UTILIZATION OF WATER HYACINTH (*Eichhornia crassipes*) AND COCONUT (*Cocos nucifera*) SHELL AS A BIO-BRIQUETTE

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ABSTRACT

PALTAO, JULIE FE B., Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippines, **June 2023, UTILIZATION OF WATER HYACINTH (*Eichhornia crassipes*) AND COCONUT (*Cocos nucifera*) SHELL AS A BIO-BRIQUETTE**

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The general objective of the research was to produce charcoal briquettes from water hyacinth and coconut shell using cassava starch as a binder. The specific objectives of the study were to: determine the charcoal yield of water hyacinth and coconut shell; determine the optimum water hyacinth and coconut shell mixing ratio; bind with cassava starch for the production of charcoal briquettes; and estimate the unit cost of production of water hyacinth and coconut shell charcoal briquettes. For the production of bio-briquettes, water hyacinth and coconut shell undergo various processes such as drying, carbonizing, shredding, combining in various proportions of biomass, binding, and densifying. Physical characteristics such as density, compressive strength, abrasive strength, and shatter resistance were assessed, as were chemical properties such as thermal efficiency, calorific value computation, burning time, and ash percentage. An analysis of variance was used to determine the significant difference between treatments, and the least significant difference was used to compare the means. Each treatment was replicated three times. For each water hyacinth and coconut shell mixture, four distinct composition ratios were used: 80:20, 60:40, 40:60, and 20:80.

The highest computed mean density, highest compressive strength, highest mean burning time, and lowest ash percentage were obtained in Treatment 1 (80:20), with a value of 2.02 g/cc, 6843.76 N, 227.75 minutes, and 8.75%, respectively. On the other hand, Treatment 4 (20:80) has the least computed compressive strength, the least mean shatter resistance, the lowest mean burning time, and the highest ash content. with a value of 1499.34 N, 65.95%, 114.57 minutes, and 27.72%, respectively. Hence, it can be inferred that Treatment 1 (80:20) is the optimum mixing ratio of coconut shell and water hyacinth bound with cassava starch.

Keywords: Charcoal yield; Optimum mixing ratio; Physical property; Combustion property; Cost analysis.

LITERATURE CITED

Afra, E., Abyaz, A., & Saraeyan, A. (2021). The production of bagasse biofuel briquettes and the evaluation of natural binders (LNFC, NFC, and lignin) effects on their technical parameters. *Journal of Cleaner Production*, *278*, 123543.

Ahmad, K. K., Sazali, K., & Kamarolzaman, A. A. (2018). Characterization of fuel briquettes from banana tree waste. *Materials Today: Proceedings*, *5*(10), 21744-21752.

Ajith, K. J., Vinoth, K. K., Petchimuthu, M., Iyahraja, S., & Vignesh, K. D. (2020). Comparative analysis of briquettes obtained from biomass and charcoal. *Mater.* Today Proc.10.1016/j.matpr.2020.02.918

Asian Charcoal Briquettes Market Research Report. (2020). Asia Charcoal Briquettes Market Overview.

Bailey, R. T. & Blankenhorn, P. R. (1982). Calorific and porosity development in carbonized wood. *Wood Science*, 15(1): 19 -28.

Chen, H. (2015). Lignocellulose Biorefinery Engineering: Lignocellulose biorefinery product engineering. *Woodhead Publishing*, 125-165.

Chirchir, D. K., Nyaanga, D. M., & Githeko, J. M. (2013). Effect of Binder Types and Amount on Physical and Combustion Characteristics. *Int. J. Engg. Res. and Sci. and Tech.* 2(1).

Corpuz, M. G. A., Tuates Jr., A. M., Aguinaldo, T. G., Villota, E. M., Mateo, W. C., & Caparino, O. A. (2017). Development of corn cob-based fuel briquettes. *Agricultural Engineering International: CIGR Journal*, 19(3), 92–96.

Davies, R. M., & Davies, O. A. (2013). Physical and Combustion Characteristics of Briquettes Made from Water Hyacinth and Phytoplankton Scum as Binder. *Journal of Combustion*, 2013, 7.

Gani, A. & Naruse, I. (2007). Effect of cellulose and lignin content on pyrolysis and combustion characteristic for several types of biomasses. *Renew. Energy*, 32, 649–661.

Go, A. W., Conag, A. T., Igdon, R. M. B., Toledo, A. S., & Malila, J. S. (2019). Potentials of agricultural and agro-industrial crop residues for the displacement of fossil fuels: A Philippine context. *Energy Strategy Reviews*, 23, 100-113.

LITERATURE CITED

Afra, E., Abyaz, A., & Saraeyan, A. (2021). The production of bagasse biofuel briquettes and the evaluation of natural binders (LNFC, NFC, and lignin) effects on their technical parameters. *Journal of Cleaner Production*, *278*, 123543.

Ahmad, K. K., Sazali, K., & Kamarolzaman, A. A. (2018). Characterization of fuel briquettes from banana tree waste. *Materials Today: Proceedings*, *5*(10), 21744-21752.

Ajith, K. J., Vinoth, K. K., Petchimuthu, M., Iyahraja, S., & Vignesh, K. D. (2020). Comparative analysis of briquettes obtained from biomass and charcoal. *Mater.* Today Proc.10.1016/j.matpr.2020.02.918

Asian Charcoal Briquettes Market Research Report. (2020). Asia Charcoal Briquettes Market Overview.

Bailey, R. T. & Blankenhorn, P. R. (1982). Calorific and porosity development in carbonized wood. *Wood Science*, 15(1): 19 -28.

Chen, H. (2015). Lignocellulose Biorefinery Engineering: Lignocellulose biorefinery product engineering. *Woodhead Publishing*, 125-165.

Chirchir, D. K., Nyaanga, D. M., & Githeko, J. M. (2013). Effect of Binder Types and Amount on Physical and Combustion Characteristics. *Int. J. Engg. Res. and Sci. and Tech.* 2(1).

Corpuz, M. G. A., Tuates Jr., A. M., Aguinaldo, T. G., Villota, E. M., Mateo, W. C., & Caparino, O. A. (2017). Development of corn cob-based fuel briquettes. *Agricultural Engineering International: CIGR Journal*, 19(3), 92–96.

Davies, R. M., & Davies, O. A. (2013). Physical and Combustion Characteristics of Briquettes Made from Water Hyacinth and Phytoplankton Scum as Binder. *Journal of Combustion*, 2013, 7.

Gani, A. & Naruse, I. (2007). Effect of cellulose and lignin content on pyrolysis and combustion characteristic for several types of biomasses. *Renew. Energy*, 32, 649–661.

Go, A. W., Conag, A. T., Igdon, R. M. B., Toledo, A. S., & Malila, J. S. (2019). Potentials of agricultural and agro-industrial crop residues for the displacement of fossil fuels: A Philippine context. *Energy Strategy Reviews*, 23, 100-113.

Huang, J. (2014). Calorific value of pressed fuel briquettes.

Idowu, A., Ayodeji, I., & Musa, A. (2020). Combustion Quality Evaluation of Briquettes Produced from Sesame Hull as Source of Sustainable Energy. *Asian Journal of Energy Transformation and Conservation*, *4*(1), 30-39.

Ikelle, I. I., Nworie, F. S., Ogah, A. O., & Ilochi, N. O. (2017). Study on the Combustion Properties of Bio-Coal Briquette Blends of Cassava Stalk Chem. *ChemSearch Journal*, 8(2), 29 – 34.

Kaliyan, N., & Morey, R. V. (2009). Factors affecting strength and durability of densified biomass products. *Biomass and Bioenergy*, 33(3), 337-359. doi: 10.1016/j.biombioe.2008.08.005

Kaliyan, N., & Morey, R. V. (2010). Densification characteristics of corn cobs. *Fuel Processing Technology*, *91*(5), 559-565.

Kaliyan, N., & Morey, R. V. (2010). Natural binders and solid bridge type binding mechanisms in briquettes and pellets made from corn stover and switchgrass. *Bioresource technology*, *101*(3), 1082-1090.

Kaur, A., Kumar, A., Singh, P., & Kundu, K. (2017). Production, Analysis and Optimization of Low-Cost Briquettes from Biomass Residues. *Adv. Res*, *12*, 1-10.

Kimutai, S. K., & Kimutai, I. K. (2019). Investigation of physical and combustion properties of briquettes from cashew nut shell and cassava binder. *International Journal of Education and Research*, 7(11).

Köser, H. J., Schmalstieg, G., & Siemers, W. (1982). Densification of water hyacinth basic data. *Fuel*, *61*(9), 791-798.

Kpalo, S. Y., Zainuddin, M. F., Manaf, L. A., & Roslan, A. M. (2020). A Review of Technical and Economic Aspects of Biomass Briquetting. *Sustainability*, 12(11). doi: 10.3390/su12114609

Macabebe, E. Q. B., Dumlao, S. M. G., & Perez, T. R. (2016). Waste to Energy: A Look into Community-Based Charcoal Briquetting in the Philippines. *International Proceedings of Chemical, Biological and Environmental Engineering*, 93.doi: 10.7763/IPCBEE. 2016. V93. 9

Mengesha, T. T., & Ramayya A. V. (2017). Performance Evaluation of Pyrolysis Cookstove Using Water Boiling Test. *American Journal of Modern Physics*, 6(5), 108-116. doi: 10.11648/j.ajmp.20170605.15

Mitchual, S.J., Frimpong-Mensah, K., & Darkwa, N. A. (2013). Effect of species, particle size and compacting pressure on relaxed density and compressive strength of fuel briquettes. Int J Energy Environ Eng, 4, 30.

Nasrin, A. B., Ma, A. N., Choo, Y. M., Mohamad, S., Rohaya, M. H., Azali, A., &Zainal, Z. (2008). Oil palm biomass as potential substitution raw materials for commercial biomass briquettes production. *American Journal of Applied Sciences*, *5*(3), 179-183.

Nyakuma, B. B., Johari, A., Ahmad, A., & Abdullah, T. A. T. (2014). Comparative analysis of the calorific fuel properties of Empty Fruit Bunch Fiber and Briquette. *Energy Procedia*, *52*, 466-473.

Obi, F. O., Ugwuishiwu, B. O., & Nwakaire, J. N. (2016). Agricultural waste concept, generation, utilization and management.

Olugbade, T., Ojo, O., & Mohammed, T. (2019). Influence of Binders on Combustion Properties of Biomass Briquettes: A Recent Review. *Bioenerg. Res.*, 12, 241–259. https://doi.org/10.1007/s12155-019-09973-w

Onukak, I. E., Mohammed-Dabo, I. A., Ameh, A. O., Okoduwa, S. I. R., & Fasanya,O. O. (2017). Production and Characterization of Biomass Briquettes from Tannery Solid Waste. *Recycling*, 2, 17. doi:10.3390/recycling2040017

Pachaiyappan, S., Seshadri, S., Sugumaran, P., Susan, V. P., Ravichandran, P., & Seshadri, S. (2012). Production and characterization of activated carbon from banana empty fruit bunch and Delonix regia fruit pod microbial inoculants view project bio-char production view project production and characterization of activated carbon from banana empty fruit bu. *J. Sustain. Energy Environ*, *3*, 125-132.

Ranada, P. (2014). New pest fast destroying coconut trees in Luzon. *Nation*, *31*.

Rathore, N. S. & Panwar, N. L. (2008). Renewable Energy Theory and Practice. Himanshu Publication, New Delhi, p. 273.

Rezania, S., Din, M. F. M., Kamaruddin, S. F., Taib, S. M., Singh, L., Yong, E. L., & Dahalan, F. A. (2016). Evaluation of water hyacinth (Eichhornia crassipes) as a potential raw material source for briquette production. *Energy*, *111*, 768-773.

Rotich, P. K. (1998). Carbonization and briquetting of sawdust for use in domestic cookers. Retrieved from http://erepository.uonbi.ac.ke/handle/11295/21571

Sengar, S. H., Mohod, A. G., Khandetod, Y. P., Patil, S. S., & Chendake, A. D. (2012). Performance of Briquetting Machine for Briquette Fuel. *International Journal of Energy Engineering*, 2(1), 28-34. doi: 10.5923/j.ijee.20120201.05.

Shuma, R., & Madyira, D. M. (2017). Production of loose biomass briquettes from agricultural and forestry residues. *Procedia Manufacturing*, *7*, 98-105.

Sluiter, A., Hames, B., Ruiz, R., Scarlata, C., Sluiter, J., & Templeton, D. (2008). Determination of Ash in Biomass: Laboratory Analytical Procedure (LAP). Retrieved from https://www.nrel.gov/docs/gen/fy08/42622.pdf

Speight, J. G. (2020). The Refinery of the Future: Production of fuels from nonfossil fuel feedstocks. *Gulf Professional Publishing*, 2, 391-426. https://doi.org/10.1016/B978-0-12-816994-0.00011-7.

Steiner, C., Bayode, A. O., & Komang Ralebitso-Senior, T. (2016). Biochar Application: Feedstock and Production Parameters: Effects on Biochar Properties and Microbial Communities. *Elsevier*, 41-54.

Sundaram, E. G., & Natarajan, E. (2009). Pyrolysis of coconut shell: An experimental investigation. *The Journal of Engineering Research [TJER]*, *6*(2), 33-39.

Supatata, N., Buates, J., & Hariyanont, P. (2013). Characterization of fuel briquettes made from sewage sludge mixed with water hyacinth and sewage sludge mixed with sedge. *International Journal of Environmental Science and Development*, *4*(2), 179.

Téllez, T. R., López, E. M. D. R., Granado, G. L., Pérez, E. A., López, R. M., & Guzmán, J. M. S. (2008). The water hyacinth, Eichhornia crassipes: an invasive plant in the Guadiana River Basin (Spain). *Aquatic Invasions*, *3*(1), 42-53.

Tesfaye, A., & Girma, A. (2017). Phytochemistry, pharmacology and nutraceutical potential of enset (Ensete ventricosum). *African Journal of Basic & Applied Sciences*, *9*(3), 112-117.

Turkenburg, W. C., & Faaij, A. (2000). *Renewable energy technologies* (pp. 219-72). UNDP/UNDESA/WEC: Energy and the Challenge of Sustainability. World Energy Assessment. New York: UNDP, 219-272.

Zakari, I. Y., Ismaila, A., Sadiq, U., & Nasiru, R. (2013). Investigation on the effects of addition of binder and particle size on the high calorific value of solid biofuel briquettes. *J. Natural Sci. Res.*, 3(12), 30-34.

Zheng, C., Ma, X., Yao, Z., & Chen, X. (2019). The properties and combustion behaviors of hydrochars derived from co-hydrothermal carbonization of sewage sludge and food waste. *Bioresource technology*, *285*, 121347.