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RESEARCH ARTICLE

EVALUATION AND DEVELOPMENT OF COCONUT HUSK (*COCOS NUCIFERA* EXOCARP) AS CHARCOAL: A SUSTAINABLE APPROACH

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Abstract

This research examines the potential of coconut husks (Cocos nucifera exocarp) as a sustainable alternative to traditional charcoal. With increasing coconut production in tropical regions, there is a substantial amount of unused coconut husks, presenting an opportunity for alternative uses. This study evaluated the physical and chemical properties of coconut husk charcoal, including heating value, ash content, and volatile matter, and compared these properties with conventional charcoal. An experimental methodology was employed, producing two types of coconut charcoal: briquettes and flakes. The study found that while the briquettes initially struggled due to binding agent issues, the flakes performed better, demonstrating that coconut husk charcoal could maintain a fire intensity similar to traditional charcoal. Additionally, using coconut husk reduces greenhouse gas emissions compared to traditional methods. The findings suggest that coconut husk charcoal is a viable and sustainable alternative, providing environmental and economic benefits by utilizing agricultural waste effectively.

Keywords: *coconut husk, charcoal, sustainable energy, biomass, environmental impact*

Introduction

Tropical countries have a significant production of coconuts, resulting in many unutilized shells in these regions (Ahmad et al., 2020). The prevailing understanding of the use of coconuts is mainly centered on their water and flesh. As per Ahmad et al. (2020), 92 countries, including the Philippines, cultivate coconut on a combined area of about ten million hectares. Furthermore, based on global survey data from 2021, the Philippines ranks second in coconut production, with a total of 14.72 million metric tons for that year (Shahbandeh, 2023). Multiple studies have demonstrated that coconuts are solely being exploited to produce coconut water, oil, and milk. Therefore, it may be inferred that aside from its water and flesh, coconut shells have no further value and are classified as coconut shell waste or agricultural waste.

Charcoal briquettes typically consist of coal dust, charcoal dust, sawdust, and wood chips, which are employed as fuel in fires and stoves (Kongprasert et al., 2019). The production of briquettes typically involves pulverizing conventional charcoal into small particles and combining it with flour and water. The mixture is then shaped and compressed into the required form (Kongprasert et al., 2019). Moreover, charcoal flakes are typically produced from the combustion of coconut shells, which are burned for 6 hours in a steel drum barrel at a temperature of 75 degrees Celsius (Budi et al., 2016).

In addition, there are economic benefits associated with producing charcoal briquettes and charcoal flakes. As a consequence, the combustion of this substance yields a reduced quantity of smoke, and it may be manufactured using a straightforward procedure (Kongprasert et al., 2019). In addition, the United Nations has raised concerns among many nations by endeavoring to reduce greenhouse gas emissions (Kabir Ahmad et al., 2022). Hence, producing charcoal briquettes and charcoal flakes from agricultural waste, such as coconut shells, can reduce the release of ash, smoke, and CO_2 compared to conventional charcoal.

The objective of this study is to examine further the viability of using coconut shell trash as a substitute for charcoal. Limited research has been conducted on the environmental implications and the process of converting coconut shells into charcoal briquettes and flakes. This study aims to address the existing information gaps. Moreover, this study can benefit those engaged in coconut-related industries, environmental advocates, and ordinary citizens.

Research Questions

Specifically, this study sought to answer the following:

1. Can coconut husk be a viable and sustainable alternative to traditional charcoal sources in terms of yield, quality, and environmental impact?
2. What are coconut husk charcoal's physical and chemical properties (e.g., heating value, ash content, volatile matter) compared to traditional charcoal?
3. How does the production of coconut husk charcoal compare to traditional methods in terms of greenhouse gas emissions and resource consumption?

Literature Review

Coconut shells are abundantly produced in tropical regions and require appropriate utilization. Nevertheless, there is a dearth of previous research specifically addressing the conversion of coconut shells into charcoal. Neither confined to a specific area nor encompassing the entire world. Therefore, the manufacturing of charcoal derived from coconuts is restricted (Ahmad et al., 2021).

The escalating costs of kerosene and cooking gas in Nigeria have necessitated the exploration of alternate energy sources. This study assessed the combustion characteristics of charcoals produced from coconut husk and cassava starch as a binding agent. A proximate analysis was performed to ascertain the components of the charcoal, such as the amount of ash, the percentage of fixed carbon, the percentage of volatile matter, and the heating value. The findings indicated that the charcoals derived from coconut husk and starch exhibited a diminished fixed carbon content and an elevated proportion of volatile matter, resulting in enhanced performance. According to the study conducted by Lawal et al. (2019), coconut husk waste can be effectively used to generate charcoals that have improved performance.

In addition, according to Yuliah et al. (2022), coconut shells in some areas of Indonesia, precisely in Mekarwangi Village, are not fully utilized and are wasted by the community. Coconut shells can be a sustainable substitute for charcoal and fuel, offering a more environmentally friendly option. Hence, it is necessary to enhance one's comprehension and consciousness regarding converting coconut shells into charcoal to augment the worth of waste and serve as an additional source of money for the population of Mekarwangi Village.

Furthermore, as reported by the seven municipalities in the southern coastal region of Bahia, approximately 1.7 million coconut shells are discarded annually. These shells can be used to produce gardening products, handicrafts, and charcoal briquettes. By doing so, emissions of CH4, which is a byproduct of coal production, can be reduced (Nunes et al., 2020).

In addition, Ahmad et al. (2021) explore the feasibility of utilizing coconut shell biomass to generate sustainable energy. The writers critically evaluate the existing body of research on the topic and pinpoint areas where further investigation is needed to fill gaps in understanding. A highlighted deficiency in the paper is the absence of scientific research regarding the carbonization process of coconut shells for charcoal production. It is observed that coconut shells can potentially be biomass sources for energy production. However, further research is required to determine the most effective techniques for turning coconut shells into charcoal. The authors propose that forthcoming studies should enhance the carbonization procedure in order to enhance the caliber and output of charcoal derived from coconut shells.

Nevertheless, Sibarani (2022) seeks to offer supplementary sources of income for young coconut entrepreneurs by tackling two distinct issues - the disposal of young coconut shells and outdated accounting methods. He suggests converting young coconut waste into biodegradable pots/polybags and utilizing peel scraps and shards of coconut shell waste as an alternative fuel for charcoal or briquettes.

Based on a study conducted by Martin et al. (2015, as referenced in Missau et al., 2021), coconut is a significant agricultural commodity in the Philippines that serves various functions, including food, fiber, and activated charcoal production. Additionally, the research revealed that coconut shells have a substantial heating value of 20880 J/g, surpassing other agricultural residues in the nation. Due to its high heating value, coconut shells are regarded as the Philippines' most promising agricultural waste material.

Similarly, this study examined the fuel characteristics of coconut husk charcoal, such as its moisture content, volatile matter, ash content, fixed carbon, gross calorific value, and elemental composition. The findings indicated that coconut husk briquette exhibited a more significant proportion of volatile combustible matter while having lower levels of fixed carbon and gross calorific value than Bitanghol-sibat bark briquette. However, the study emphasizes the possibility of creating renewable energy sources by utilizing coconut husk to produce charcoal (Mendoza et al., 2020).

Although tropical countries produce a large amount of coconut shells, their use as a source of charcoal is limited because there is a dearth of previous research on this topic. Neither local nor global study has thoroughly investigated the possibilities of coconut shells for charcoal manufacturing. Hence, it is imperative to undertake additional studies on this subject in order to enhance and streamline the manufacturing process of coconut-derived charcoal. This would aid in the sustainable exploitation of this byproduct and offer an alternate fuel source.

Methodology

This section introduces the methodology employed in the study, which aimed to explore the production and quality determination of coconut shells as a potential alternative to traditional charcoal. The research design adopted for this study was experimental, involving the creation of two distinct versions of charcoal: briquettes and flakes. The methodology encompasses the steps undertaken to produce these two versions and the subsequent evaluation of their quality as fuel sources. By employing this experimental approach, the study aimed to provide valuable insights into the feasibility and efficacy of utilizing coconut shells as a sustainable and renewable option for charcoal production.

Materials and Equipment

Coconut Husk:

- Dried and mature coconut husks (Cocos nucifera exocarp)
- Distilled water (for washing - optional)

Charcoal Production (depending on the chosen method):

- **Traditional Kiln Method:**
    - Clay bricks or metal drum
    - Heat source (e.g., firewood, charcoal)
- **Retort Kiln Method:**
    - Metal retort with lid and cooling system
    - Inert gas (e.g., nitrogen) - optional
- **Biochar Method (optional):**
    - Organic materials for bulking agents (e.g., leaves, sawdust)

Analysis (depending on chosen tests):

- Grinding equipment (for sample preparation)
- Moisture meter
- Ash content determination equipment (crucible, furnace)
- Heating value determination equipment (bomb calorimeter)

Processing:

- Hammer mill or grinder (for crushing coconut husks)
- Sieve (for size separation - optional)
- Metal trays or containers

Charcoal Production:

- **Traditional Kiln Method:**
    - Temperature monitoring tools (thermometer, pyrometer)
- **Retort Kiln Method:**
    - Heating source (electric furnace, biomass burner)
    - Pressure gauge (optional)

Experimental Setup

This project's main goal was to utilize coconut shells as the primary constituent. Two distinct techniques were utilized to manufacture the desired products: one involved using a furnace to produce charcoal briquettes and igniting a steel drum barrel with fire to create charcoal flakes. A binder made from cornstarch and water was used to shape the mixture into a plastic cup to form the charcoal briquettes.

Treatment/ General Procedure

The experiment consisted of two variations: one for manufacturing charcoal briquettes and the other for generating charcoal flakes.

In the initial iteration, the coconut shells underwent a meticulous cleansing process to remove contaminants, such as fiber and soil. The shells that had been cleaned were exposed to sunshine for two days in order to decrease their moisture level. Afterward, the dehydrated coconut shells were introduced into a furnace and subjected to carbonization at a temperature of 80 degrees Celsius for a duration of 24 hours. The resulting ashes were pulverized into charcoal powder via milling and screening. An adhesive made from cornstarch and water was employed to bind the charcoal powder. Subsequently, the charcoal blend was shaped into briquettes with a cup, and the resulting briquettes were subjected to a 24-hour drying period to eliminate any residual moisture. The briquettes' quality was evaluated by assessing their heating value and potential as a substitute for conventional charcoal.

In the subsequent iteration, the process commenced by purifying and dehydrating the coconut shells in identical ways. Instead of a furnace, the desiccated coconut shells were inserted into a steel drum barrel. The barrel was set ablaze and allowed to burn for 24 hours. As a consequence of this technique, charcoal flakes were produced. The evaluation of the charcoal flakes also considered their heating value and appropriateness as a fuel source.

This section provides a detailed explanation of the approach used, which includes all the steps from the initial processing of raw materials to the assessment of the quality of briquettes and flakes. The subsequent chapters will show the outcomes derived from the experimental methodologies delineated in this chapter and comprehensively analyze the discoveries.

Results and Discussion

During the early phases of the investigation, the researchers initially aimed to create a charcoal briquette using coconut shell waste. The initial strategy was subsequently implemented, but the outcome did not produce the expected result. The initial production of charcoal briquettes utilizing coconut shell waste was unsuccessful due to inadequate product desiccation, although passing the test. Consequently, following the 24 hours, the researchers returned to assess any alterations that were placed within the specified timeframe. The briquettes made from the residue of coconut shells were not densely packed and were slightly moist despite being left to dry in the open air overnight. During the fire resistance test, the briquettes proved unsuccessful as the glue used to shape the burnt coconut shell powder prevented it from catching fire. The researchers documented the errors and subsequently attempted a different configuration.

In the second configuration, rather than pulverizing the burnt coconut shells, the researchers examined the inherent ability of burnt coconut shells to maintain a fire. To do this, the researchers deviated from using a furnace and instead burned the coconut shells for around 24 hours in a steel drum barrel. The researchers investigated whether burnt coconut shells could maintain a fire intensity comparable to standard charcoal. By omitting cornstarch and water, the researchers determined that the outcome of the second experiment yielded a more refined charcoal variant than the first experiment. It retains the inherent characteristics of coconut shells, such as being odorless, without hindering itself.

The fire resistance of the coconut shells was subsequently assessed. Minimal quantities of cinders and embers were produced during the combustion of the coconut shells. This demonstrates that charred coconut shells exhibit significant potential as a substitute for charcoal. Moreover, it provides evidence that the binder used in the initial experiment was the cause of the failure of the briquettes to burn.

Several trials have been conducted to demonstrate the study's aims, and they confirm the efficacy of using coconut shells as a replacement for charcoal briquettes. The researchers developed a way to utilize organic trash and addressed critical societal concerns related to waste management and deforestation.

A significant obstacle encountered by the researchers throughout the investigation was the limited availability of time. Due to the experimental design of this study, it is necessary to spend a significant amount of time at each stage to thoroughly examine each outcome and its contribution towards achieving the target product. Furthermore, it is crucial to evaluate the appropriate materials employed in this study and the correct measurements, particularly in creating charcoal briquettes. This is necessary to ensure accurate processes and techniques, which are essential for creating a viable charcoal substitute. Close monitoring of the storage conditions for both the briquettes and flakes is essential, as it can significantly impact the product's efficacy. Consequently, additional research should be conducted to determine how much coconut shells can be used as a substitute for traditional charcoal.

Recommendation

- Investigate methods to enhance the efficacy of combusting coconut shells in a regulated manner, perhaps including alterations in combustion duration, temperature, and container selection (such as drum barrel versus choices).
- If the goal is to continue producing briquettes, it is recommended to explore alternate binders that do not impede combustion but maintain the briquettes' structural integrity. Trials will be conducted using various binding substances and concentrations to determine the most favorable equilibrium.
- Formulate ways to expand the production process from its experimental phase to a commercially feasible scale. This may entail the development of larger combustion chambers or the investigation of continuous combustion methods.
- Perform a thorough analysis of the charred coconut shell product. Examine the characteristics of the fuel, such as its calorific value, combustion duration, ash content, and volatile matter content, compared to conventional charcoal. Perform combustion tests to assess its combustion characteristics and effectiveness.
- Examine the ecological consequences of producing coconut shell charcoal on a wide scale. Consider variables such as potential air emissions, the sustainability of coconut shell sourcing, and the life cycle assessment compared to conventional charcoal production.

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