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Thermal Energy Estimates of Briquettes Produced from Bio Char Sawdust of *Gmelina arborea* Roxb.

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Abstract

Briquettes are bio-fuel substitute to firewood and charcoal. Briquettes are mostly used in the developing world where cooking fuels are not as easily available or expensive to buy. Briquettes are used for domestic cooking and heating of industrial boilers in order to produce electricity from steam. Biomass briquettes are a renewable source of energy and avoid adding fossils carbon to the atmosphere. Briquettes were produced from bio char residues of *Gmelina arborea* at seven different temperature regimes. The heating value bio-char briquette produced from *Gmelina arborea* were obtained as 28.48 at 600 ^{o}C, 28.61 at 650 ^{o}C, 28.86 at 700 ^{o}C, 29.89 at 750 ^{o}C, 31.09 at 800 ^{o}C, 32.70 at 850 ^{o}C and 32.82 at 900 ^{o}C (Mj/kg) respectively. This indicated that the bio-char briquette produced at 900^{o}C has the highest mean heating value while briquette produced at 600^{o}C has the least mean heating value respectively and this is attributed to thermal destruction of the biomass during the process of carbonization. The bio-char briquettes produced from *Gmelina arborea* sawdust have good handling and favorable combustion properties which implied that it could be transported over a long distance without disintegrating. The bio-char briquettes produced have high caloric value when compared to briquette made from un-pyrolysed materials.

Keywords: Bio-char briquette, renewable energy, *Gmelina arborea*, temperature regimes heating value

Introduction

Renewable source of energy is the fastest-growing source of world energy, with consumption increasing by 3% per year (EIA, 2009). This is due to its environmental friendliness as against the rising concern about the environmental impacts of fossil fuel use and also strong government incentives for increasing renewable penetration in most countries around the world (EIA, 2009). Biomass is one of the most common and easily accessible renewable energy resources. Globally, biomass currently provides around 46 exajoules (EJ) of bioenergy in the form of combustible biomass and wastes, liquid biofuels, solid biomass/charcoal, and gaseous fuels. This share is estimated to be over 10% of global primary energy, but with over two-thirds consumed in developing countries as traditional biomass for household use (IEA, 2009).Sequel to the increasing adverse environmental impacts related to the use of conventional fossil fuels, there is strong interest worldwide in the development of technologies that exploit renewable energy sources; and also, new measures to limit greenhouse gas emissions are continuously sought.

Fuel wood gathering takes a significant proportion of the working days of women and children and has led to extensive deforestation desertification and environmental degradation. Rural dwellers that use these fuels have to seek for alternative fuel sources for their domestic uses. Vegetable matter (biomass) if not properly disposed litter the environment thereby causing air and water pollution. At present, owing to obvious limitations in the availability of fossil fuel, research work has shifted from conventional processing of coal, biomass and wastes into more convenient environmentally green solid fuel known as briquettes.

Traditionally, energy in the form of firewood and charcoal has been the major source of renewable energy for many developing countries for which Nigeria and Ghana is no exception (Emerhi, 2011).

Biomass, a naturally abundant domestic energy source is seen as the most energy alternative to mitigate greenhouse gas emissions (Bain, 2004). Biomass is the third primary energy source after coal and oil and is set to become an important contributor to the world energy mix (Demirbas, 2010 and Sugumaran, 2010). Biomass refers to non-fossil biodegradable organic materials from plants, animals and microbial origin. Biomass materials include products, by-products, residues and wastes from agricultural and forestry activities, non-fossil and biodegradable fractions from municipal and industrial wastes.

Among the several kinds of biomass resources, agricultural residues and sawdust have become one of the most promising choices as cooking fuels due to their availability in substantial quantities as waste annually.

Sawdust and agricultural residues in their natural form are bulky materials, they have low bulk density, low heat release and generate excessive amounts of smoke (Akowuah, *et al*., 2012). It is estimated that the highest bulk density of unprocessed wood residue is around 250 kgm^{-3} (Demirbas, 2001). This makes its transportation and storage about five times more costly and also less efficient source of fuel than alternatively using it in the form of briquettes or pellets (Aruna, *et al*., 1997). Densification of agricultural residue and wood biomass waste into pellets and briquettes is now a major source of energy in Europe, North America and Asia (Bridgewater *et.al*.,1999).

A briquette is a block of compressed coal, biomass or charcoal dust that is used as fuel (Onuegbu, 2010). Briquetting is a high pressure process which can be done at elevated temperature (Che, 2003) or at ambient temperature (Mohammed, 2005, CCTJ, 2009) depending on the technology one applies. In some briquette techniques, the materials are compressed without addition of adhesive (binder less briquette) (Mangena and Cann, 2007, Mangena and Korte, 2004) while in some adhesive materials are added to assist in holding the particles of the material together (Mohammed, 2005, CCTJ, 2009). Briquetting process has focused on the production of smokeless solid fuels from coal and agricultural wastes. However, briquetting of organic materials (agricultural wastes) requires higher pressure as additional forces is needed to overcome the material springiness of these materials. This involves the destruction of the cell walls through some combination of pressure and heat. Most recently, researcher showed that blending of coal and biomass will give rise to a briquette with better burning properties and environmentally friendly, and this type is called bio-coal briquette or bio-briquette.

Previous studies conducted to examine the economic impacts of using biomass energy clearly shown that the benefits of production of briquettes for many economies clearly exist. Briquettes are used for heating of homes, cooking, as well as for other industrial heating and generation of electrical energy. A good briquette which has sufficient toughness to withstand exposure to weather and shocks during transportation has a much higher net calorific value than firewood (Adegoke and Fuwape, 2008). It is also easier to kindle than a solid wood since most of its volatile substances as well as the moisture are removed during its manufacture. Briquettes are considered to be carbon neutral and therefore more environmentally friendly than fossil fuels (Duruaku et.al. 2016). They are uniform in size and quality and also easy to transport and store. Additionally, utilization of briquettes will help to reduce pressure on the forest by providing substitute to fuel wood and charcoal and thereby reduce the time spent by women and children on basic survival activities like gathering of firewood. Briquetting also provides solution to the disposal problems associated with sawdust. It can also lead to the creation of jobs and increased revenue for sawmills and farmers in localities where briquettes are produced.

Advantages of using Briquettes Compared to other Solid Fuels

- Briquettes are cheaper than coal.
- Oil, coal or lignite, once used, cannot be replaced.
- There is no sulfur in briquettes, thus does not pollutes the environment.
- Biomass briquettes have a higher practical thermal value.
- Briquettes have much lower ash content (2-10% as compared to 20-40% in coal).
- Combustion is more uniform compared to coal

- Briquettes are usually produced near the consumption centers and supplies do not depend on erratic transport from long distances.
- Briquettes give much higher boiler efficiency because of low moisture and higher density.

The utilization of *Gmelina arborea* as timber specie been currently processed in most Nigeria sawmill necessitated this research as the sawdust can be harness as an alternative to charcoal and firewood through briquette production.

MATERIALS AND METHODS

Sample Collection and Preparation

Bio-char left over from the pyrolysis of *Gmelina arborea,* were collected for production of briquette. The sawdust was sieved with 2mm µm wire mesh to reduce the particle size into fine particles. Briquettes were produced in a locally fabricated molding machine using cassava starch as binder. Briquette was produced using 100g of bio char to 20g of binder from each of the temperature regimes used for pyrolysis. Six replicates of each temperature regimes from the mixing proportion were produced making a total numbers of 42 briquettes. The briquettes produced were oven-dried for 48 hours. After oven-drying, the briquettes were subjected to test for calorific value of product in Mj/kg; which was determined by burning a weighed sample in an oxygen-bomb calorimeter, Leco AC-350 under controlled conditions based on ASTM D-480. The test procedure consists of adding the weighed of bio char briquette samples to the cup (approximately 1.0 – 2.0 g), installing a fuse, and charging the bomb with oxygen to approximately 200 psi. The heat of combustion was computed from temperature observations before, during, and after combustion, with proper allowance for thermo-chemical and heat transfer corrections. The data generated were subjected to Analysis of Variance (ANOVA) in Completely Randomized Design. Least Significant Difference (LSD) was used as a follow up test for the relationship that is significant at 5% level of probability.

Results and Discussions

The result presented in Table 1 revealed the highest and least mean for the heating value of the bio char briquette which ranged from 28.48 at 600 to 32.82 at 900 ^{o}C Mj/kg which indicated that the bio-char briquette produced at 900^{o}C has the highest mean heating value while briquette produced at 600^{o}C has the least mean heating value respectively and this is further illustrated in Fig. 1. The heating values bio-char briquette produced from *G. arborea* were obtained as 28.48 at 600 ^{o}C, 28.61 at 650 ^{o}C, 28.86 at 700 ^{o}C, 29.89 at 750 ^{o}C, 31.09 at 800 ^{o}C, 32.70 at 850 ^{o}C and 32.82 at 900 ^{o}C (Mj/kg) respectively. The results obtained are in conformity with Abdu Zubairu *et. al.* (2014) in his research on production and characterization of briquette charcoal by carbonization of Agro-wastes in which the average heating value for the briquette grades formulated in his work was 32.43MJ/kg. It is further shown that there are significant variations in the heating values of bio-char briquette across the temperatures regimes used as illustrated in Table 2. The use of higher temperature lead to increased carbon content in the char and this resulted in an increase in the calorific value of the bio-char briquette. This denotes high heating values as good combustion characteristics for energy generation and to acquire alternative source of energy for domestic and industrial application (Adegoke and Fuwape, 2008). The briquettes produced are illustrated in plate 2.

Conclusions and Recommendations

This study investigated the thermal energy estimates of briquette produced from bio-char residues of *G. arborea* sawdust. From the experimental results it can be concluded that pyrolysis temperature has significant effect on the net calorific values of briquettes produced from G. arborea bio-char with highest mean calorific value of 32.82 Mj/kg for briquette produced at 900 ^{o}C. As it is known, the high carbon content of char makes it suitable to act as fuel and chemical feedstock. The production process (pyrolysis) has eliminated all the volatile and extraneous components of the feedstock prior briquette production. The bio-char produced have good handling property which implied that it could be transported over a long distance without disintegrating. Hence, any of these temperature regimes can be use for production of carbonized briquette. The bio char/ carbonized briquette produced are good alternative source energy to firewood and charcoal and it can be used for indoor application because it's a cleaner energy form when compared with un-carbonized briquette. The bio-char briquettes produced from *Gmelina arborea* have favorable combustion property; high in caloric values across the various temperature regimes used when compared to briquette made from un-pyrolysed material. The bio char briquette would be good for heat generation for domestic cooking and industrial purposes.

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Table 1: Results of calorific values of bio char briquette produced from sawdust of *Gmelina arborea*

Temperature regime (^{o}C)	Calorific value of bio char briquette (Mj/kg)
600	28.48 ±3.296^{g}
650	28.61 ±0.806^{f}
700	28.86 ±1.687^{e}
750	29.89 ±2.716^{d}
800	31.09 ±5.296^{c}
850	32.70 ±2.202^{b}
900	32.82 ±1.125^{a}

Table 2: Analysis of Variance Result for heating value of bio char briquette

SV	Sum of Squares	Df	Mean Square	F	Sig.
Temp. regime	7227508.619	6	1204584.770	25140.410	0.000*
Error	1677.000	35	47.914		
Total	7229185.619	41			

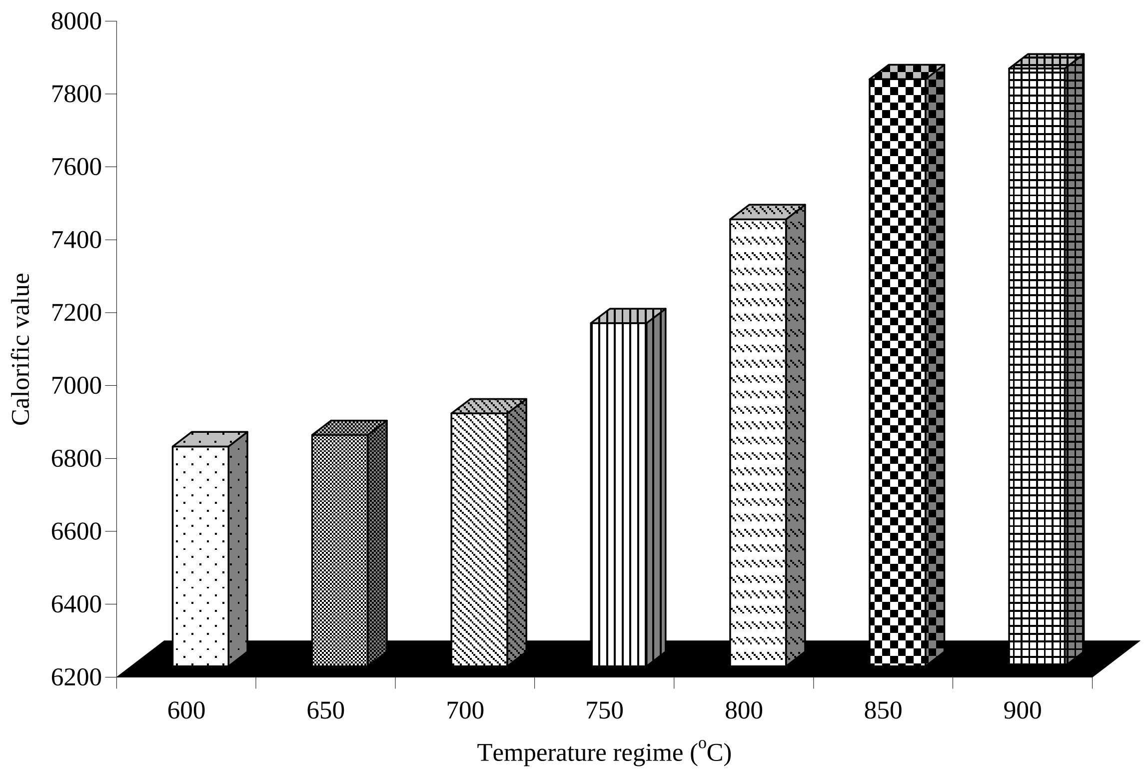

Fig 1: Mean heating value for bio char briquette (mj/kg)

Plate 1: Charcoal briquettes produced from *Gmelina arborea*