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Research article

COMPARATIVE STUDIES ON THE COMBUSTION PERFORMANCE OF BRIQUETTES PRODUCED FROM SELECTED BIOMASS RESIDUES IN MAIDUGURI

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ABSTRACT

With the increase in demand and over dependence on fossil fuel, the improper utilization of agro-residues in many developing countries gives rise to environmental pollution. In this study, biomass residue briquettes were produced and utilized in order to ascertain their combustion performances. Waste agricultural biomass converted into energy resource and the relationship between different combustion parameters were investigated. Within a time frame, a known amount of water was boiled by burning the briquettes produced from sawdust, rice husk and groundnut shell residues in a combustion chamber. The briquette fuels were produced with varying compression pressure of 40, 50, 60, 70, 80 and 90kN/m^2 respectively. Starch gel was used as a binder. From the experiments, the burning rates, percentage heat utilized and power output of Sawdust and Groundnut shell briquettes increased up to 0.000213 kg/s, 35%, and 3.25kJ/s respectively. The specific fuel consumption of Sawdust, Rice husk and Groundnut shell decreased up to 0.144 (kg fuel/kg water). In terms of burn rate, specific fuel consumption and power output, sawdust and Groundnut shell briquettes make a better fuel. Rice husk briquettes are recommended in terms of percentage heat utilized.

Keywords: Biomass, Briquette, Groundnut shell, Rice Husk, Sawdust

INTRODUCTION

Many of the developing countries produce huge quantities of agro residues but they are used inefficiently causing extensive pollution to the environment [1]. With the current demand and over dependence on fossil fuel, the improper utilization of agro-residues in many developing countries results in environmental pollution. Hence, there is need to convert the agro-waste into energy. Energy is considered the basis for the progress and prosperity of nations and societies [2]. Hence, the need for the development of alternative energy sources has become paramount so as to curtail such problems.

One of the promising solutions to the problems of unutilized agricultural residues and saw dust is the application of briquetting technology [3]. The technology may be defined as a densification process for improving the handling characteristics of raw materials and enhancing volumetric calorific value of the biomass [4]. Indeed, agricultural residues in their raw state are often bulky and difficult to handle and in combustion they often burn fast and are smoky [5]. Densification of the material results in marked improvement in combustion characteristics compared with loose bio-waste [6]. Biomass is the fourth largest source of energy worldwide and provides basic energy requirements for cooking and heating of rural households in developing countries [7].

Briquettes production thereby, turns the biomass waste materials into fuel source [8]. In developed countries biomass is used mainly for space heating and power generation [2]. In developing countries biomass is the most significant source of energy for the three quarters of the world's population who live in them [9]. Biomass contributes about 12% of world's total primary energy supply [10].Bio energy is the energy resulting from the use of biomass as fuel or feedstock to produce heat, electricity, liquid and solid fuel. Nearly half the world's populations, almost all in developing countries cook using biomass solid fuels, predominantly wood [11, 12, and 13]. Briquettes have advantages over fuel wood in terms of greater heat intensity, cleanliness, convenience in use, and relatively smaller space requirement for storage [14, 15]. Therefore, the aim of this work is to compare the combustion performance of briquettes produced from selected biomass residues in Maiduguri.

MATERIALS AND METHODS

Sample Collection

The sample used for the work which are Sawdust, rice husk and Groundnut shell residues were sourced from their various waste dump areas around Maiduguri Metropolis, Borno state North-Eastern Nigeria. The materials collected were screened of all external materials like dirt, stones, and sand. After the sorting for dirt and impurities, the groundnut shell was ground using a grinder to a similar size to that of saw dust and rice husk.

Briquette Production

Starch was used as the binder in this study. The prepared starch binder was added to each of the samples. Then the mixture of the binder and the residues was stirred rigorously to ensure a proper mix. A mould (15 cm height, 10 cm diameter) was used in producing the biomass briquettes. The binder/residue mixture was fed into the lower part of the mould. The upper part of the mould was assembled, and the mould was placed in the space between the upper plate and the lower plate of the compression machine and compressed at pressure of $40kN/m^2$, $50kN/m^2$, $60kN/m^2$, $70kN/m^2$, $80kN/m^2$ and $90kN/m^2$. Briquettes were produced while varying the compression pressure for the same particle size the briquettes were ejected after holding time of 5 minutes is observed.

Figure 1: Groundnut Shell Briquette

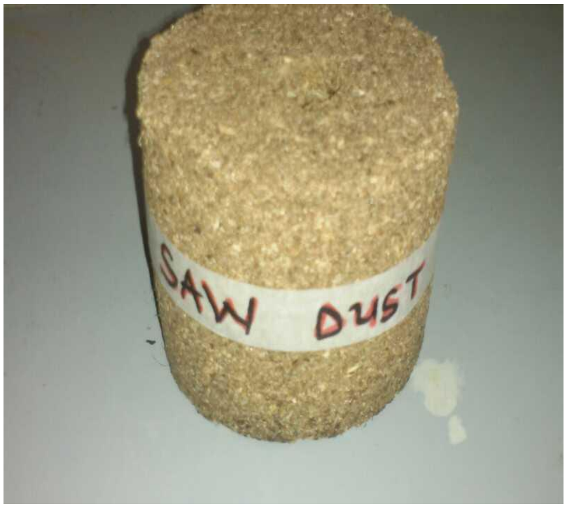

Figure 2: Saw Dust Briquette

Figure 3: Rice Husk Briquette

Combustion Experiment

In this study, the performance of biomass briquette fuel in a combustion chamber was carried out. The water boiling test was implemented to replicate cooking conditions when briquette fuel is utilized. The combustion performance of each briquette produced was recorded. Tables for the combustion parameters were made to determine the best or optimum condition for the production of briquette and to ascertain the combustion performance of each of the briquette. The effects of the varying compression pressure were considered.

Percentage Heat Utilized

This is otherwise known as thermal efficiency or energy:

$$P.H.U = \left(\frac{m_w \, c_p \, (T_b - T_o) + m_c \, L}{m_f \, E_f} \right) \times 100 \text{ ....(1.1)}$$

The numerator gives the net heat supplied to the water, while the denominator gives the net heat liberated by the fuel.

Power Output

This determines the available amount of energy released from the fuel in a given time.

$$P = (m_f \times E_f)/t............(1.2)$$

Specific Fuel Consumption

This is defined as the amount of solid fuel equivalent used in achieving a defined task divided by the weight of the task. It can be expressed as:

$$S.F.C = m_f / m_w............(1.3)$$

Burning Rate

This determines the rate at which a certain mass of fuel is combusted in air. It can be evaluated as:

$$B.R = m_f / t............(1.4)$$

Where:
P.H.U = Percentage Heat Utilized (%); P = Power Output (KW); S.F.C = Specific Fuel Consumption (kg of fuel/kg of water); B.R = Burning Rate (kg/s); Mw = mass of water in the pot (kg); T_O = Initial temperature of water (K); T_b = Boiling temperature of the water (K); Mc = mass of water evaporated (kg); L = Latent heat of evaporation (KJ/kgmol); Mf = Mass of fuel burnt (kg); E_f = Calorific value of the fuel (KJ/kg); t = time taken to burn fuel (s).

RESULTS AND DISCUSSION

Results

The results obtained from the experimental work of this project are presented in the Figures 4, 5, 6, and 7. The figures include results for the combustion characteristics for each of the briquettes produced from the different biomass residues.

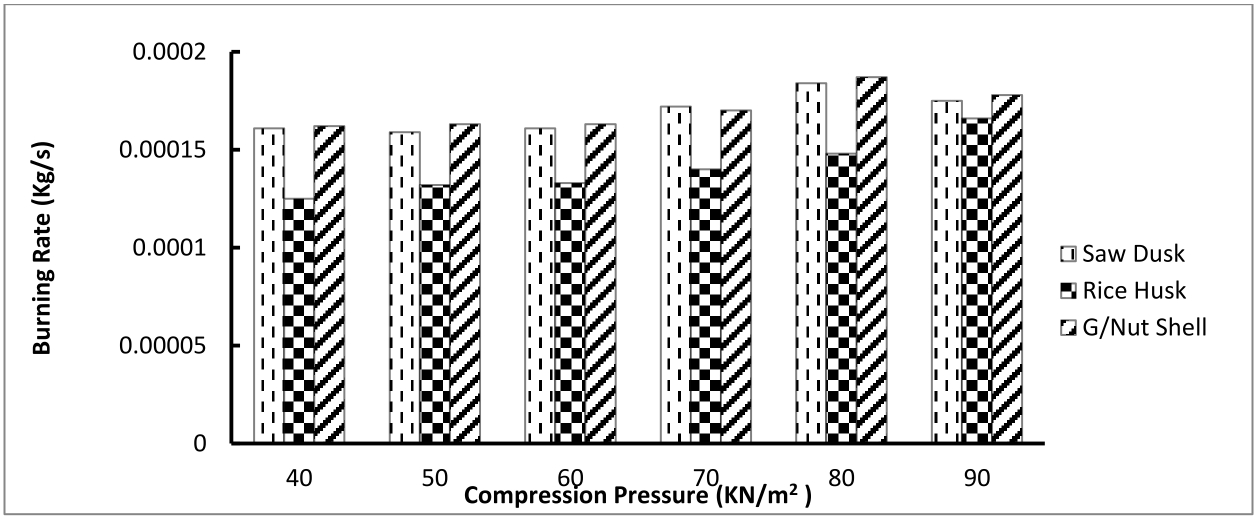

Figure 4: Burning Rate of Saw Dust, Rice Husk and Groundnut Shell

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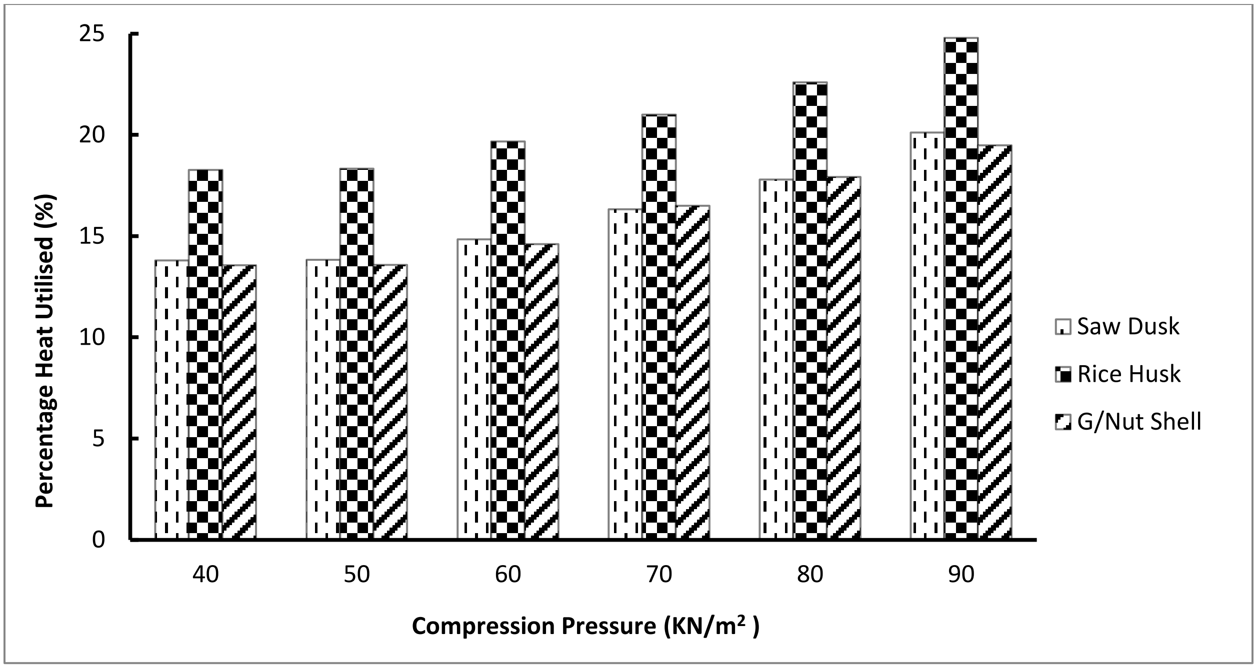

Figure 5: Percentage Heat utilized of Saw Dust, Rice husk and Groundnut shell

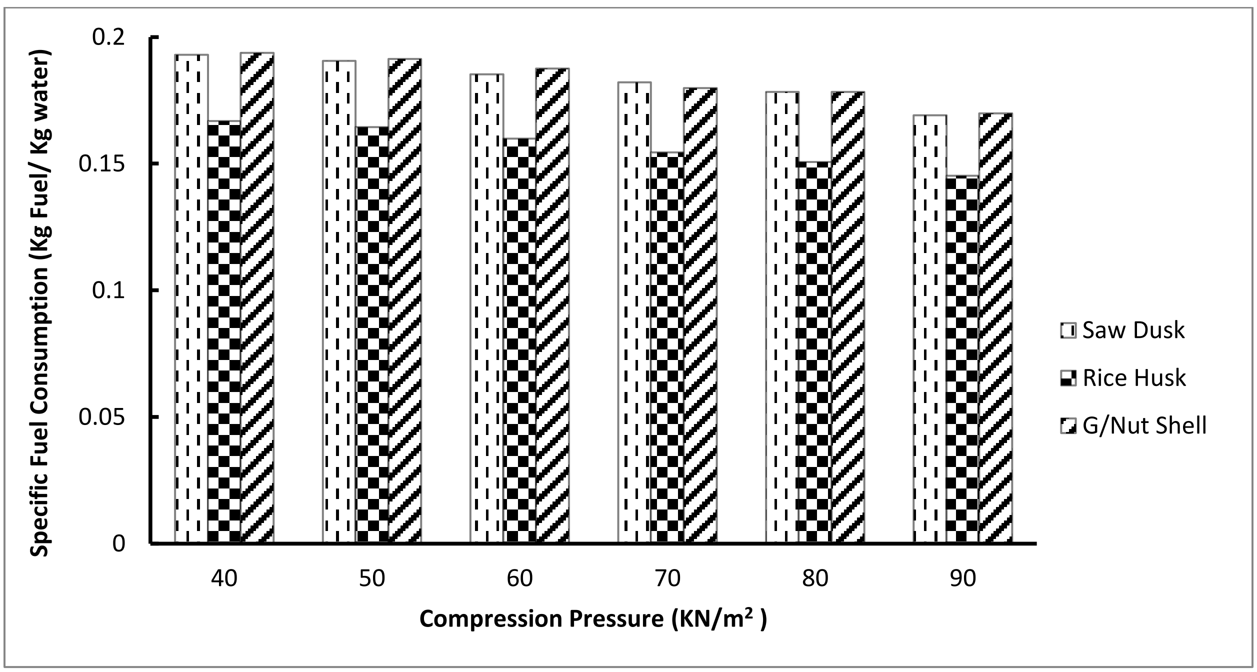

Figure 6: Specific Fuel Consumption of Saw Dust, Rice Husk and Groundnut Shell

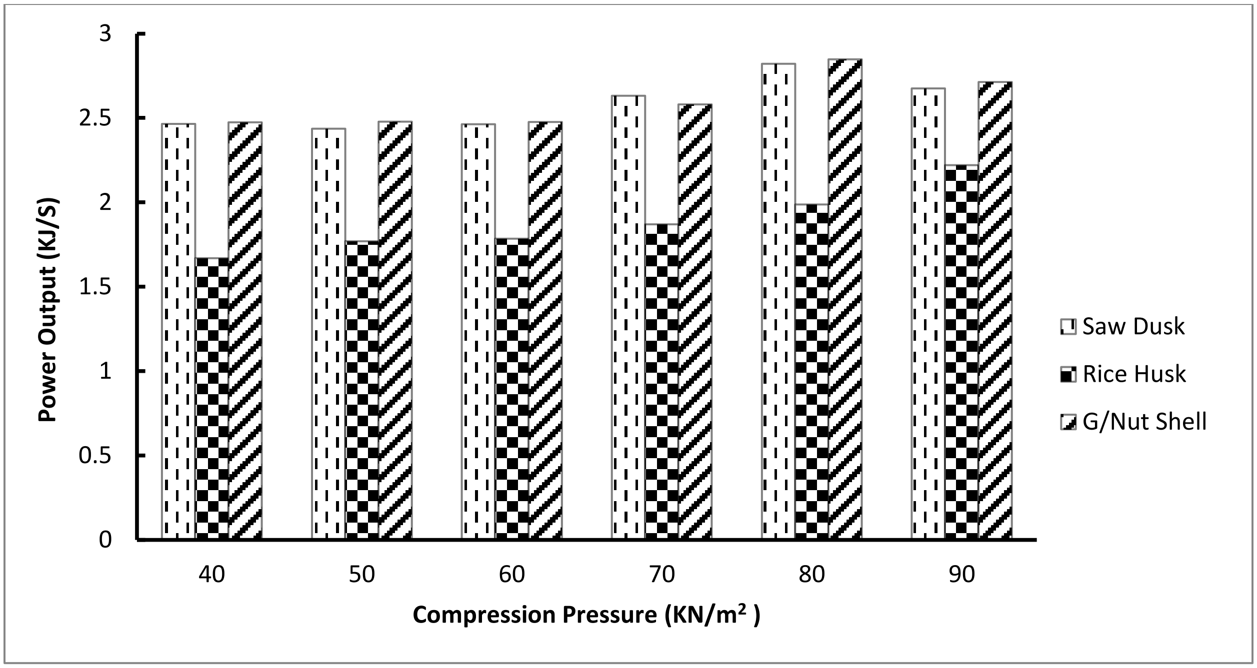

Figure 7: Power Output of Saw Dust, Rice Husk and Groundnut Shell

Discussion

From the experiments, the burning rates of all the briquettes produced from the different residues increase with increase in compression pressure as shown in figures 4-7. The increase in burning rate of the briquette with increase in compression pressure reveals that high compression pressure improves burning rate of the briquettes. It also indicates the better performance of the briquettes when employed for combustion purposes as reported by [2].

Figure 4 indicates that at compression pressure of 80 KN/m^2, the burn rate becomes relatively constant for the briquettes from the different residues. This shows that at much higher compression pressure, the burning rate becomes steady and thus briquettes produced with moderate compression pressure do better [16].

Figures 4-7 also indicate that the burning rate of briquettes produced from sawdust and groundnut shell residue is higher than rice husk residue briquettes. This shows that sawdust and groundnut briquettes burn more effectively than rice husk briquettes, this compare well with the performance of composite sawdust briquettes [17, 18].

The figures indicate that the percentage heat utilized for sawdust, rice husk and groundnut shell briquettes increase with increase in compression pressure respectively. This indicates that with time, the net heat supplied to the water increases and the net heat liberated by the fuel decreases. Briquettes from Rice husk residue have higher percentage heat utilized [19]; this is followed by groundnut shell and sawdust briquette, which is not in agreement with [20].

Figures 6 show that, the specific fuel consumption decreases irrespective of particle size variations for sawdust, Groundnut shell and rice husk briquette. This decrease shows that as the combustion of the briquettes proceed, the amount of the briquette consumed decreases. This is an important attribute that qualifies the quality of a good solid fuel. The specific fuel consumption for sawdust briquette decreases as compression pressure is increased, but at higher compression pressure the specific fuel consumption remains constant as shown in figure 6. Rice husk briquettes have moderate specific fuel consumption, which is in agreement with that of [2].

The power output also increases with increase in compression pressure irrespective of the difference in particle size of the different briquettes. The amount of energy released by the fuels for combustion is dependent on the pressure of compression. The increase is however not pronounced at 80 KN/m^2 and 90 KN/m^2 compression pressure as indicated in figure 7.

Figure 7 also indicates that the power output drops at 90 KN/m^2 compression pressure for sawdust briquette and Groundnut shell while that of rice husk increases, sawdust and groundnut shell briquettes have higher power output. This implies that they release more energy in combustion than rice husk briquettes [21].

CONCLUSIONS

In this research work, study of the combustion performances of briquette produced from biomass residues was carried out. The research results indicate that the burn rates of the briquettes produced from the different biomass residues increase with increase in compression pressure irrespective of the different particle size variations. The burn rate of briquettes produced from sawdust residue and Groundnut shell is higher than rice husk residue briquettes. At higher compression pressure, the burn rate becomes relatively constant for the briquettes from the different residues.

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