PHYSICAL CHARACTERIZATION OF BRIQUETTES COMPOSED OF CORN COB AND SAWDUST WASTE MIXTURES

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ABSTRACT

Corncobs were agricultural waste, while sawdust was waste of furniture industries. Both materials can well decomposition naturally, but it was still time-consuming. The aim of this research to provide both wastes by converting them into sustainable and worthwhile solid-fuels briquettes format. In this research, variation of mixture ratio of corn cob powder and sawdust in briquettes used was 50:50, 60:40, 70:30, 80:20, and 90:10. 1:1 ratio of tapioca starch and water was used as the adhesive to bond the briquette mixture well. Compaction process used hydraulics by 2 tons pressing load. Testing of physical characteristics includes calorific value, moisture, and ash content. The lowest calorific value was 4589.94 kCal/g, which was achieved in the 50:50 mixture of corn cob and sawdust. The highest calorific value was 6579.87 kCal/g, which was achieved in the combination of a corn cob and sawdust ratio of 90:10. The calorific value continued to increase with more mixture of corn cob. Highest moisture content was 20.00%, achieved in 50:50 combination mixture of corn cob and sawdust. Moisture content decreased as the ratio of corn cobs used in the briquettes increased, with the lowest content obtained at 8.88% using a 90:10 mixture of corn cobs and sawdust. Highest ash content on this research 16.85%, was achieved in the 50:50 combination of corncob and sawdust. Ash content also tended to decrease with the increase of corn cob powder used in the briquettes. Lowest ash content was obtained at 10.10% using a mixture of corn cob and sawdust 90:10.

Keyword: Ash content, Briquettes, Calorific value, Corn cob, Moisture content, Sawdust

1. INTRODUCTION

Sawdust and corncobs are two typical forms of industrial and agricultural waste that have attracted more attention for the potential to be utilized in sustainable applications [1]. After harvest, corncobs, the cylindrical inner core of the grain, are frequently discarded as agricultural waste. Similar to this, sawdust fine wood particles produced during the making of furniture is commonly seen as industrial waste. These waste materials can be turned into eco-friendly briquettes through procedures including compaction and binding, offering an eco-friendly substitute to conventional fossil fuels and lessening the pressure on landfills. Corncobs and sawdust debris are now a promising source for sustainable resource usage as this not only deals with waste management issues but also makes a contribution to renewable energy solutions [2] Waste solids in the agricultural sector contribute highly. Interestingly, almost all agricultural activities generate waste, whether it is easily decomposed naturally or not. These wastes are generated in large quantities. These wastes will have consequences if they are not handled. Waste utilization and waste management need to be running simultaneously [3].

Traditional solid fuels like wood and coal was replaced by briquettes, which are flexible and environmentally beneficial. These compressed chunks of biomass or charcoal have many advantages for the consumer and the environment [4]. Briquettes sustainable development is one of their main benefits as they are frequently created from renewable resources like sawdust, agricultural byproducts, or even recycled materials. Briquette make helps prevent deforestation and trash disposal problems by using waste materials. Additionally, briquettes burn very efficiently, providing more heat and less smoke as compared to loos biomass. So far, briquettes cannot be used as fuel for on powerplant feeding, because their calorific value is still far below that of coal [5]. Briquettes are very capable if used in the small-scale industrial sector, such as heating and cooking. This, makes them a good option for cleaner and more energy-efficient. Briquettes are a practical fuel source for a variety of applications, from family cooking stoves to industrial furnaces, in addition to being simple to store and carry around [6]. Several essential characteristics describe top-notch briquettes. These briquettes frequently have moisture contents below 10%, which makes for easy ignition and effective combustion. Due to their excellent density, they burn for longer periods of time and produce higher temperatures. larger calorific ratings denote a larger energy content per unit of mass. Limited binder use promotes maximum energy efficiency while low ash composition reduces residue during burning. Briquettes of high grade have a consistent, precise shape. They are suited for indoor usage because they burn cleanly and emit a pleasant aroma [7].

A research observing on briquette made of mixtures Madan wood and coconut shells. The process involved mixing crushed charcoal with cassava starch and molding them before air-drying. This research using pure Madan wood briquette, pure coconut shells, mixing Madan wood and Coconut shell with 80:20 and 50:50 ratio. Remarkably, pure Madan wood-based briquettes exhibited the highest calorific value at 6,622 Cal/g. This discovery implies that Madan wood waste could emerge as a promising and renewable resource for the production of briquettes, thereby contributing to the development of alternative energy sources [8]. In another experiment, providing effects of mixed ratios to generate briquette products, focusing on storage, transportation, and advantages associated with banana-based fuel briquettes. The investigation involved various tests to assess thermal, combustion, and mechanical properties. Notably, samples with higher ratios of banana leaves yielded less mass residue during thermogravimetric analysis and displayed calorific values ranging from 12–22 MJ/kg. Combustion analysis revealed parameters such as ash content, volatile matter, moisture content, and dry matter basis, with several samples falling within standard ranges. In terms of mechanical properties, all briquettes exhibited a compressive strength of approximately 13 MPa, meeting the standards for household heating briquettes. Among the samples, those with a higher ratio of banana leaves and banana Pseudostem [9]. One more research observing the influence of various binders at different concentrations and die pressures on the physical properties of briquettes from carbonized corncob. Binders such as cassava starch, corn starch, and gelatin were used at concentrations of 10%, 20%, and 30%, with compaction pressures of 50, 100, and 150 kPa. The results demonstrated that moisture content ranged from 4.43% to 7.62%, relaxed density of the briquettes ranged from 729 to 987 kg/m3, and compressive strength varied from 1.02 to 8.32 MPa. Higher binder concentrations and compaction pressures consistently yielded superior quality briquettes, making them suitable for storage and transportation [10]. Reported by this research,100 grams of dried corncobs have about 70 calories. Carbohydrates make up about 15-20 grams of the dried corn cobs, the second most important component. Afterward, 100 grams of 8 grams of fiber. Less than 1 gram of fat per 100 grams and a tiny quantity of protein (about 1-2 grams) can be found in dried corncobs [11]. They also include a variety of vitamins, including vitamin B6, niacin, and folate, as well as minerals like potassium and phosphorus. Complements previous research, reported that corncob containing Lignin 6%, ash1.5%, Cellulose 83.5%, dietary fiber 32%, solid acid tin-bentonite (Sn-BTN) 33,36% Raw Protein 2.8,% Lipid 0,7%, Raw Fiber 32,7% [12].

Dried sawdust typically has a moisture level of less than 10%, making it appropriate for a variety of uses. Between 40% and 50% of it is made up mostly of cellulose, which provides the main source of energy when utilized as fuel. 20% to 35% of it is hemicellulose, which adds to its combustibility. Lignin serves as a natural binder and affects combustion qualities, making about 20% to 30% of the substance. Typically, ash content is less than 1%. Protein and lipids may be present in traces, however in very little amounts. Sawdust is useful for making particleboard and animal bedding because of its fibrous structure and cellulose and lignin content.

2. RESEARCH METHODS

The materials used in making briquettes are corncob powder and sawdust. The adhesive material was a mixture of tapioca flour and distilled water. The weight of the briquettes was controlled at 55 grams. With 50 grams consisting of a mixture of corncob and sawdust. The 5 grams of adhesive material consists of tapioca starch and distilled water in a 50:50 ratio. The geometry of the briquettes in this study is cylindrical with a diameter of 30 mm and a briquette height of 150 mm. The selection of cylindrical briquettes based on this research, in this research it was reported that briquettes with cylindrical shapes were easier to ignite and were able to retain heat longer than cube shapes [3] Briquette composition is the independent variable in this research. The controlled variables are briquette geometry and adhesive composition. The independent variables are shown in Table 1. Performance of briquette on this research measure by calorific value, ash content and moisture content. The trinity performance of briquette measure using bomb calorimeter like was conducted in this research [14][15].

Table 1. Research's independent variable

Specimen	Corncob (%)	Sawdust (%)
1	*50*	*50*
2	*60*	*40*
3	*70*	*30*
4	*80*	*20*
5	*90*	*10*

In order to conduct this research, the initial phase entailed the preparation of the sawdust and corncob. The sawdust underwent processing through a mesh 20 screen, whereas the corncob was subjected to milling. Both materials were thereafter subjected to a 6-hour period of solar drying. Subsequently, the carbonisation process was conducted by exposing the materials to a temperature of 300°C for a duration of 2 hours. This method facilitated the conversion of organic resources into charcoal. The corncob and sawdust were combined after undergoing carbonisation, adhering to the specified independent variables as described in Table 1. Subsequently, the blend was subjected to compression using a hydraulic press adjusted to apply a 2-ton force. Furthermore, the briquettes were subjected to a temperature of 80°C for a duration of 5 minutes in order to guarantee their stability. In order to guarantee the excellence of the briquettes, a comprehensive quality inspection was conducted to prevent any anomalies or flaws in the end result. This encompassed the examination of briquettes for irregular or inadequately shaped structures. In addition, calorimetric experiments were performed using a boom calorimeter to ascertain the energy content of the briquettes. The test yielded crucial data on the briquettes' potential thermal energy release during combustion. Furthermore, the water content and ash content of the briquettes were also examined, in addition to the calorific test. These tests yielded information about the moisture content and the quantity of inorganic residue in the briquettes, respectively. Ultimately, the collected data underwent meticulous analysis in order to get significant conclusions and valuable insights from the research. Reseach flow sollowing flowhart diagram shown on Figure 1.

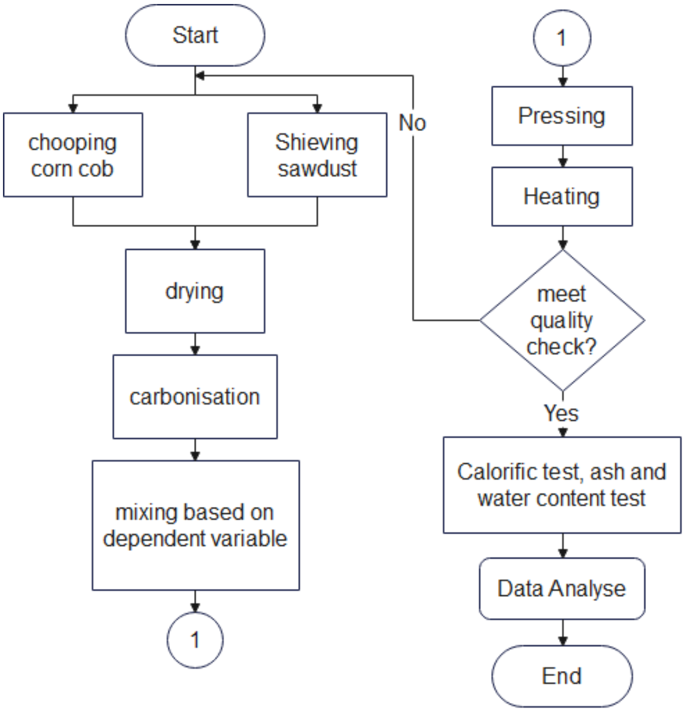

Figure 1. Research flowchart

3. RESULT AND DISCUSSION

The density of briquettes composed of a mixture of sawdust and corn cob is determined to be 0.1296 g/cm^3. While the visual appearance of the briquettes may not exhibit noticeable distinctions across different combinations, their density serves to emphasize their high level of compactness and robust structure. The uniform density of the briquettes guarantees efficient combustion and a dependable fuel supply. Moreover, the resemblance in visual characteristics suggests a unified and skillfully crafted product, hence augmenting the attractiveness of these briquettes as a substitute fuel option. The briquette shown on Figure 2.

Figure 2. Result of briquette made of sawdust and corncob

3.1 *Calorific value*

The calorific value produced continues to increase significantly with the greater amount of corn cob mixture variation employed in the solid fuel manufacturing process, as evidenced by the data presented in Table 1. This observation underscores the pivotal role that the composition of the corn cob mixture plays in enhancing the energy content of the resulting fuel. One particular note is the substantial variation in calorific values achieved across different compositions.

Table 2. Result of Calorific test

Specimen	*Corncob (%)*	*Sawdust (%)*	*Calorific Value (Cal)*
1	*50*	*50*	*4589.94*
2	*60*	*40*	*5569.83*
3	*70*	*30*	*6079.87*
4	*80*	*20*	*6358.92*
5	*90*	*10*	*6579.87*

Table 2 reveal highest recorded calorific value, an impressive 6579.87 cal/gram, was attained using a mixture primarily comprised of corn cob (90%) in conjunction with a modest addition of sawdust (10%). This outcome highlights the potential for optimizing solid fuel quality by carefully adjusting the blend of raw materials. Conversely, it's worth noting that the lowest calorific value of 4589.94 cal/gram was obtained when the corn cob mixture and sawdust were evenly balanced at a 50%:50% ratio. This result serves as a crucial data point, illustrating that the composition of the mixture can significantly impact the energy yield of the final product, further underscoring the importance of meticulous formulation in the solid fuel manufacturing process. These findings provide valuable insights for fuel production, emphasizing the potential for fine-tuning mixtures to achieve desired calorific values and energy efficiency. A higher calorific value indicates a greater energy content within the briquette, making it more efficient for heating or power generation applications. Briquettes with a high calorific value are sought after as they provide longer burn times, produce more heat, and generate fewer emissions compared to those with lower calorific values.

3.2 *Water content*

The objective of performing the water content analysis in this study is to assess the moisture content in the samples of solid fuel. The moisture content is a critical determinant that can have a substantial influence on the combustion process of solid fuels Table 3 displays the results of the water content test, offering a visual depiction of the data.

Table 3. Result of water content test

Specimen	*Corncob (%)*	*Sawdust (%)*	*Water content test (%)*
1	*50*	*50*	*20.00*
2	*60*	*40*	*20.25*
3	*70*	*30*	*18.30*
4	*80*	*20*	*12.50*
5	*90*	*10*	*8.88*

Based on data in Table 3 test indicated disparate water content percentages among distinct combinations of corn cob and sawdust. The sample consisting of 60% corn cob and 40% sawdust yielded the greatest water content of 20.25% among the mixes that were tested. This specific blend demonstrated a comparatively elevated moisture content, suggesting a possible reduced rate of combustion as a result of the heightened water concentration. Conversely, the sample containing

90% corn cob and 10% sawdust had the lowest water content of 8.88%. This combination had a comparatively lower moisture level, indicating a greater probability of accelerated and more effective burning as a result of the diminished water content. The results emphasize the importance of the composition ratio in determining the moisture content of the solid fuel. The findings offer useful insights into the prospective combustion characteristics of various mixtures, where a larger water level may result in a slower and less efficient combustion process, while a lower water content suggests a greater rate of combustion.

The water content of solid fuel significantly impacts its quality and performance. A low water content indicates a superior quality of solid fuel, rendering it more suitable for various uses. The water content of solid fuel is influenced by various factors, such as the duration of the drying process. Desiccation is crucial for reducing the moisture level in solid fuel, particularly briquettes. An enforced drying process decreases the moisture level of the fuel. Enhancing the combustion and performance of solid fuel is achieved by decreasing the water content. The water content of solid fuel is also influenced by the size of its particles. Particles with smaller sizes contain lower amounts of water compared to those with bigger sizes. Reduced-sized particles exhibit an increased surface area, hence accelerating the processes of drying and evaporation. Particles of greater size have a reduced surface area in relation to their volume, hence increasing the difficulty of water extraction. To achieve optimal solid fuel quality, it is essential to have a comprehensive grasp of both particle size and water content. Scientists have the ability to modify the distribution of particle sizes in order to achieve a specific level of water content. This regulation enhances the efficiency of solid fuel combustion to achieve increased energy generation and reduced emissions. To summarize, the quality and performance of solid fuel are contingent upon the concentration of water. A low water content is indicative of high fuel quality, and it is essential to dry the solid fuel in order to minimize its water content. The water content is inversely proportional to the size of the particles, meaning that smaller particles have a lower amount of water.

3.3 *Ash Content*

The ash content of solid fuel is a significant indicator of its quality, especially when evaluated post-combustion. A greater quantity of ash content generated signifies inferior solid fuel, while a lesser quantity of ash content implies superior solid fuel. The research involved conducting experiments to assess the solid fuel's quality by analyzing its ash concentration. The findings of these experiments are visually depicted in Table 4.

Table 4. Result of ash content test

Specimen	*Corncob (%)*	*Sawdust (%)*	*Ash Content (%)*
1	*50*	*50*	*16.85*
2	*60*	*40*	*18.30*
3	*70*	*30*	*15.30*
4	*80*	*20*	*12.50*
5	*90*	*10*	*10.10*

Table 4 indicate the sample consisting of 60% corn cob and 40% sawdust exhibited the highest ash concentration of 16.85% among the mixes that were evaluated. This specific blend demonstrated a comparatively elevated ash level, suggesting a potentially inferior solid fuel as a result of the greater quantity of residue remaining after combustion. Conversely, the sample composed of 90% maize cob and 10% sawdust yielded the lowest ash concentration of 10.10%. The mixture had a comparatively lower ash level, indicating a superior solid fuel with less residue behind after combustion. The results emphasize the importance of the composition ratio in influencing the ash concentration of the solid fuel. The findings offer useful insights into the possible combustion properties and overall excellence of the various combinations, with a reduced ash content indicating a superior solid fuel. Through meticulous manipulation of the composition and proportions of the solid fuel constituents, scientists can enhance the fuel's excellence and reduce the quantity of ash residue generated during combustion. Lowering the ash concentration is vital because it enhances combustion efficiency, decreases emissions, and improves the overall quality of the solid fuel.

The ash concentration of solid fuel is a crucial factor that impacts its quality and performance. When utilizing a combination of corn cobs and sawdust as the solid fuel, the amount of ash present generally diminishes as the proportion of corn cobs in the mixture increases. A greater quantity of corn cobs in the mixture leads to a reduced level of ash content. Conversely, decreasing the proportion of corn cobs and reducing the amount of corn cob mixed with sawdust leads to an increase in the ash content generated. Figure 4.3 clearly depicts the correlation between the ratio of maize cobs to sawdust and the resulting ash content. The results indicate that the makeup of the solid fuel blend is essential in determining the amount of ash present. An increased ratio of maize cobs in the mixture results in a decreased ash concentration, suggesting a solid fuel of potentially superior quality that leaves behind less residue after burning. On the other hand, reducing the percentage of corn cobs and increasing the quantity of sawdust in the combination leads to a higher level of ash content. Consequently, the solid fuel's inferior quality may be attributed to the augmented quantity of residue remaining post-combustion. These findings emphasize the need of meticulously regulating the composition and proportions of the solid fuel constituents. Researchers can enhance the quality of the solid fuel and reduce the ash content generated during combustion by modifying the ratio of maize cobs and sawdust in the mixture. Reducing the ash concentration is advantageous as it enhances combustion efficiency, decreases emissions, and elevates the overall quality of the solid fuel. Researchers can optimize the quality and performance of solid fuel for various applications by analyzing the connection between the mixture's composition and the resulting ash content.

4. CONCLUSION

Briquettes made from a mixture of corn cob and sawdust the phenomenon that occurs is that the mixture of corn cob and calorific value is directly proportional, while it is inversely proportional to the water content and ash content. this is in contrast to the addition of sawdust. The findings indicate that the calorific value of the solid fuel rises substantially as the fraction of corn cob in the mixture increases. A combination consisting of 90% maize cob and 10% sawdust yielded the highest calorific value of 6579.87 cal/gram. On the other hand, the lowest calorific value of 4589.94 cal/gram was achieved when using an equal proportion of corn cob and sawdust 50%:50%. These findings emphasize the significance of precisely modifying the composition of the solid fuel mixture in order to attain the intended calorific value. Higher values suggest a higher energy content and enhanced efficiency for heating or power generation purposes. An increased ratio of corn cob leads to elevated water content, whilst a decreased ratio results in reduced water content. For instance, a combination consisting of 60% corn cob and 40% sawdust demonstrated a water content of 20.25%, whereas a mixture including 90% corn cob and 10% sawdust displayed a water content of 8.88%. These findings highlight the significance of regulating the composition ratio in order to attain the most favorable moisture levels in the solid fuel. Reducing the amount of water present increases the efficiency of combustion and speeds up the burning process. An increased percentage of corn cob leads to a decreased ash content, whereas a decreased percentage results in an increased ash content. For example, when a combination of 60% corn cob and 40% sawdust was tested, it was found to have an ash concentration of 16.85%. Similarly, a mixture of 90% corn cob and 10% sawdust had an ash content of 10.10%. These findings emphasize the significance of precisely regulating the composition ratio in order to limit the amount of ash present. Lower values imply a higher-quality solid fuel that leaves behind less residue after combustion.

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