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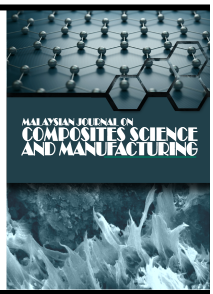

Effect of Water Content in Raw Material Mixtures on the Proximate, Physical, and Mechanical Properties of Coconut Shell Charcoal Briquettes Produced with a Screw Extruder Machine

Samsudin Anis[1,*], Ahmad Agus Khoirul Madjid[1], Faalih Labiib[1], Diva Alkmar Riadi[1], Sebastian Akbar Firmansyah[1], Febryan Pratama Putra[1], Adhi Kusumastuti[2], Deni Fajar Fitriyana[1], Aldias Bahatmaka[1], Tezara Cionita[3], Januar Parlaungan Siregar[4,5], Rozanna Dewi[6], Medyan Riza[7]

[1] Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Semarang, Kampus Sekaran, Gunungpati, Semarang, 50229, Indonesia
[2] Faculty of Engineering, Universitas Negeri Semarang, Kampus Sekaran, Gunungpati, Semarang, 50229, Indonesia
[3] Faculty of Engineering and Quantity Surveying, INTI International University, Nilai 71800, Malaysia
[4] Automotive Engineering Center (AEC), Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), Pahang, Malaysia
[5] Faculty of Mechanical & Automotive Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Pekan 26600, Malaysia
[6] Chemical Engineering Department, Malikussaleh University, Lhokseumawe 24353, Aceh, Indonesia
[7] Chemical Engineering Department, Syiah Kuala University, Banda Aceh 23111, Aceh, Indonesia

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ABSTRACT

Coconut shell charcoal briquettes offer a green and productive energy option. However, past studies have looked at single factors without exploring how water levels in raw material mixes affect briquette performance. This research aims to fill this gap by looking at how different water contents in the raw material mixture (44.9%, 46.5%, 49%, and 52.5% for Specimens A, B, C, and D) impact the quality of briquettes made with a screw extruder machine. To produce briquettes, the process involves several steps: preparing coconut shell charcoal powder, mixing this powder with a binder (5% tapioca), adjusting water content to reach the desired levels, blending the mixture thoroughly, forming the mixture using a screw extruder machine, and drying the resulting briquettes. The study used established techniques to assess proximate properties, physical characteristics, and mechanical performance (compressive strength and friability). The findings demonstrate that Specimen C, displaying a water content of 49%, showed the most favourable overall performance. The data indicates the highest fixed carbon content at 71.80%, a calorific value of 7,102 Cal/g, and a density of 0.57 g/cm³ while also showing the minimum friability at 9.43%. Conversely, Specimen D, exhibiting the highest water content at 52.5%, showed the lowest friability at 40.19% and a compressive strength of 14.58 kg/cm². The results of this study indicate that the water content of 49% significantly improves briquette quality, achieving a balance between structural integrity and combustion efficiency. This study offers essential findings on enhancing briquette production processes, creating high-quality briquettes for domestic and international markets, and supporting the sustainable use of coconut shell waste.

Keywords:
Water content; proximate; physical; mechanical

[*] *Corresponding author.*
E-mail address: samsudin_anis@mail.unnes.ac.id

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1. Introduction

Energy concerns are a primary issue for nearly every nation due to their significant economic impact. Nonetheless, despite the restrictions of conventional fuel resources, the desire for energy to achieve economic growth complicates the issues further [1]. Biomass acts as a feasible substitute for traditional energy sources. It relates to organic substances generated via photosynthesis, including primary products and byproducts. Biomass encompasses plants, grasses, trees, agricultural byproducts, tubers like yams, and animal excrement. Biomass is frequently employed as an alternative energy source, mainly from materials of negligible economic value or those deemed waste after extracting primary products [2]. Briquettes from biomass represent a growing alternative energy source, presenting numerous advantages compared to fossil fuels. They are more cost-effective, lighter, and simpler to manufacture while delivering substantial economic benefits [3–7]. The primary raw materials for briquettes are organic materials and consist of lignocellulose, a high molecular weight natural polymer with significant energy potential. This adaptability enables the use of diverse resources, as organic waste is abundantly accessible across Indonesia. Sources comprise industrial and processing byproducts and domestic trash, rendering them suitable for briquette manufacturing [8,9].

Coconut shell charcoal is widely utilized in briquette form due to its recognition as a more environmentally sustainable fuel source. The conversion of carbonized coconut shells into briquettes has been a prevalent practice for many years. Researchers have extensively examined this material because of its distinctive features and possibilities [10]. Coconut shell is the best material for producing high-quality briquettes due to its composition of K_2O, Na_2O, CaO, MgO, Fe_2O_3, Al_2O_3, P_2O_3, SO_3, and SiO_2, which are present at 45.01%, 15.42%, 6.26%, 1.32%, 1.39%, 4.64%, 5.75%, and 4.64%, respectively [11]. In addition, the coconut shells contained cellulose, lignin, pentosan, and ash at concentrations of 33.61%, 36.51%, 29.27%, and 0.61%, respectively [12]. Indonesia has exported 163,178.266 tons of coconut shell briquettes by 2022 [13]. This demonstrates the substantial profit potential of coconut shell briquette products. Moreover, this substantial export volume illustrates the economic feasibility of coconut shell briquettes and effectively manages coconut shell waste. According to their elevated energy density, less smoke emission, and reduced ash residue, coconut shell charcoal briquettes are utilized for home and industrial purposes. With the progression of international initiatives aimed at promoting renewable energy sources and mitigating environmental impacts, it has become imperative to tackle enhancing the quality and efficiency of coconut shell charcoal briquettes [14–18].

The water content of the raw material.is one of the main factors that significantly influence the quality of briquettes. The water content in the coconut shell charcoal before processing affects many essential properties of the obtained briquettes. These properties include proximate, physical and mechanical properties. Excessive water can compromise the binding process, leading to brittle briquettes with diminished energy efficiency. However, insufficient water content can diminish the material's flexibility, hindering successful briquette formation [19–22]. Several studies have been conducted to ascertain the impact of water content in raw materials on the quality of briquettes. Nurek *et al.,* [19] indicated that biomass's 10% water content produces briquettes with the best durability coefficient. Aal *et al.,* [22] indicated that an 8% water content in Ficus nitida tree can produce high-quality briquettes. Saeed *et al.,* [23] discovered that agricultural waste with a water content of 14% could generate briquettes with the highest calorific value of 17.688 MJ/kg. The results of the study conducted by Tumuluru *et al.,* [24] showed that varying the water content of the feedstock can affect the characteristics of the briquettes produced. Using particle sizes of 4.8 and 12.7 mm and water contents of 12% and 15% can produce briquettes with better density and durability. Demirel et *al.,* [25] explained that for a given compression force, the density of briquettes made from ground sunflower stalks and hazelnut shells tends to decrease as the particle size or water content increases. Larger particles create more void space, while high water content generates vapor during compression, which can interfere with compaction. In addition, the higher water content in the feedstock reduces the energy efficiency of the compaction process. This is due to the vapor generated by water, which can interfere with the compaction process and cause energy loss. Nurek *et al.,* [19] in their research, indicated that various water contents in biomass have been examined for briquette manufacture, specifically 5-10%, 8-12%, and 15-20%. The water content of raw materials for briquette manufacturing's can vary according to the biomass type and the selected production method.

The manufacturing of briquettes from coconut shell charcoal normally includes a few phases, including the transformation of coconut shell charcoal into powder, mixing (which comprises the mix of coconut shell charcoal powder, water, and adhesive), homogenizing the mixture (blending), moulding, cutting, and drying. Most investigation focuses on the adhesive type, grain size and water content of coconut shell charcoal powder on the strength and nature of the resultant briquettes. However, research specifically examining the influence of water content in the raw material mixture during the mixing phase on briquette quality is still few. This study aims to determine the water concentration in the raw material mixture during the optimal mixing process to manufacture high-quality briquettes. This study aims to examine the influence of water content in the raw material mixture during the mixing process on the quality and durability of coconut shell charcoal briquettes manufactured using a screw extruder machine. The anticipated result of this research is the delivery of theoretical advantages through scientific contributions regarding the influence of water content in raw material composition on briquette quality, alongside a reference for other studies. In practice, the findings of this investigation can function as a technical manual for enhancing the quality of briquettes, including their combustion efficiency and compressive strength. Increasing the competitiveness of products in the market, these discoveries have the potential to support renewable energy-based enterprises from an economic perspective. In addition, this research promotes using coconut shell waste as an environmentally benign alternative energy source, which has environmental benefits.

2. Material and Method

2.1 Materials

The coconut shell charcoal utilized in this study was obtained from a charcoal maker in Tuntang, Semarang, Jawa Tengah, Indonesia. This coconut shell charcoal's calorific value, fixed carbon, water content, and ash content are 7,744 kcal/kg, 73%, 15%, and 3%, respectively [26]. We used a disc mill machine to crush the charcoal into a 40-mesh powder, which served as the main ingredient for briquette production. In this study, tapioca flour acted as a binder because it produced high-quality briquettes [26,27]. Water was added until it reached the desired water content.

2.2 Specimen Fabrication and Testing

In this study, Figure 1 illustrates the briquette-fabricating procedure. The amounts of coconut shell charcoal powder and tapioca flour are 4 kg and 200 g. The deliberate coconut shell charcoal powder and tapioca flour were then positioned into a compartment, and 500 mL of water was added. The mixing method was directed using a Tekiro Hand Devices blender machine (Yogyakarta, Indonesia) at 900 rpm for 15 minutes. During the mixing, water was slowly added until the mixture achieved the predetermined water content varieties of 44.9% (Specimen A), 46.5% (Specimen B), 49% (Specimen C), and 52.5% (Specimen D). We used a digital moisture meter AR991 series, to measure the water content in the raw material mixture.

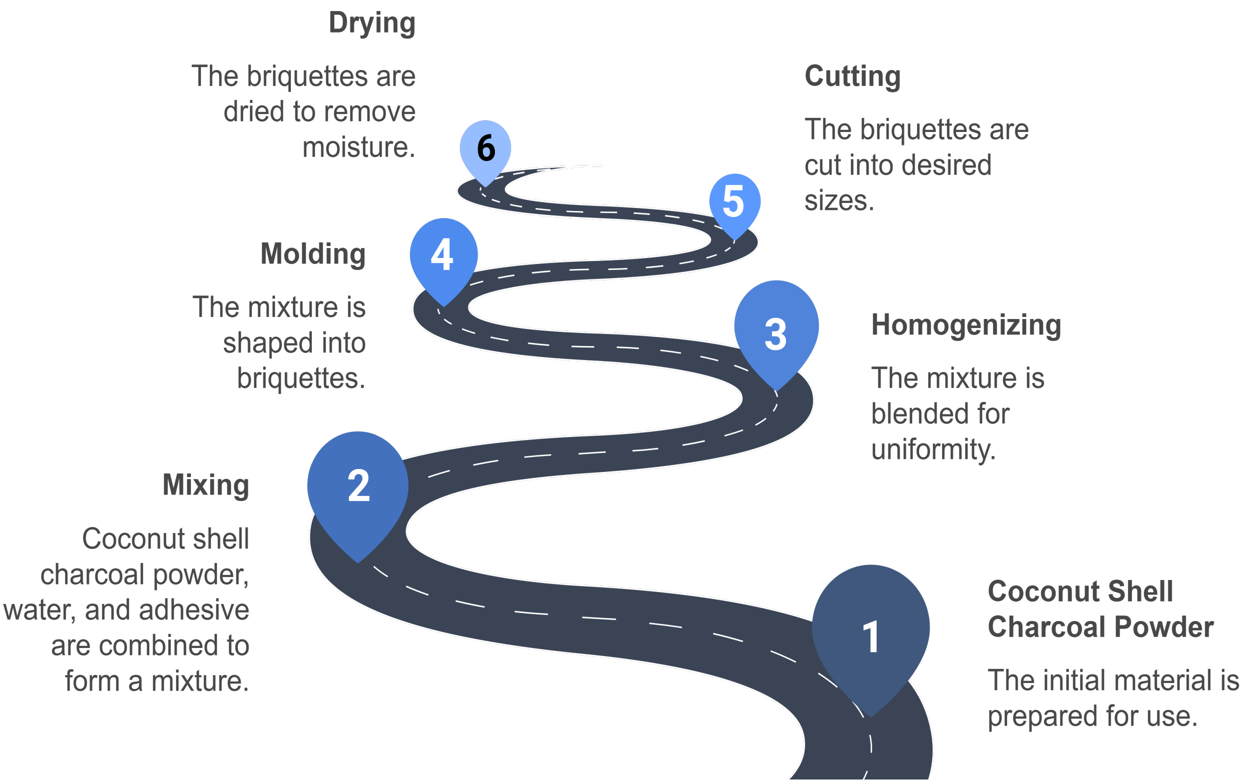

Fig. 1. Briquette fabrication process

The obtained mixture of raw materials is subsequently placed into the screw extruder machine for blending. This operation guaranteed the homogenous mix of coconut shell charcoal powder, tapioca flour, and water. The blending operation was conducted with the diesel engine running at 1650 rpm. The blending procedure is performed with three passes to ensure the raw materials are entirely homogenous. After blending, the mixed materials were formed using a screw extruder machine with a single nozzle. The diesel engine works at 1650 rpm on the moulding stage. After moulding, the briquettes were cut to desired dimensions (25 mm x 25 mm x 25 mm). The briquettes were dried for 3 hours in an oven at 110°C. The briquettes which were obtained in this study are illustrated in Figure 2.

Fig. 2. Coconut shell charcoal briquette specimens

This study utilized proximate (water content, volatile matter, fixed carbon, and ash content), density, calorific value, compressive, and drop tests to determine how the water content of the raw material mixtures influenced their briquette quality. In this study, the specimen's water content was tested by ASTM D-3173-17. Ash content testing was performed according to ASTM D-3174-12. The specimens were tested according to ASTM D-3175-17 for volatile matter content analysis. The fixed carbon content was evaluated according to ASTM D-3172-13. Moreover, the caloric value was determined according to ASTM D-240. The briquettes were subjected to density testing with ASTM B-311-17. The drop test was performed by dropping from 1.83 m height of coconut shell charcoal briquettes to a hard surface. Briquettes produced were subjected to a drop test to ascertain their dimensional stability. This examination corresponds to ASTM D-440-07 R02. The compressive test assesses the material's strength capacity under applied pressure. Compressive testing is conducted by positioning the specimen on a universal testing machine and applying pressure until deformation occurs on the briquette, maintaining a steady pressure within the range of 4 kg/cm² per second. We performed each test three times and subsequently calculated the average. Subsequently, the Indonesian standard (SNI 01-6235-2000) was employed to evaluate the result of each test. It is crucial to guarantee that the coconut shell charcoal briquettes obtained in this investigation align with the applicable regulations.

3. Results and Discussion

3.1 Proximate Analysis of Coconut Shell Charcoal Briquettes

The results of water content measurement for the briquette specimens are shown in Figure 3. A, B, C and D specimens have 3.83%, 4.68%, 2.91% and 3.18% water contents, respectively. The results generated claim that all the specimens meet the SNI 01-6235-2000, with the provisions that the water content in briquettes be less than 8%. On the other hand, this research study concluded that increasing the amount of water in the raw material mixture would not significantly affect the briquettes' water content. The water content directly impacts the quality of the produced briquettes. Briquettes with a lower water content possess a higher calorific value and are combustible, conversely.

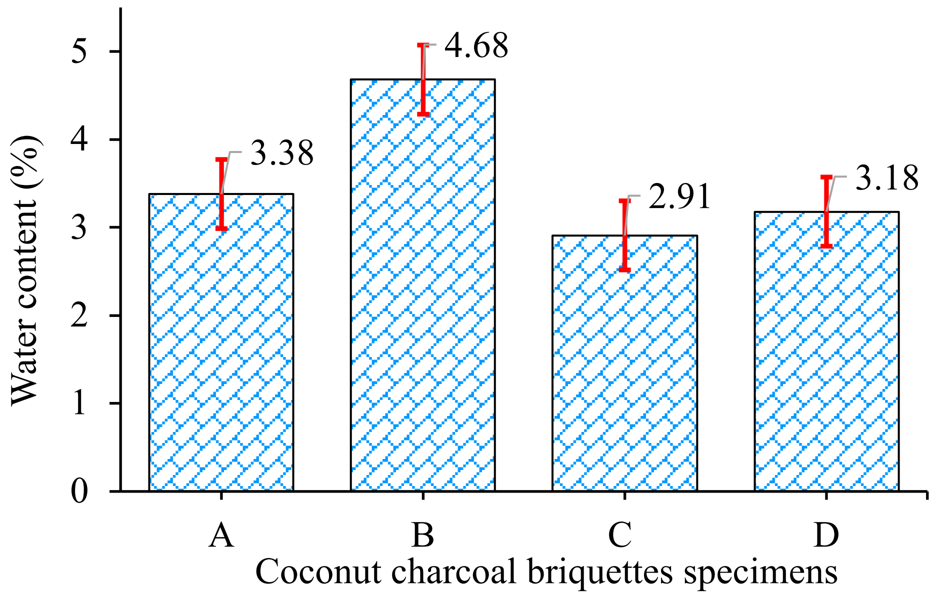

Fig. 3. Water content of the briquette specimens

The water content achieved in this study is lower than that reported by Sunardi *et al.,* [28]. They found that the water content of agricultural waste-derived charcoal briquettes was between 6% and 8.9%. They determined that a decreased water content makes the briquettes more combustible while an increased water content makes them less flammable. These results are similar to our study, in which briquettes made with low water content tend to have high calorific values and better combustibility. In comparison, those with elevated water content demonstrate lower calorific values and reduced combustibility. The water content of durian skin briquettes produced by Sitogasa *et al.,* was higher than that obtained in the present study. Specifically, Sitogasa *et al.* [29], reported a 5% to 9% water content range for briquettes made solely from durian skin. On the other hand, briquettes made from mixed durian skin and coconut shell had moisture content between 4.2% and 7.7%. Researchers explain that the water content of briquettes has a key impact on their quality; optimizing this content increases their calorific value and combustibility. High moisture levels in these briquettes can lead to longer ignition and lower combustion temperature.

According to Nurba *et al.,* [30], the water content of briquettes plays a significant role in their heating value; the lower the water content in briquettes, the higher the heating value. In their study, the water content of wood charcoal briquettes was lower than that of corncob briquettes, documented as 3.4% and 3.8%, respectively. The difference between the recovery is that, during the drying process, the water contents within the corncob particles are not eliminated altogether. The water content affects the ease of combustion of the briquette since a lower water content makes it easy to burn due to its higher calorific value, which is inversely proportional to the moisture content.

The ash content measurement results for the briquette specimens are demonstrated in Fig. 4. The ash content of specimens A, B, C, and D was 5.43%, 1.61%, 2.17%, and 1.70%, respectively. Specimen B exhibited the lowest ash content at 1.61%, whereas Specimen A recorded the highest at 5.43%. Specimen B exhibited the lowest ash content at 1.61%, whereas Specimen A reported the highest at 5.43%. All specimens obtained in this study fit the SNI 01-6235-2000 standard for ash content, which requires that ash levels remain below 8%. Ash content represents the unburned minerals that persist after the combustion of briquettes. Elevated ash content can adversely affect briquette quality by reducing its calorific value, decreasing energy efficiency and impairing combustion performance [31].

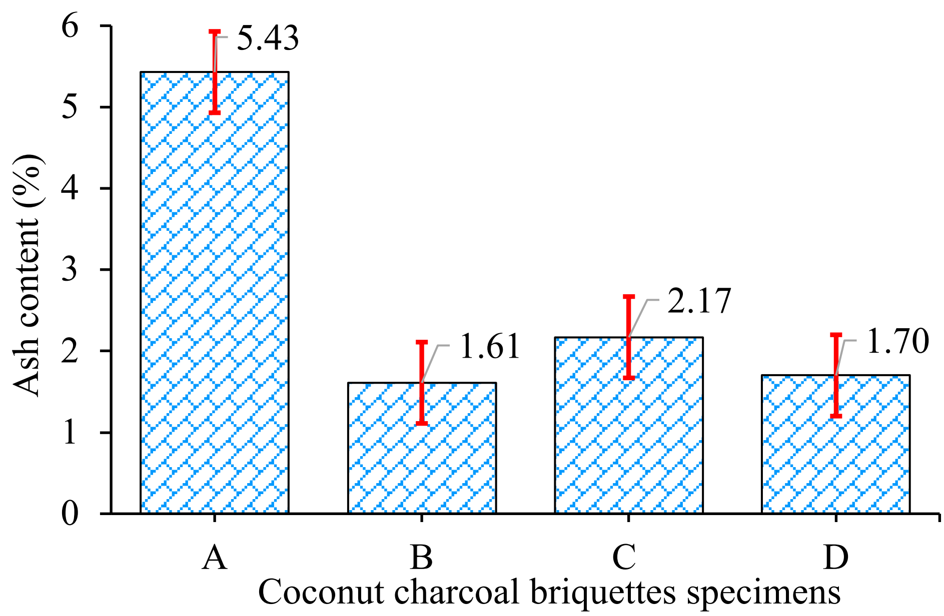

Fig. 4. Ash content of the briquette specimens

The ash content identified in this study is inferior to that recorded by Ajimotokan *et al.,* [32] who generated fuel briquettes from charcoal particles and sawdust agglomerates, exhibiting ash contents between 1.4% and 6.0%. Their findings reveal that increased ash content in fuel briquettes correlates with a higher quantity of combustion leftovers yet leads to a diminished heating value. Solid fuels' ash content substantially impacts the diffusion of oxygen and heat to the fuel surface during combustion. Consequently, an inordinate amount of ash in solid fuels is detrimental to the proper combustion process. This study aligns the findings of Kipngetich *et al.,* [33] who assert that increased ash contents lower the calorific value of fuels and impair combustibility due to enhanced thermal resistance, resulting in decreased heat transmission within the fuel bed. The ash content of briquettes derived from tannery solid waste by Oyelaran *et al.,* [34] varied between 2.41% and 5.01%. Their investigation indicates that ash content significantly affects briquettes' burning rate and ignition time. An increased ash concentration in fuel is associated with a diminished calorific value, as it obstructs the combustion rate by reducing heat transmission to the fuel's interior and impeding oxygen diffusion to the briquette surface during burning. Furthermore, Oyelaran *et al.,* [34] asserted that the allowable ash content in solid fuels must be below 4%.

Figure 5 presents the volatile matter content of the briquette specimens. The volatile matter content in specimens A, B, C, and D was 26.72%, 24.79%, 23.12%, and 22.06%, respectively. Specimen D exhibited the lowest volatile matter content at 22.06%, whereas Specimen A demonstrated the highest at 26.72%. The results demonstrate that all briquette specimens higher than the SNI 01-6235-2000 standard for volatile matter, which states that volatile content must not exceed 15%. According to Inegbedion, Francis, [35] briquettes with 10% to 25% volatile matter are deemed high quality. Furthermore, a study by Anis *et al.,* [26] revealed that commercial coconut charcoal briquettes designed for international commerce contain a volatile matter level of only 17.25%. Moreover, they indicated that the criteria set by Japan and the United States allow volatile matter contents of 15% to 30% and 19% to 28%, respectively.

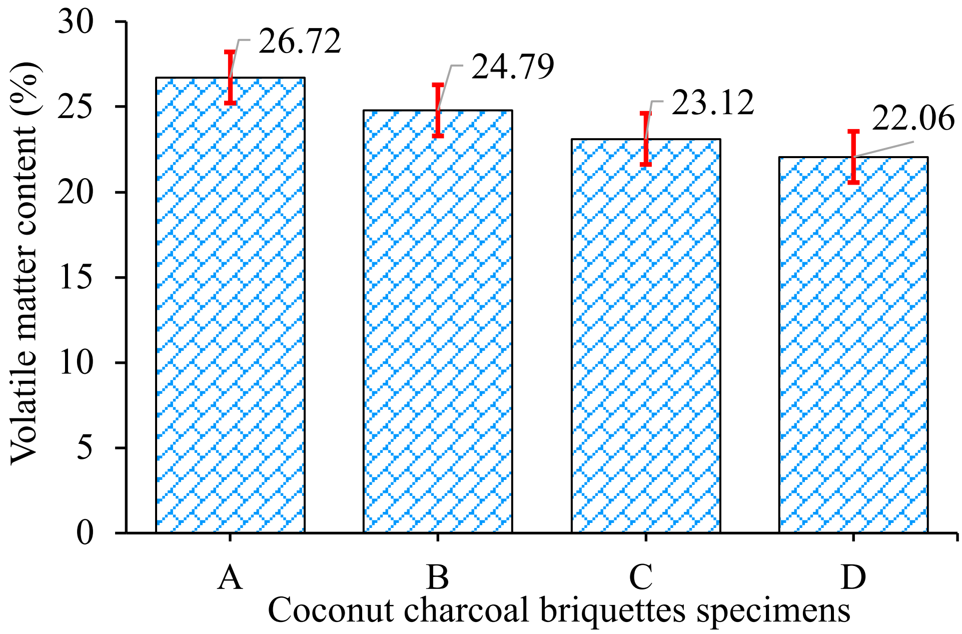

Fig. 5. Volatile matter of the briquette specimens

The results obtained in this study are consistent with those reported by Yuliah *et al.,* [36]. They found that briquettes made from rice husk and coconut shell charcoal exhibited a volatile matter content ranging from 21.70% to 25.61%. Specifically, the lowest volatile matter content of 21.70%

was achieved in briquettes composed of a balanced mixture. In comparison, the highest volatile matter content of 25.61% was observed in briquettes with a composition of 20% rice husk and 80% coconut shell charcoal. Elevated volatile matter content might adversely affect the combustion characteristics and overall energy efficiency of briquettes. Elevated volatile content may cause incomplete combustion, resulting in diminished calorific values and increased emissions of volatile organic compounds [37].

Specimens A, B, C, and D have a fixed carbon content of 64.02%, 68.85%, 71.80%, and 73.06% respectively as shown in Figure 6. Specimen A shows the lowest fixed carbon content, while the highest fixed carbon content was found in Specimen D. The results demonstrate that all briquette samples meet the Japanese criteria for fixed carbon content, which requires a minimum of 60% [26]. The fixed carbon content is essential in assessing the heating value of briquettes during combustion. Increased fixed carbon content is directly associated with enhanced calorific values, improving the briquettes' energy generation and overall performance. The fixed carbon content obtained in this study is higher than the research conducted by Sundari *et al.,* [38] and Lestari *et al.,* [39]. Specifically, in their studies, briquettes produced from Kenari's Charcoal exhibited fixed carbon contents ranging from 55.90% to 67.50% [38]. In contrast, briquettes made from Corncob Charcoal and Sago Stem demonstrated between 70% and 73% fixed carbon contents [39]. Furthermore, the fixed carbon levels achieved in this study are consistent with previous research findings [26], where coconut shell charcoal briquettes exhibited fixed carbon contents in the 69% to 78% range. However, compared to commercial coconut shell charcoal briquettes intended for global trade, the fixed carbon content achieved in this study is relatively lower. Commercial briquettes for the worldwide market possess fixed carbon levels exceeding 80% [26].

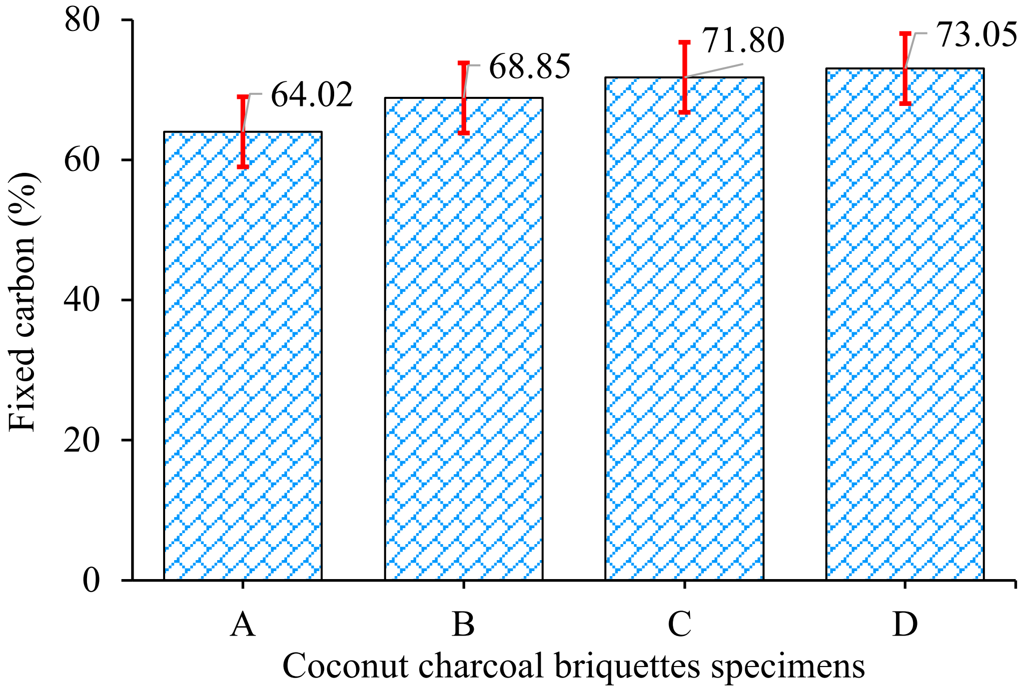

Fig. 6. Fixed carbon content of the briquette specimens

The outcomes of this research show that as the water content level in the raw material mixture increases, the briquettes' fixed carbon content also increases. This condition occurs because the level of volatile matter has decreased due to the addition of water content. Reduced volatile matter typically correlates with increased fixed carbon, as these components are proportionally interrelated

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in briquette composition [26]. An increased fixed carbon content indicates enhanced briquette quality, as fixed carbon directly influences calorific value and combustion efficiency. Briquettes with elevated fixed carbon content generate more energy during combustion, have extended burning durations, and produce less ash residue than those with lower fixed carbon content [40,41].

3.2 Calorific Value Analysis of Coconut Shell Charcoal Briquettes

The calorific values of specimens A, B, C, and D are 6,192 cal/g, 7,034 cal/g, 7,102 cal/g, and 7,103 cal/g, respectively (Figure 7). Specimen A showed the lowest calorific value, while the highest calorific value was found in Specimen D. All briquette specimens produced in this study produced calorific values that exceeded the SNI 01-6235-2000 standard (minimum calorific value of 5,000 cal/g). In addition, the calorific values derived in this study are comparable to those reported by Hersztek *et al.,* [42] who noted that the compositions of raw materials influence fluctuations in calorific values. The study's findings demonstrate that increased water content in the raw material mixture from Specimen A to Specimen C resulted in an elevation of calorific value. This increase is primarily due to the rise in fixed carbon content, which is crucial in determining the energy production of briquettes by directly influencing their calorific value. Nevertheless, as the moisture content in the raw material mixture escalated from Specimen C to Specimen D, the calorific value stayed comparatively constant. The observed stability is probably attributable to the carbon content in Specimens C and D, which exhibit no significant differences. This study corroborates the findings of Arellano *et al.,* [43] who indicated a favourable correlation between fixed carbon content and calorific value. An elevated fixed carbon concentration directly enhances calorific value, as fixed carbon is the principal energy source during combustion.

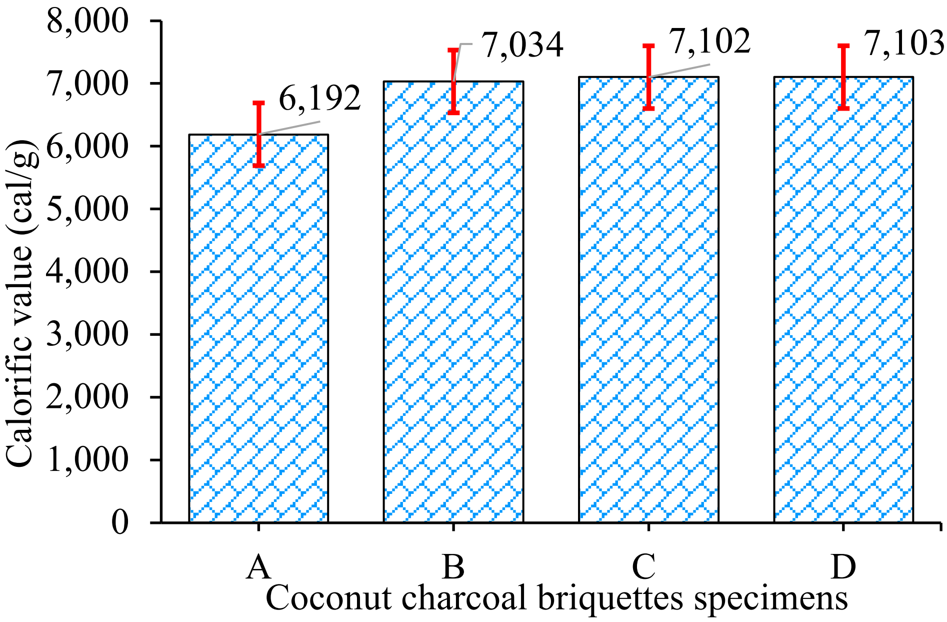

Fig. 7. Calorific value of the briquette specimens

The calorific value established in this study is less than the findings of Prihatin *et al.,* [44], which reported a maximum calorific value of 7,158.9 cal/g for briquettes manufactured from coconut shell as raw material and Styrofoam as binder. However, the calorific value obtained from this study is higher than that of briquettes made from rice husk and jatropha pulp. According to Suryaningsih *et al.,* [45], the caloric value of briquettes made using rice husk and jatropha pulp ranges from 4,776 to

5,650 cal/g. The calorific values obtained from this study, particularly concerning Specimens B, C, and D, also correlate with previous research, which posits that the calorific value of coconut shell charcoal briquettes would range from 7000 to 7200 cal/g [26].

3.3 Physical and Mechanical Properties of Coconut Shell Charcoal Briquettes

The density test results are presented in Figure 8. In terms of density measurement, specimens A, B, C and D measured at 0.55 g cm^3, 0.54 g cm^3, 0.57 g cm^3, and 0.55 g cm^3, respectively. Specimen B was recorded to have the least density at 0.54 g/cm3, whereas the greatest density at 0.57 g/cm3 was recorded with specimen C. It can be concluded, that all briquette samples have passed SNI 01-6235-2000 with the requirement of having a minimum of 0.44 g/cm^3 density. The combustion characteristics of briquette specimens are affected based on density. In addition, higher density causes the briquettes to burn better, and last longer [46]. The findings of this study demonstrate that Specimen C possesses the lowest water content among the briquette specimens, yielding the maximum density relative to the others. This result underscores the correlation between water content and briquette density, wherein reduced water content facilitates superior particle compaction, resulting in enhanced density. Increased density improves briquette quality by enhancing structural integrity and combustion efficiency, rendering it a more effective and dependable fuel source. Nurek *et al.,* [19] found that the maximum briquette density of 1215 kg/m^3 was attained by compressing material with 10% water content at a temperature of 73°C. On the other hand, material with 20% water content compacted at 22°C had the lowest density, 799 kg/m^3. The researchers determined that maximum briquette densities were consistently achieved, with materials exhibiting a minimal water content of 10%. This finding corresponds with the study's results, indicating that reduced water content in the briquette correlates with increased briquette density. According to Cabrales *et al.,* [47] moisture content influences briquette density 2.8 times more than fiber length. Moisture content directly influences the intensity of bonding structures among biomass fibers, particularly by activating lignin and facilitating the plasticization of densified biomass. Lignin functions as a natural binder in the densification process, with optimal moisture levels facilitating its activation, resulting in enhanced bonding between fibers and increased briquette density.

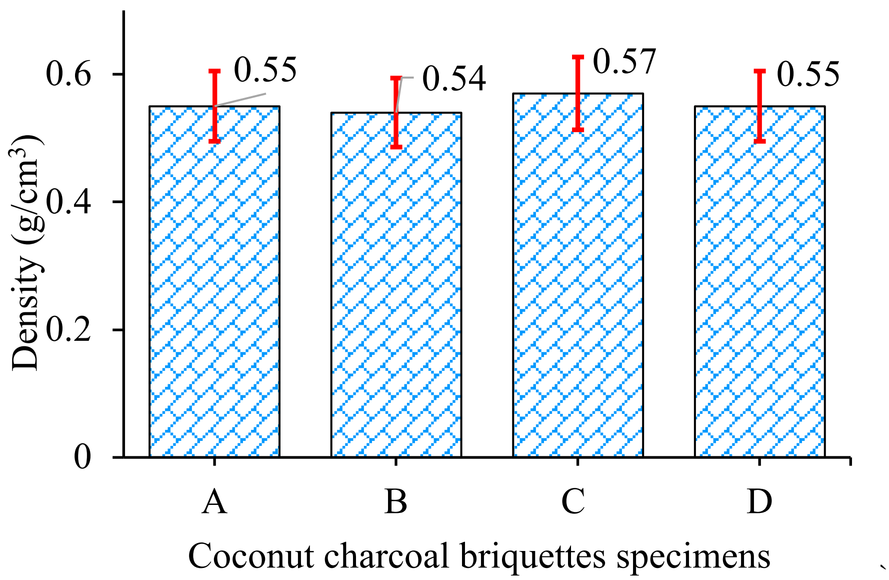

Fig. 8. Density of the briquette specimens

In Figure 9, the compressive strength of the briquette specimens prepared from the raw materials with different water content can be observed. The compressive strength of Specimens A, B, C and D was 13.66, 24.88, 19.06 and 14.58 kg/cm², respectively.

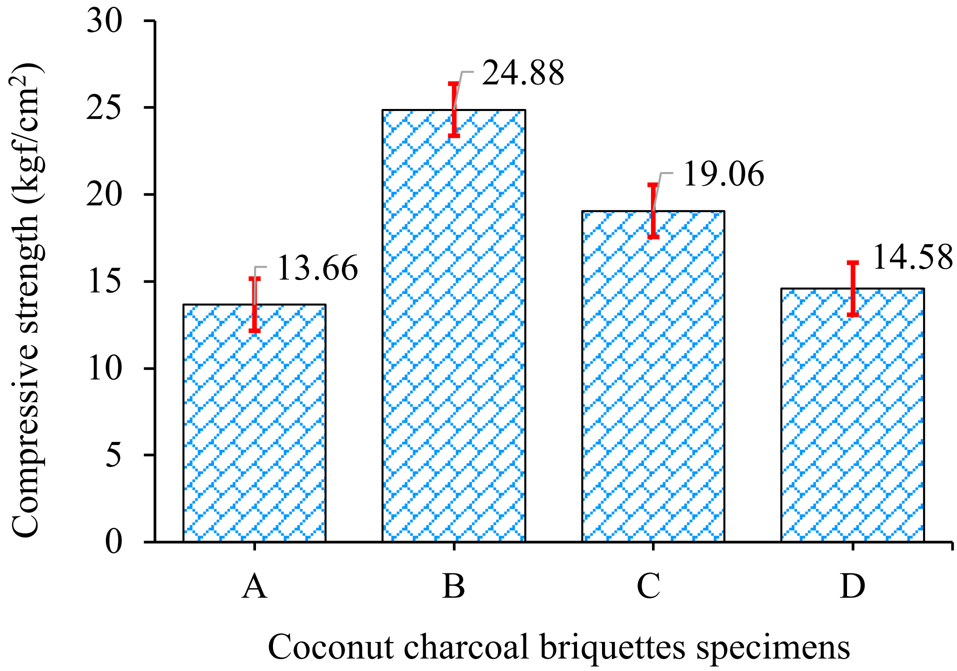

Fig. 9. Compressive strength of the briquette specimens

Compared to the other specimens, Specimen A compressive strength was lowest at 13.66 kgf/cm², in contrast, Specimen B was the highest at 24.88 kgf/cm². The results show that all specimens do not meet the standard compressive strength of 32 kgf/cm² required for commercial briquettes traded in the world [26]. The findings of this study reveal that only Specimen B exhibits compressive strength approaching that of commercial products. On the other hand, the compressive strength obtained in this investigation surpasses that of Pramudia *et al.,* [48], Nasbey *et al.,* [49], and Ansar *et al.,* [50]. For instance, the compressive strength of briquettes composed of a blend of teak leaf and maize cob was the highest at 135.82 N/cm² (13.85 kgf/cm²) [48]. Likewise, coconut shell briquettes that used tapioca flour as a bonding adhesive reached a maximum compressive strength of 16.62 kgf cm² [49] while other coconut shell briquettes had a compressive strength of 12 kgf cm² [50].

The drop test results on the briquette specimens in completely burned conditions are presented in Figure 10. The drop test method and friability calculations for the briquette specimens were conducted based on the methodology outlined in a previous study. The friability values of specimens A, B, C, and D were 16.95%, 35.8%, 9.43%, and 40.19%, respectively. Specimen C exhibited the lowest friability, with a friability value of 9.43%, whereas Specimen D showed the highest friability at 40.19%. These findings indicate that Specimen C surpasses the friability standards for commercial briquettes (15.05%), showcasing excellent durability [26]. In contrast, Specimens A, B, and D did not fulfil the commercial product standards. Friability is a critical quality parameter, as it directly impacts the briquettes' durability during handling, transportation, and combustion. A lower friability value reflects better quality, indicating stronger resistance to mechanical stress and reduced risk of fragmentation [51]. The results of this study demonstrate that Specimen C exhibited the best friability performance, attributed to its low water content compared to the other specimens. A lower water content in briquettes enhances the Impact Resistance Index (IRI), reducing friability. These findings are consistent with the study conducted by Mkini *et al.,* [51] which highlighted the significant influence of moisture content on the friability and combustion properties of briquettes. Their research reported that briquettes with higher moisture content exhibited an IRI range of 55 to 71, whereas briquettes with lower moisture content achieved a much higher IRI, ranging from 80 to 160. The friability test performed by Gebresas *et al.,* [52] indicated that 85.2% of the briquettes remained intact, whereas 14.8% were observed as flakes and powder. The test was conducted by placing 250 g of briquettes into a plastic bag and releasing them from a height of 2 meters onto a concrete surface, with five repetitions performed. The friability of briquettes derived from Kenyan biomass was measured at 48% using the same testing method. Similarly, the friability of briquettes produced from Macadamia nut shells was evaluated. Seventy-six per cent of the Macadamia nut shell briquettes maintained their integrity, representing the highest value achieved in the study.

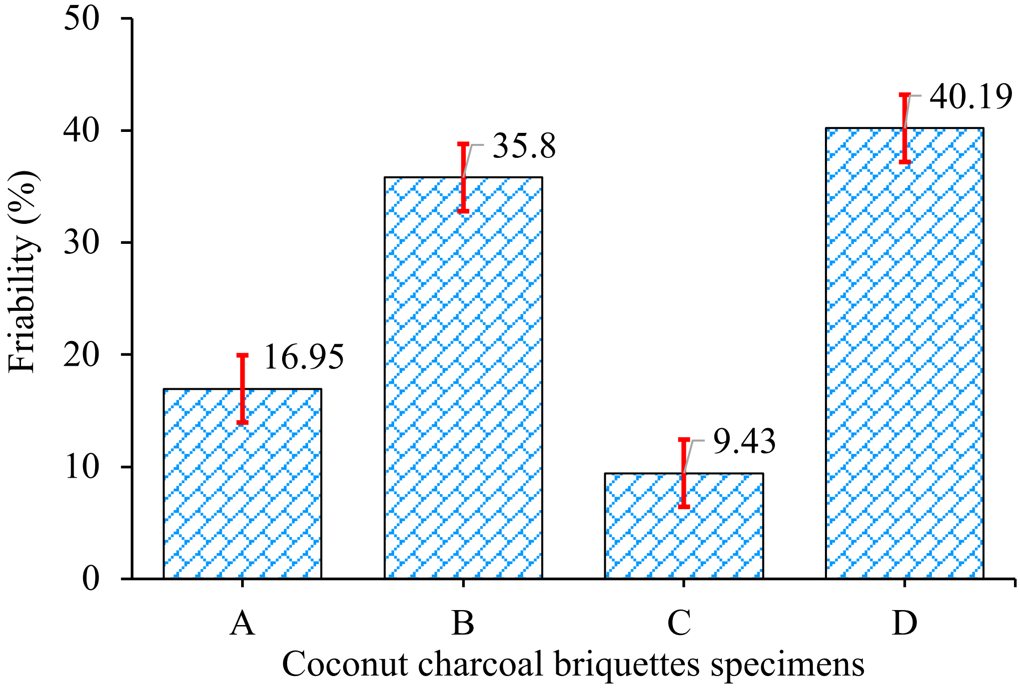

Fig. 10. Friability of the briquette specimens

4. Conclusion

The study examines the influence different levels of water content in raw material mixtures have on the proximate, physical, and mechanical properties as well as the calorific value of coconut shell charcoal briquettes made with a screw extruder machine. In this study, the amount of water in the raw material mixture of Samples A, B, C, and D are set to 44.9%, 46.5%, 49% and 52.5%, respectively. The results provide important insights into the effects of water content on briquette quality, establishing groundwork for briquette production confined to commercial and international specifications. The findings indicated that all specimens complied with the SNI 01-6235-2000 standard for water content, with Specimen C exhibiting the lowest moisture level at 2.91%. The findings indicated a positive relationship with enhanced briquette quality, showcasing an increased fixed carbon content of 71.80% and a reduced volatile matter level of 23.12%, which conforms to global standards for high quality briquettes.

Furthermore, Specimen C demonstrated exceptional characteristics, with a calorific value of 7,102 cal/g and a density of 0.57 g/cm³, exceeding the established minimum standards. Moreover, Specimen C demonstrated outstanding friability, achieving a value of 9.43% that surpassed commercial standards for coconut shell charcoal briquettes. Specimen B exhibited the highest compressive strength at 24.88 kg/cm^2, while Specimen C also showed notable mechanical durability with a 19.06 kg/cm^2 compressive strength. Specimen C, exhibiting a 49% water content in the raw material mixture, showcased the most favourable overall performance, establishing it as a standard for sustainable energy solutions and the effective use of coconut shell waste in briquette production.

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