2) Pyrolysis using a 540-watt microwave at 300–400°C for 20 minutes, and (3) Briquette production using sago starch binder at a 10:1 ratio. The analysis results indicated that 30% NaOH pretreatment significantly reduced cellulose, hemicellulose, and lignin contents to 1.07, 0.52, and 1.10%, respectively, compared to the 10% NaOH (6.11%, 5.71%, and 6.03%). The moisture content of biochar decreased to 2.53–2.65%, in accordance to SNI 06-3730-1995 standard of 10% maximum . However, the ash content increased to 45.99–53.78%, exceeding the SNI limit of 15%. Briquettes made from 30% NaOH-pretreated biochar had the longest burning time (26.54 minutes), outperforming the 10% NaOH (12.32 minutes). This study found that sago dregs have the potential to serve as a high-quality biochar raw material due to its moisture content meets the SNI standard, although its high ash content limits its use as fuel. Sago dregs biochar briquettes can be considered a renewable energy alternative, while the high ash content offers potential applications in soil or water remediation.

Corresponding Author(s):

Diyah Yumeina
Faculty of Agriculture, Hasanuddin University
Jl. Perintis Kemerdekaan KM.10, 90245, Tamalanrea, Makassar, Sulawesi Selatan, Indonesia
Email: Dyumeina@unhas.ac.id

1. INTRODUCTION

Sago dregs are waste derived from sago pith after the starch has been extracted. The starch content of sago is approximately 18.5%, while the remaining 81.5% consists of sago dregs containing 20% cellulose and 21% lignin (Juniarto & Anggono, 2018). Given the proportion between sago starch and sago dregs, the amount of waste generated from sago processing is substantial. Currently, this waste has not been optimally utilized and is simply left to accumulate at sago processing sites.

South Sulawesi has plantations dedicated to sago production, particularly in North Luwu Regency, which recorded a total sago plantation area of 1,805 hectares in 2018, making it the largest sago-producing region in South Sulawesi (Directorate General of Estates, 2019). The center of sago production in the regency is Malangke Barat District. With such an extensive plantation area, the potential waste generated is also considerable, as sago processing in this region primarily focuses on fulfilling staple food needs. Based on direct observations at sago flour processing locations in Malangke Barat, the sago dregs produced after starch extraction are not utilized and are simply left around the processing site. At locations situated near rivers, sago waste is frequently disposed of into the river, posing a risk of water contamination.

To prevent environmental pollution, sago dregs must be reused, such as being converted into activated carbon (Syauqiah et al., 2022). Additionally, another promising approach is its conversion into biochar, as sago dregs are organic materials that can function in soil remediation and serve as an alternative energy source, including

powering agricultural equipment. The use of alternative energy sources not only reduces operational costs but also enhances system performance (Pien et al., 2024). Furthermore, promoting environmentally friendly methods supports pollution reduction while simultaneously contributing to renewable energy generation.

In this study, sago dregs were utilized for biochar production through a pretreatment process involving immersion in a strong alkaline solution (NaOH) and employing fast pyrolysis, as conventional pyrolysis methods for biochar production require extended processing times. The immersion process in a strong alkaline NaOH solution aims to degrade the lignocellulosic bond structure within sago dregs. NaOH functions by breaking down lignin that encases cellulose and hemicellulose, leading to the disruption of these molecular bonds (Widyawati & Argo, 2014). The degradation of lignin and hemicellulose structure increases the amount of free cellulose present in the material. In a sago dregs immersion solution containing NaOH, ionic conduction facilitates energy transfer, causing heating (Winarsih, 2013). To further enhance lignin degradation, microwave exposure is incorporated. Moreover, NaOH treatment has been shown to improve biochar's effectiveness in adsorbing toxic substances (Norberto et al., 2023).

This research aimed to produce biochar by utilizing sago dregs through microwave pyrolysis and NaOH immersion pretreatment. The resulting biochar then compared against SNI 06-3730-1995, which sets standards based on moisture content and ash levels.

2. MATERIALS AND METHODS

2.1 Materials

This study utilized various tools, including a SHARP R-728(K)-IN microwave, 100 mL measuring cups, digital scales, filters, spatulas, cutting tools, 2-inch PVC pipes, and a thermocouple to support the experimental procedures and temperature monitoring.

The materials used in this research comprised sago starch dregs, distilled water, and NaOH, which were essential for the biochar production and pretreatment processes.

2.2. Research Procedure

2.2.1. Control

In preparing the control samples, the sago starch dregs were first dried by drying in the sun for 1 week with the aim of reducing the water content value to 12%, which was obtained by measuring the water content value using a moisture analyzer. The fibers of dried sago starch dregs were taken and then cut into 2 cm.

2.2.2 Experimental Test 1 (Pretreatment)

Samples of sago dregs fiber were weighted at 10 g, then washed with distilled water for further immersion in NaOH solution with a concentration of 10% and 30%, respectively. This immersion was carried out for 6 hours with the aim of degrading lignocellulose in sago dregs fiber. After the soaking process was complete, the samples were then drained, followed by a microwave pyrolysis process at 540 watts for 20 minutes to produce biochar.

The biochar obtained from the preparation of control samples and samples prepared by soaking in NaOH werewas then tested for cellulose, hemicellulose and lignin content using the Chesson-Datta method, and analyzed for water content using a moisture analyzer. Furthermore, the biochar sample was then tested for the ash content by weighing 1 gram of the sample and then putting it into the furnace until it became ash at a temperature of 650°C for approximately 5 hours. The resulting ash was put into a desiccator for cooling and weighing.

2.2.3 Experimental Test 2 (Briquette Making)

Charcoal powder (Biochar) that has been obtained from the previous process was then made into briquettes.In this process, 10 g of charcoal powder was weighed first on 3 variations of the sample. After that, it was continued with making adhesives with sago flour mixed with hot water until it reached the desired thickness. Next, a briquette mold using a PVC pipe with an inner diameter of 5.5 cm and a height of 2 cm was prepared. Each sample of charcoal powder was mixed with the adhesive in a ratio of 10:1 and then pressed under pressure by hand until it was solid. The printed briquettes were then dried in the sun for 3 days. Test the burning time of dry briquettes by burning them, then calculate the burning time using a stopwatch until the briquettes turn to ashes.

3. RESULTS AND DISCUSSION

3.1. Production of Sago Dregs Biochar

The production and characterization of sago dregs biochar were conducted using the microwave pyrolysis method in a closed or airtight (anaerobic) condition. During the manufacture of sago dregs biochar, gravimetric analysis was performed to determine the moisture content, ash content, and the composition of lignocellulose, hemicellulose, and cellulose. The goal was to obtain high-quality biochar with low water and ash content, ideally adjusted to the ash content standards of SNI 06-3730-1995, which is 8-10%. Before the pretreatment process, the sago dregs were dried in the sun for one week until the water content reached 12%, in accordance with SNI 06-3730-1995.

Table 1. Results of Sago Dregs Biochar Analysis

Composition	Control	Pretreatment	
		NaOH 10 %	NaOH 30 %
Water content (%)	12.00	2.53	2.65
Ash Content (%)	3.55	45.99	53.78
Cellulose (%)	30.03	6.11	1.07
Lignin (%)	4.58	6.03	1.10
Hemicellulose (%)	18.47	5.71	0.52
Burning Time (Minute)	3.29	12.32	26.54

3.2. Water Content

Table 1 showed the differences between the control and the pre-treatment process, indicating that pre-treatment and microwave heating affect the water content. A decrease in water content in sago dregs was observed in the samples after pre-treatment by immersing them in NaOH at concentrations of 10% and 30%, followed by heating in a microwave at 540 watts for 20 minutes. For biochar samples with 10% NaOH concentration, the water content was 2.53%, while for 30% NaOH concentration, the water content was 2.65%. The water content in the sample treated with 30% NaOH was slightly higher by approximately 0.12%. However, this value was still lower than the standard set by SNI 06-3730-1995, which specifies a maximum water content of 10%.

The water content in biochar decreased by more than 9% after the heating process. This indicates that the water content before treatment was higher than after becoming biochar. If the water content in biochar is high, it can affect its quality when used as an alternative energy source, as the stored heat in the biochar would first be used to remove existing moisture before producing usable heat for combustion (Iskandar & Rofiatin, 2017). The water content in a material significantly affects its quality and characteristics. Therefore, it is expected that biochar should have a low water content to maintain its quality. Water content is one of the most crucial factors in determining the quality of biochar as an alternative fuel.

3.3. Ash Content

Table 1 showed a significant difference between the results of the control analysis and the pre-treatment process. The ash content produced varies, with 3.55% for the control sago dregs. After pre-treatment and microwave pyrolysis at 540 watts, the samples soaked in 10% NaOH had an ash content of 45.99%, while those with a 30% NaOH concentration had an ash content of 53.78%. The results indicated that the highest ash content was found at a 30% NaOH concentration.

This ash content value was significantly higher than the SNI 06-3730-1995 standard, which sets a maximum of 15%. However, biochar with high ash content was well-suited for plant cultivation, as it still contains residual minerals (Asyifa et al., 2019).

The difference in ash content occurs because the ash in a material originates from the material itself. The ash content in biochar comes from inorganic compounds in the form of mineral oxides, which do not evaporate and are non-flammable. It is known that the higher the ash content in a material, the more inorganic compounds in biochar can influence its functional properties or its use as a renewable alternative energy source (Suparnawati et al., 2021). In addition, the temperature and duration of the pyrolysis process influence the composition of biochar, including its ash content (Siswati et al., 2022). Therefore, adopting a system capable of controlling temperature and process time, such as a fuzzy-based system (Ayusari et al., 2024), is necessary.

3.4. Analysis of Cellulose, Lignin and Hemicellulose content

Comparison of cellulose, lignin, and hemicellulose can be seen in Table 1. Ten grams of sago dregs after pre-treatment with NaOH immersion, with the concentrations used being 10% and 30%, then microwave exposure for 20 minutes with 540 watts of power. The results obtained showed that there were differences before pre-treatment (control) and after pre-treatment (non-control) on sago dregs. The cellulose content before pretreatment was 30.03%, while after pretreatment with 10% NaOH concentration and 20 minutes microwave pyrolysis, it was 6.11%, and 30% NaOH was 1.07%. The higher the NaOH concentration, the lower the cellulose content. This happens because the composition of cellulose was released freely due to immersion in chemical solutions (NaOH). That the cellulose content was higher before pre-treatment (control) than after pre-treatment (non-control). This was due to the influence of the regular, open structure of cellulose, and the cellulose molecules are dispersed freely in the solvent (NaOH). This is due to the cellulose being washed to the bottom by the solvent during filtering (Larasati et al., 2019).

The data displayed for the value of lignin content showed that the value increased compared to before pretreatment (control), i.e. 4.58%. After pretreatment with 10% NaOH concentration and after the microwave pyrolysis process, the value was 6.03%, and in samples with a concentration of 30% NaOH and after the

microwave pyrolysis process, the value decreased to 1.10%. The longer the microwave exposure, the greater the lignin degraded, due to the heat generated during the long microwave exposure and also alkaline pretreatmen,t which can cause polymers to decompose in the cell walls by breaking hydrogen and covalent bonds. The decreased lignin content can also be caused during the sample filtering process after soaking in NaOH, due to the influence of lignin molecules, which are dispersed freely in the solvent (NaOH), so that the lignin molecules are washed to the bottom by the solvent during filtering (Widyawati & Argo, 2014).

The decrease in hemicellulose was caused by degradation through alkalis or what was called "feeling off". Alkali and high temperatures cause hydrolytic decomposition of glucosidic bonds, where the decomposition is caused by acids. Cellulose has glucosidic bonds that can be broken in a chain reaction involving free radicals. As a result, when heated at high temperatures using alkali, the glucosidic bonds in hemicellulose can also be broken (Rahmatullah et al., 2020).

3.5. Sago Dregs Briquettes

In its use as an alternative fuel, sago waste was made in the form of briquettes. This showed that sago dregs biomass waste had the potential to be used as an economical and environmentally friendly alternative fuel. To get briquettes with better characteristics, several treatments needed to be carried out in the manufacturing process. Sago waste biomass briquettes were obtained through several stages, namely composing, mixing with adhesive, molding, and drying. In making sago dregs briquettes using adhesive from sago flour. Making briquettes with the use of adhesives will produce better results than without using adhesives. In addition to increasing the fuel value of the briquettes, the strength of the charcoal briquettes from external pressure was also better (not easily broken). The quality of briquettes is influenced by the adhesive in the briquettes, both the type and the amount of adhesive used (Denitasari, 2011).

The results of sago dregs briquettes can be seen in Table 1. The sago dregs briquettes themselves had a hard, dense, and light texture. Ten g of sago dregs charcoal powder was used, the adhesive used 10% sago flour, with an inside diameter of 5.5 cm, and the diameter of the resulting briquettes was 5.5 cm. The burning time of sago dregs briquettes for control was 3.29 minutes, sago dregs charcoal briquettes after 10% NaOH immersion and microwave pyrolysis with 540 watts of power was approximately 12.32 minutes, and 30% NaOH immersion and microwave pyrolysis with 540 power watts was 26.54 minutes. In briquettes whose charcoal powder had gone through the pretreatment process of NaOH immersion and microwave pyrolysis, the burning rate was longer than that of briquettes without pretreatment (control). The control sample had a larger fiber size compared to the biochar sample, so the amount of adhesive used in one briquette mold will be reduced. This was because the calorific value was affected by the amount of adhesive; the greater the amount of adhesive used, the lower the calorific value. A low calorific value equals a faster burning rate (Denitasari, 2011).

4. CONCLUSION

Based on the results of the research, it can be concluded that:

1. Waste from sago dregs can be processed into biochar with a moisture content that meets the SNI 06-3730-1995 standard.
2. Soaking in NaOH, followed by pyrolysis using a microwave, affects the cellulose, hemicellulose, and lignocellulose content, where higher NaOH concentrations resulted in lower levels of these components.
3. The burning rate of biochar soaked in 30% NaOH lasts longer compared to 10% NaOH.
4. The ash content in sago dregs biochar with pre-treatment NaOH soaking did not meet the SNI 06-3730-1995 standard for fuel. However, it can be utilized for soil or water remediation.

REFERENCES

Asyifa, D., Gani, A., & Rahmayani, R. F. I. (2019). Karakteristik Biochar Hasil Pirolisis Ampas Tebu (Sacharum Officanarum, Linn) Dan Aplikasinya Pada Tanaman Seledri (Apium Graveolens L). *Jurnal IPA & Pembelajaran IPA*, *3*(1), 15–20. https://doi.org/10.24815/jipi.v3i1.13292

Ayusari, Waris, A., & Sapsal, M. T. (2024). Application of Fuzzy Control and IoT Monitoring on Small Scale Biofermentor for Making Virgin Coconut Oil. *Salaga Journal*, *02*(2), 58–64. https://doi.org/10.70124/salaga.v2i2.1776

Denitasari, N. A. (2011). *Briket Ampas Sagu sebagai Bahan Bakar Alternatif*. Institut Pertanian Bogor.

Directorate General of Estates. (2019). *Tree Crop Estate Statistics Of Indonesia 2018 - 2020 : Sago*. Secretariate of Directorate General of Estates, Ministry of Agriculture.

Iskandar, T., & Rofiatin, U. (2017). Karakteristik Biochar Berdasarkan Jenis Biomassa Dan Parameter Proses Pyrolisis. *Jurnal Teknik Kimia*, *12*(1), 28–34. https://doi.org/10.33005/tekkim.v12i1.843

Juniarto, A., & Anggono, A. D. (2018). *Pemanfaatan Limbah Plastik Polipropilen Sebagai Material Komposit Plastik Biodegradable Dengan Penambahan Serbuk Ampas Aren*. Universitas Muhammdiyah Surakarta.

Larasati, I. A., Argo, B. D., & Hawa, L. C. (2019). Proses Delignifikasi Kandungan Lignoselulosa Serbuk Bambu Betung dengan Variasi NaOH dan Tekanan. *Jurnal Keteknikan Pertanian Tropis Dan Biosistem*, *7*(3), 235–244. https://doi.org/10.21776/ub.jkptb.2019.007.03.03

Norberto, J., Benis, K. Z., Soltan, J., & McPhedran, K. (2023). H3PO4 and NaOH Treated Canola Straw Biochar for Arsenic Adsorption. In R. Gupta, M. Sun, S. Brzev, M. S. Alam, K. T. W. Ng, J. Li, A. El Damatty, & C. Lim (Eds.), *Proceedings of the Canadian Society of Civil Engineering Annual Conference 2022* (pp. 1019–1032). Springer International Publishing.

Pien, M. R., Haerani, & Munir, A. (2024). Comparative Analysis of the Performance of Gasoline and LPG-Powered Water Pumps in Shallow Wells. *Salaga Journal*, *01*(1), 1–7. https://doi.org/10.70124/salaga.v1i1.1102

Rahmatullah, Selpiana, Sari, E. O., Putri, R. W., Waluyo, U., & Andrianto, T. (2020). Pengaruh Konsentrasi NaOH terhadap Kadar Selulosa pada Proses Delignifikasi dari Serat Kapuk sebagai Bahan Baku Biodegradable Plastic Berbasis Selulosa Asetat. *Seminar Nasional AVoER XII 2020*, *November*, 305–308.

Suparnawati, S., Warsidah, W., Harlia, H., & Aritonang, A. B. (2021). Produksi dan Karakterisasi Biochar Ampas Tebu (Saccharum Officinarum Linn) Production and Charaterization of Bagasse Biochar (Saccharum Officinarum Linn). *Indonesian Journal of Pure and Applied Chemistry*, *4*(2), 91–101.

Syauqiah, I., Harivram, A. S. K., Elma, M., Putri, D. A. C., & Safitri, N. G. (2022). Pemanfaatan Ampas Sagu (Metroxylon sp .) Sebagai Karbon Aktif Untuk Penurunan Kadar Fe Pada Laruran Artifisial Fe 2 (SO 4) 3. *Prosiding Seminar Nasional Lingkungan Lahan Basah*, *7*(April), 216–221.

Widyawati, N. L., & Argo, B. D. (2014). Utilization of Microwave Pretreatment Process Degradation of Lignin in Dregs Sugarcane (Bagasse) in Bioethanol Production. *Jurnal Teknologi Pertanian*, *15*(1), 1–6.

Winarsih, S. (2013). *Pemanfaatan Jerami Padi untuk Produksi Bioetanol dengan Pretreament Microwave alkali dan Hidrolisis Menggunakan Enzim Kasar dari Trichoderma reesei dan Aspergillus niger*. Universitas Brawijaya.