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Production of Biomass Briquettes Using Bio-Waste by Carbonized Process

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Keyword

Coconut Shell, Sawdust, Starch, Carbonized Coconut Shell, Carbonized Bamboo Dust, Molasses.

Abstract

Biomass briquettes are an eco-friendly and cost-effective alternative to fossil fuels, offering a sustainable solution to meet industrial and domestic energy needs. This project focuses on the production and evaluation of two distinct biomass briquette compositions: (1) Coconut Shell (60%), Sawdust (30%), and Starch (10%), and (2) Carbonized Coconut Shell (70%), Carbonized Bamboo Dust (20%), and Molasses (10%). The selected materials are abundant, renewable, and capable of delivering significant calorific values while reducing environmental pollution. The research highlights the steps involved in the carbonization process, including feedstock collection, drying, pyrolysis, and briquette formation. The resulting briquettes were evaluated for key properties such as calorific value, ash content, moisture retention, and combustion efficiency. Experimental results demonstrate that carbonized bio-waste briquettes provide a high-energy yield while minimizing environmental impact. Additionally, the process contributes to waste management by reducing landfill accumulation and greenhouse gas emissions.

The project explores the complete briquetting process, including material preparation, carbonization (where applicable), mixing, pressing, and drying. Both compositions were analysed for calorific value, combustion efficiency, ash content, and emissions to identify their suitability for various industrial applications. Composition 1 provides a moderate calorific value (~18,010 kJ/kg), making it ideal for applications such as brick kilns, textile dyeing units, and small-scale food processing. Composition 2 delivers a higher calorific value (~26,100 kJ/kg) and is suited for high-energy applications like cement kilns, metallurgical industries, and power plants.

Cost analysis, energy efficiency (kJ/₹), and environmental benefits were also evaluated to determine the economic and sustainable advantages of these briquettes. The results highlight the potential of biomass briquettes as a reliable and renewable energy source, contributing to reduced dependency on coal and other non-renewable fuels. This study reinforces the role of bio-waste utilization in achieving energy sustainability and environmental conservation.

1. INTRODUCTION

The growing energy crisis and environmental concerns have highlighted the need for renewable and sustainable energy sources. The first composition consists of coconut shell (60%), sawdust (30%), and starch (10%) as a binder. [1-8] this mixture utilizes readily available raw materials to create a solid fuel with promising calorific properties. The second composition employs carbonized coconut shell (70%), carbonized bamboo dust (20%), and molasses (10%) as a binder. [9-12] Carbonization enhances the energy density and combustion efficiency of the briquettes, while molasses serves as a sustainable binding agent. [13-18] The research aims to compare the performance of these compositions in terms of calorific value, combustion duration, ash content, and overall efficiency. [19-23].

2. USED MATERIAL DETAILS

First Composition: Coconut Shell (60%): A readily available bio-waste with high lignin content, which enhances the briquette's density and burning efficiency, Sawdust (30%): Acts as a filler material, aiding in combustion uniformity and reducing waste disposal issues, Starch (10%): A natural binder that provides structural integrity to the briquettes, ensuring durability during transportation and handling. [24-27].

Fig: 1.1 Raw Material of First Composition

Second Composition: Carbonized Coconut Shell (70%): Provides high energy density and reduces smoke during combustion, Carbonized Bamboo Dust (20%): Enhances calorific value and combustion efficiency, ensuring cleaner burning, Molasses (10%): A sustainable and low-cost binding agent that improves the briquette's structural strength and cohesion. [28-31].

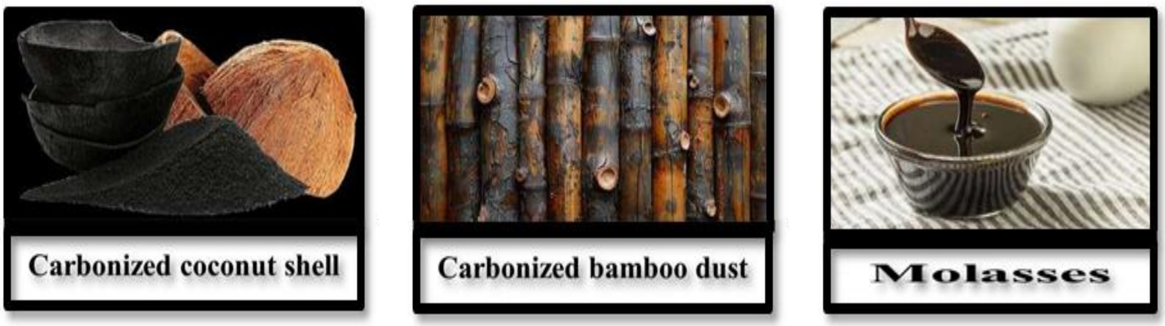


Fig: 1.2 Raw Material of Second Composition

3. OBJECTIVES & METHODOLOGY

- To develop sustainable biomass briquettes from bio-waste materials, optimizing composition and production processes for efficient energy output and durability.
- To evaluate and compare the performance of briquettes made from carbonized and non- carbonized materials in terms of calorific value, combustion efficiency, and environmental impact.

1. Collection of raw materials

Materials Used: Coconut shell, sawdust, bamboo dust (carbonized or non-carbonized).
Binding agents: Starch and molasses.

2. Preparation of moulds

Materials for Moulds: Use mild steel for its durability and ability to withstand high pressure.
Specifications:
Mould shape: Hollow cylindrical. Diameter: 30 mm
Height: 50 mm

3. Mixing and settling

Preparation:
Dry all raw materials (if not carbonized) to reduce moisture content to below 10%.
Grind raw materials (coconut shell, sawdust, bamboo dust) to fine particles for uniform mixing.

4. Compacting and drying
    - Loading the Moulds
    - Compaction process
    - Mould ejection
    - Procedure
    - Drying duration
5. Quality check

Ensure the briquettes are hard, durable, and free of cracks.

Material Selection

1. Material

Specifications Coconut
Shell:
Source: Agricultural waste from coconut processing.
Properties: High lignin content, moderate density, and calorific value around 18,000-28,000 kJ/kg (non-carbonized vs. carbonized). [32-34]
Sawdust:
Source: Wood industry by-product.
Properties: Low density, fine particle size, calorific value around 17,500 kJ/kg. [35]
Bamboo Dust (carbonized):
Source: Waste from bamboo processing.
Properties: Lightweight, high carbon content when carbonized, calorific value around 27,000 kJ/kg. [36]
Binders (Starch and Molasses):
Starch: Organic binder derived from crops, providing cohesion during briquette formation.
Molasses: By-product of sugar production acts as a binder and has a minor contribution to calorific value. [37]

2. Cost Analysis

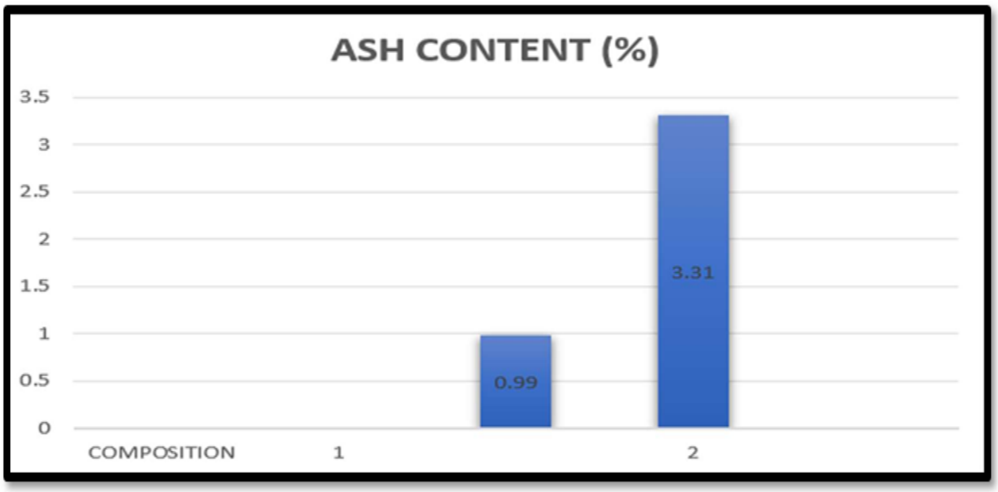
Budget	Amount
a) Materials / Consumables (coconut shell, saw dust, bamboo dust, starch, molasses)	Rs. 435
b) Fabrication of Briquettes	Rs. 205
c) Testing of Briquettes	Rs. 720
Total	Rs. 1,360

3. Why This Composition Over Others?

1. The high percentage of carbonized coconut shell (70%) ensures a dense energy source, while the carbonized bamboo dust (20%) contributes to combustion uniformity. [38]
2. Molasses (10%) acts as a cost-effective and eco-friendly binder, eliminating the need for synthetic binders. [39]
3. This specific mix provides an excellent balance between energy output, cost, and environmental benefits, making it a preferred choice for industrial and renewable energy applications. [40]

4. RESULTS AND DISCUSSION

COMPOSITION	ASH CONTENT (%)	MOISTURE CONTENT (%)	CALORIFIC VALUE (KJ/kg)
01	0.99	7.25	21776.29
02	3.31	6.92	24209.98



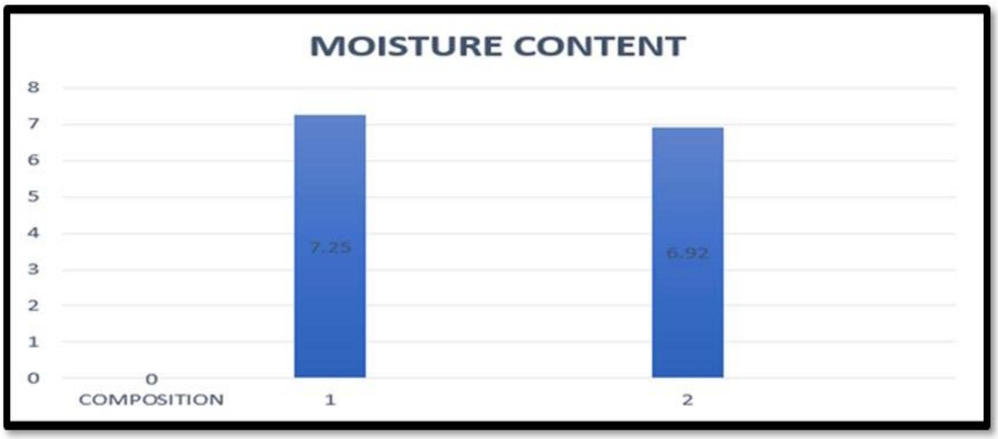


Fig: 4.1 Result and comparison graph

4.1 ASH CONTENT TEST COMPOSITION – 01

1. Weight of the sample after heating it for 1hr at 550°C = 15.902 grams [41]
2. Ash content = 15.902 – 15.881
   = 0.021 grams [42][43]
3. Ash content % = (100 x 0.021)/2.123 = 0.99%

COMPOSITION – 02

1. Weight of the sample after heating it for 1hr at 550°C = 22.930 grams [45]
2. Ash content = 22.930 – 22.817
   = 0.113 grams [46]
3. Ash content % = (100 x 0.113)/3.41= 3.31%

4.2 MOISTURE CONTENT TEST COMPOSITION - 01

1. Empty crucible weight = 15.881 grams
2. Crucible + sample weight = 18.004 grams
3. Sample weight = 2.123 grams
4. Weight of the sample after heating it for one hour at 140 °C = 17.850 grams
5. Moisture Content = 18.004 – 15.881
6. = 0.154 grams [47][48]
7. Moisture % = (100 x 0.154)/2.123 = 7.25 %

COMPOSITION - 02

1. Empty crucible weight = 12.988 grams
2. Crucible + sample weight = 15.950 grams
3. Sample weight = 2.962 grams
4. Weight of the sample after heating it for one hour at 140 °C = 15.745 grams
5. Moisture Content = 15.950 – 15.745= 0.205 grams [49][50]
6. Moisture % = (100 x 0.205)/2.932 = 6.92%

4.3 CALORIFIC VALUE TEST

COMPOSITION-01

$$\text{Formula - } CV = \frac{(Tmax+Tc)\times W-(CVt+CVw)}{M}$$

$$CV = \frac{2.25\times 2325-(21+9.32)}{1}$$

$$CV = 5200.93 \times 4.187$$

$$\mathbf{CV = 21776.29\ KJ/kg}$$

COMPOSITION-02

$$\text{Formula - } CV = \frac{(Tmax+\ \ )\times W-(CVt+CVw)}{M}$$

$$CV = \frac{2.50\times 232\ \ (\ 21+9.32)}{1}$$

$$CV = 5782.18 \times 4.187$$

$$\mathbf{CV = 24209.987\ KJ/kg}$$

5. CONCLUSION

Composition 1 (Coconut Shell 60%, Sawdust 30%, Starch 10%)

1. **Low Ash Content (0.99%):**
2. **Moisture Content (7.25%):**
3. **Calorific Value (21,776.29 KJ/kg):**

This composition is best suited for domestic and small-scale applications, such as cooking and heating, where clean and efficient energy is required. Its low ash content and decent calorific value make it a cost-effective and sustainable alternative to conventional fuels like wood and charcoal.

Composition 2 (Carbonized Coconut Shell 70%, Carbonized Bamboo Dust 20%, Molasses 10%)

1. **Higher Ash Content (3.31%):**
2. **Moisture Content (6.92%):**
3. **Calorific Value (24,209.98 KJ/kg):**

This composition is best suited for industrial applications, such as furnaces, kilns, and boilers, where high-energy output and thermal efficiency are critical. The slightly higher ash content is offset by its superior calorific value, making it a highly efficient and sustainable fuel alternative.

6. OVERALL CONCLUSION:

Both compositions have proven to be effective as sustainable alternatives to traditional fuels:

Composition 1 is ideal for domestic and small-scale applications due to its low ash content and moderate energy output.

Composition 2 is more suitable for industrial applications that require higher energy output and can manage slightly higher ash residues.

These results validate the feasibility of using bio-waste materials to produce briquettes that are eco- friendly, cost-effective, and tailored for diverse energy requirements.

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Conflict of Interest:

Authors here by declared that, there is no conflict of interest.

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