Eco-charcoal: Efficacy of the Leaf Litter and Rice Hull (*Oryza sativa*) as Charcoal Briquettes

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ABSTRACT

Bio-briquette products a commonly used as an energy source for electricity generation heat and cooking fuel. Leaf litter and agricultural waste such as rice hull are commonly left piled in the field to decompose or burned in open fires which pose risks to the environment, animals, and human health. However, biomass is always a widely available source of renewable energy worldwide. Thus, this study aimed to determine the efficacy of the Leaf litter and Rice Hull (Oryza sativa) as charcoal briquettes. Rice hull (Oryza sativa) and Leaf litter were carbonized and turned into a fined charcoal mixed with a binder and molded with an improvised bamboo molder. This study utilized an experimental research design. Charcoal briquettes made of different treatments, Treatment A (Leaf litter), Treatment B (Rice hull, Oryza sativa), Treatment C (combination of Leaf litter and Rice hull, Oryza sativa), and Treatment D (control; the wood charcoal) were used to boiled water, grilled fish, and cooked rice with 3 replicates each. The result of the experiment showed that treatment B boiled water faster (410.00s±171.164), treatment D grilled fish(218.00s±.000), and cooked rice faster (1010.33s±408.118). The study concludes that treatments A, B, and C as briquettes are found to be as efficient as charcoal briquettes and that there is a significant difference. It is recommended that leaf litters and Rice hull (Oryza sativa) as charcoal briquettes can be used as household cooking fuel.

Keywords: Bio-Briquettes, Leaf Litter, Rice Hull *(Oryza Sativa)*

Introduction

Charcoal briquettes are compressed blocks of agricultural waste such as rice hull or husk, coconut coir, sawdust, wood chips, or biomass that could be used as household cooking fuel. In areas where cooking fuels are scarce, particularly in developing countries, biomass briquettes are a popular eco-friendly substitute for coal and charcoal (Gupta, 2020).

Bio-briquettes from agricultural waste are sustainable, eco-friendly, healthy, and non-dependent on fossil fuels (Sanchez et al., 2022). Briquettes are less expensive and they burn longer and much hotter than traditional charcoal made from wood chunks (Lenkiewicz & Webster, 2019).

Eco-charcoal is a type of coal that is produced and used in environmentally friendly ways.

The coal extraction and its process contain sustainable practices that minimize the environmental impact and also implement cleaner technologies to reduce emissions when the coal is burned for energy that aims to balance the needs of energy with ecological considerations and foster a greener and more responsible coal industry.

The manufacturing of charcoal in tropical settings is frequently regarded as having detrimental ecological and environmental impacts. The most frequently reported impact is the clearance of forest or woodland, also known as deforestation. The Philippines continues to stand as one of the most severely deforested countries (Grantoza & Ramirez, 2022).

To find an alternative to wood charcoal, various initiatives have looked into waste-derived briquettes, which are commonly referred to as green charcoal, also known as eco-charcoal. Biomass such as plant leaves are commonly used for their nutritional values (Casuga & Natividad, 2023; Navarro et al., 2018), disinfectants (Garcia et al., 2023), nanotechnology applications (Medina et al., 2018), and as feedants (Martin et al., 2018). A study by Malak et al. (2016) revealed the ability to produce solid bio-fuel briquettes through a roasting process, which was found to be more effective than the traditional carbonization method, as demonstrated by simulation techniques.

In terms of the amount of storage space, heat produced, moisture content, and per unit mass, biomass briquettes are superior to traditional cooking fuels like wood and do not increase carbon footprints (Sanchez et al., 2022). In addition, compared to other raw materials, bio briquettes have improved energy characteristics, a greater density, a higher calorific value, and a lower water content (Stolarski et al., 2013). Ramesh (2020) investigated the properties of biomass briquettes made from varying ratios of dry leaves, sawdust, and rice husk with starch as a binder.

In the study of Oladele & Okoro (2015), cassava starch works effectively as a binder as one of the most common organic components. Dry leaves can be used to make briquettes because of their heating value and durability performance. de Oliveira (2014) tested for approximate and ultimate chemical composition, bulk and energy density, linear shrinkage, mechanical compressive strength, high heating value, thermogravimetric analysis, and differential thermal analysis the results made of semi-dried banana leaves are comparable to other biomass. Likewise, in the study of Khorasgani (2019), both grass and tree leaves have superior mechanical and thermal characteristics that can be employed in a variety of industrial applications.

Additionally, the carbonization process results in briquettes that absorb less moisture, which is necessary to prolong its storage life by keeping it from deteriorating and rotting (Lubwama & Yiga, 2018). When compared to their raw materials, the carbonized briquettes made from rice and coffee husks all had greater fixed carbon percentages, lower moisture contents, and volatile matter—all signs of high-quality goods. Bio-briquettes, according to Solano et al. (2016), also assist farmers socially and economically by reducing their reliance on energy imports, bolstering local and regional companies, and creating more jobs in rural regions.

With its ability to serve as a feasible alternative to traditional charcoal, eco-charcoal presents an opportunity to tackle this problem by providing a different source of energy and opening up potential avenues for livelihood (Adams, 2022). It has several positive benefits as well as lessens deforestation, can be used in conjunction with fuel-efficient stoves to cut consumption, burns cleanly, and may help reduce respiratory diseases, it can also be an income source for makers. It can be manufactured in small groups or more formal, industrial settings.

Province of Antique, Philippines with its presence of agricultural land where agricultural wastes were abundant, the people living in the community have great potential to produce charcoal briquettes formed from agricultural waste as their livelihood and alternative to charcoal made of wood chunks. Thus, this study aimed to develop charcoal briquettes made up of biomass residues.

Specifically, the study answered the following questions:

1. What is the most efficient among leaf litter, rice hull (Oryza sativa), and the combination of leaf litter and rice hull (Oryza sativa) as charcoal briquettes in terms of boiling cups of water, grilling fish, and cooking rice?
2. Is there a significant difference in the efficacy of the briquettes made from leaf litter, rice hull (Oryza sativa), and the combination of leaf litter and rice hull (Oryza sativa) in terms of boiling cups of water, grilling fish, and cooking rice?

This study can be used as the basis of information dissemination and campaigns about the efficacy of Leaf litter and Rice Hull charcoal briquettes as an alternative to wood charcoal. The study can help people in the community reduce the use of wood charcoal as a domestic heating tool and can be purchased as an alternative to charcoal. Homeowners can adopt this type of briquette process for them to make their charcoal briquettes as well as save a significant amount of money from buying wood charcoal for it involves a less laborious process. Further, this study can provide insights into the potential for creating new business opportunities and promoting entrepreneurship in the production and marketing of charcoal briquettes. Importantly, it will help the charcoal producers maintain their source of income without violating the laws and policies mandated by the DENR.

Materials and Methods

Materials

The materials that the researchers used for this study are the weighing scale, measuring cups, a pan or a big can, thongs, mortar and pestle, an improvised bamboo molder, leaf litter, and rice hull (Oryza sativa).

Research Design

In this study, the researchers used experimental research design. Experimental research design is a method used to investigate the interaction between independent and dependent variables (Saigo, 2022). This is used to determine a cause-and-effect relationship. This research design is considered appropriate because it has examined the efficacy of leaf litter and rice hull (Oryza sativa) as charcoal briquettes.

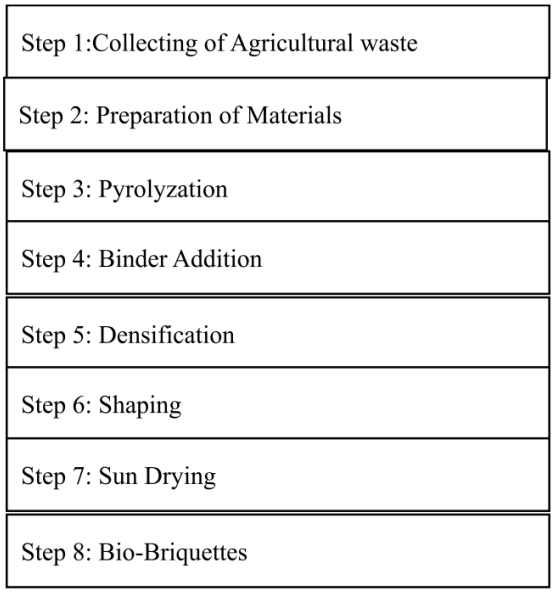

Figure 1. Eco-Charcoal Briquetting Procedure

Data Gathering Procedure

The researchers visited Barangay San Antonio, Barbaza, Antique and Poblacion, Tibiao, Antique looking for, the leaf litter and rice hull (Oryza Sativa). After finding some sources they sought approval from the property owners asking permission to gather the said material. When the researchers had been given permission to collect the materials they collected the materials in a sack and brought it to where they conducted the experiment. The researchers also prepared utensils and materials such as big cans, thongs, pans, mortar, and pestle, measuring cups, ladle, basin, water, and cassava starch. Now that the variables or essentials are gathered and the utensils and materials are prepared the researchers are ready to conduct the experiment. The amount of each variable was followed according to Table 1. In experimenting, the first step was putting the different essentials into different cans and putting them through a roasting process. Second, when the essentials were fully roasted and burned, they transferred to the mortar and ground it using a pestle until it formed into fine biochar. while the others are grinding the essentials the others prepare the binding agent, dilute some cassava starch into water, and pour it into a heated pan continuously mixing it until it forms a paste-like substance. Third, when the biochar is finely pulverized and the binding agent is prepared, transfer both substances into a basin then start compressing both substances with each other undergoing a process called densification. If the substance is now fully densified, charcoal briquette is now achieved. However, the last step is molding the charcoal briquette into the shape of desired forms.

Statistical Analysis

All data were subjected to Mean, Standard Deviation, Analysis of Variance, and Duncan's Multiple Range Test (DMRT) at 1% and 5% levels of significance. JAMOVI software was used.

Results and Discussion

The Efficacy of Leaf Litter, Rice Hull (Oryza sativa), and the combination of Leaf Litter and Rice Hull (Oryza sativa) as charcoal briquettes in terms of boiling 2 cups of water

The data in Table 2 shows that Treatment II (rice hull) boiled 2 cups of water faster (M=410.00 s) (Sd= 171.764) compared to Treatment IV (control) (427.33s ± 175.460), Treatment III (mixed leaves and rice hull) (477.67s ± 48.170), and Treatment I (dried leaves) (547.00s ± 119.512). However, Analysis of Variance showed that no significant differences were seen in the average boiling time of the treatments. This shows that the different materials were evaluated based on their efficacy in boiling water which shows that Treatment II (rice hull) is very efficient and comparable to control. The result of the study correlates with the study of Kesmayanti and Ilmi (2023), who stated that bio-briquettes made

Table 1
Treatments and amount of each variable

Treatments	volume of water (g)	amount of starch (g)	amount of pyrolyzed sample (g)
Rice hull	80 g	20 g	100 g
Dried Leaves	80 g	20 g	100 g
Mixed	80 g	20 g	50 g + 50 g

from agricultural waste husk charcoal can be used as an alternative energy to replace petroleum and gas fuels because they have good combustion and composing power.

The Efficacy of Leaf Litter, Rice Hull (Oryza sativa), and the combination of Leaf Litter and Rice Hull (Oryza sativa) as charcoal briquettes in terms of grilling of 3 pcs of fish.

Table 3 shows that Treatment IV (control) grilled 3 pcs of fish faster (218.00s ±.000), compared to dried leaves (311.00s ± 122.976), mixed leaves (446.00s ±.000), and rice hull (459.67s ± 152.919). The different materials were evaluated based on the efficacy of grilling fish. Duncan's Multiple Range Test analysis shows that the control and dried leaves eco-charcoal are significantly more efficient compared to other treatments in terms of grilling time. Rich heat and minimal smoke are produced by charcoal, making it ideal for high-temperature searing or low-temperature grilling. Because lump charcoal burns hotter and quicker and cools down rapidly, many prefer using it for hot and fast cooking methods including rotisserie cooking and direct grilling (Ngoc, 2023). However, according to Mohamed Muhudin Ali's report from 2023, the methods employed now to produce charcoal have seriously degraded the environment, increased desertification, and reduced biodiversity.

The Efficacy of Leaf Litter, Rice Hull (Oryza sativa), and the combination of Leaf Litter and Rice Hull (Oryza sativa) as charcoal briquettes in terms of cooking rice.

Table 4 shows that the control cooked rice comparably (1010.33s ± 408.118) to mixed leaves and rice hull (1203.33s ± 510.737), rice hull (1359.33s ± 37.740) and significantly different to dried leaves (1744.67s ± 215.642). The result of the study based on Table 3 shows that the control is significantly efficient compared

Table 2

The Efficacy of Leaf Litter, Rice Hull (Oryza sativa), and the combination of Leaf Litter and Rice Hull (Oryza sativa) as charcoal briquettes in terms of boiling 2 cups of water.

Treatments	Mean (seconds)±SD
Treatment I (Dried Leaves)	547.00s ± 119.51
Treatment II (Rice Hull)	410.00s ± 171.76
Treatment III (Mixed Leaves and Rice Hull)	477.67s ± 48.17
Control	427.33s ± 175.46

Table 3

The Efficacy of Leaf Litter, Rice Hull (Oryza sativa), and the combination of Leaf Litter and Rice Hull (Oryza sativa) as charcoal briquettes in terms of grilling 3 pcs of fish.

Treatments	Mean (seconds)±SD
Treatment I (Dried Leaves)	311.00s ± 122.98^{ab}
Treatment II (Rice Hull)	459.67s ± 152.92^{b}
Treatment III (Mixed Leaves and Rice Hull)	446.00s ± .00^{b}
Control	218.00s ± .00^{a}

Values (mean±SD) with the same superscripts are not significantly different (P>0.05)

to other treatments in terms of cooking except in treatment I. The study's findings run counter to those of Brenda, Innocent, Omuna, and Abdu's (2017) investigation, which found that regardless of the heat source, charcoal was used more frequently than briquettes for brief periods of time.

This indicates that while charcoal burns rapidly, briquettes store their energy for a longer period of time, requiring more to maintain the fire. Because of their availability and better performance, briquettes are becoming more and more in demand as wood from forests.

Table 4

The Efficacy of Leaf Litter, Rice Hull (Oryza sativa), and the combination of Leaf Litter and Rice Hull (Oryza sativa) as charcoal briquettes in terms of cooking 1 cup of rice.

[14]

Treatments	Mean (seconds)±SD
Treatment I (Dried Leaves)	$1744.67s \pm 215.64^{b}$
Treatment II (Rice Hull)	$1359.33s \pm 37.74^{ab}$
Treatment III (Mixed Leaves and Rice Hull)	$1203.33s \pm 510.74^{ab}$
Control	$1010.33s \pm 408.12^{a}$

Values (mean±SD) with the same superscripts are not significantly different (P>0.05)

Conclusions

Based on the results of the study, leaf litter, rice hull, and the combination of leaf litter and rice hull as charcoal briquettes were efficient in terms of boiling water, grilling of fish, and cooking of rice. Moreover, community-based charcoal briquettes are less messy, easier to handle, compacted, and uniform in size. In addition, people in the rural community have access to the agricultural area where rice hulls and other raw materials are abundant. It was concluded that Eco-Charcoal Briquettes can be used as household cooking fuel.

Implications to Science Education

This study has several implications for science education, particularly in the areas of environmental science, sustainability, and practical applications of scientific research. Here are some key implications:

1. **Interdisciplinary Learning**:

This study exemplifies the intersection of biology (understanding leaf litter and rice hulls), chemistry (process of pyrolysis and combustion), and environmental science (sustainability and waste management). Experiments encourages an interdisciplinary approach to learning and problem-solving as it helps the constructivist mind of students (Natividad, 2022) and inclusivity in classrooms (Jardinez & Natividad, 2024).

2. **Sustainability and Environmental Education**:

The research highlights the potential of using agricultural waste to create eco-friendly charcoal, promoting sustainability. It can be used to teach students about sustainable practices and the importance of reducing waste and finding alternative energy sources.

3. **Practical Applications of Science**:

By investigating how agricultural by-products can be converted into useful materials, this study shows students how scientific research can lead to practical solutions for real-world problems. This can inspire students to think about how they can apply their scientific knowledge to address environmental issues.

4. **Experimental Design and Methodology**:

The study provides a concrete example of how to design and conduct experiments, including control of variables[1,4] data collection, and analysis. This is valuable for teaching students about the scientific method and research processes.

5. **Innovation and Entrepreneurship**:

The study can inspire students to think creatively and innovatively about how to use natural resources and waste products. It can also introduce concepts related to social entrepreneurship, where scientific research leads to products that can benefit communities and the environment.

6. Awareness of Local and Global Issues:

By addressing the use of local agricultural waste, the study helps students understand how local issues can have global implications, fostering a sense of global citizenship and responsibility.

7. Promoting Critical Thinking:

Students can critically analyze the study's findings, discuss the advantages and limitations of using leaf litter and rice hulls as charcoal briquettes, and explore other potential applications or improvements.

8. Hands-On Learning Opportunities:

The concepts explored in the study can be adapted into classroom experiments or projects where students can create their own eco-charcoal briquettes. This hands-on approach can enhance learning and retention.

9. Linking to Curriculum Standards:

The study can be linked to various curriculum standards in science education, such as those related to environmental science, renewable energy, waste management, and scientific inquiry.

Incorporating this study into science education can provide students with a comprehensive understanding of how scientific research can contribute to sustainability and environmental stewardship, while also equipping them with the skills and knowledge to tackle future challenges.

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