

COMBUSTION CHARACTERISTICS AND WATER BOILING RATE OF BRIQUETTES PRODUCED FROM SAWDUST OF *Parkia biglobosa* AND *Tectona grandis*

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Abstract

Briquetting has the potential to meet the additional energy demands of urban and industrial sectors thereby making a significant contribution to the economic advancement of developing countries. This study evaluated the combustion properties of briquettes produced from sawdust of two wood species (*Tectona grandis* and *Parkia biglobosa*). A locally fabricated cylindrical mould was used to produce briquettes using starch as binder. Combustion properties assessed were [volatile matter (VM), ash content (AC), fixed carbon (FC)]% and heating value (kcal/kg). Combustion properties of the briquettes were determined according to ASTM E711-8. Descriptive and inferential statistics were used for data analysis. The mean values for combustion characteristics revealed that *Tectona grandis* had higher heating value (6006.20 kcal/kg), VM (79%) and lowest AC (1.43%) compared to that of *Parkia biglobosa*. *Tectona grandis* boiled water at a faster rate (3.02) minutes. There were significant differences ($P \leq 0.05$) in combustion properties based on the species of sawdust. The study recommended that briquettes produced from *Tectona grandis* could be used as an alternative source of energy.

Keywords: Briquettes; Combustion Characteristics; *Parkia biglobosa*, *Tectona grandis*, Sawdust.

Introduction

Over exploitation of wood for domestic uses has been the major cause of deforestation, desertification and erosion due to increase in population. Thus, leading to the depletion of over 75% of the total forest cover in many sub-Saharan countries and thus leading to environmental crises (Stout and Best, 2001). The high and rapid demand for wood fuel consumption is considered as a major contributing factor to the fuel wood crisis in Nigeria (Himraj, 1993). With the increase in the rate of tree felling for furniture making and charcoal production as well as for firewood, the forest ecosystem has been greatly disturbed and altered thus leading to a high rate of environmental pollution. Energy from biomass which includes agricultural waste, has made the greatest contribution to national energy consumption in both developed and developing countries. The problems of acute scarcity and deficit in supply of wood have resulted in energy crisis in arid and semi arid regions of developing countries (Fuwapé, 2003). The percentage composition of the combustible elements in the agricultural waste whether in loose form or briquette form are very low compared to fossil fuels (Musa, 2007). Hence, the low emissions of the oxides of the combustible elements, the emission of CO₂ from the

combustion of biomass (agricultural waste) is equivalent to the amount of CO₂ absorbed during its growing cycle, so the net CO₂ released is approximately zero by mass (Wilaipon, 2007). However, inefficient wood conversion and low biomass recovery from the timber processing in local forest industry have led to the prevalence of sawdust heap around sawmills, thereby constituting a visual blight to the local environment and a breeding ground for wood decaying organisms. Ogunsanwo (2001) reported that about 50% of the wood volume is left as residue.

Statement of Problem

One of the promising solution to the problems of unutilized saw dust is the application of briquetting technology. The production of briquettes from sawdust exemplifies the potential of appropriate technology for converting wood waste to wealth. In order to make a significant impact as a fuel source, there is the need to improve and promote its production technology (Grover *et al.*, 1996).

Objectives of the study

The main Objective of this study is to compare boiling characteristics of briquettes produced from sawdust of *Parkia biglobosa* and *Tectona grandis*

Specific objectives of the study are to:

- ✓ produce briquette from two different indigenous wood species using simple method.
- ✓ evaluate the physical properties and burning characteristics of briquettes produced from sawdust of *Parkia biglobosa* and *Tectona grandis*

Justification

It is obvious that most of the world's energy demand can not be met mainly by fossil fuel such as coal, crude oil and natural gas. The under-utilized sawdust heap would serve as alternative energy source which is environmentally friendly (Adegoke, 2002). In order to reduce the effects of deforestation through production of fuelwood, alternative approach using briquettes becomes imperative.

Materials and methods

Study was carried out at Oyo State College of Agriculture and Technology (OYSCATECH), Teaching and Research Farm Igboora, Oyo State.

Sample collection and preparation

Sawdust of *Parkia biglobosa* and *Tectona grandis* were collected from sawmill (Igbole sawmill). Sacks were used in collecting sawdust from extractor outlet of the horizontal band saw (CD4) with the sacks tightened and carried to and fro on the rail of the stationary headrig as it moves until the log was totally converted, twines were used to tighten the open outlet of sacks for easy conveyance. This was done at each

time a particular specie is been converted. Sawdust were obtained from each species of wood and produced using a locally fabricated mould. The briquettes was produced in a simple press using cassava starch as binder, the starch stirred thoroughly to produce the 30% of starch with 250ml of hot water at 102°C to form prepared stock. The briquette was oven dried at a temperature of 100 °C, 5 replicates of each sets of briquettes sample were produced.

Determination of briquettes density

Density is defined as mass per unit volume of a sample (g/cm³). Meter balance was used to determine the mass of each sample volume taken by dimension and the samples were replicated three times.

Water boiling test

Water boiling is one of the very important test for assessing combustion efficiency of briquette, fixed mass of 100mls water was boiled using the briquettes produced and the briquettes were assessed by comparing the time taken to boil the water. The burning characteristics of briquette is important in assessing both performance and acceptance in domestic fireplace.

Experimental design and data analysis

The experimental design in a Randomized Complete Block Design (RCBD). Data were subjected to two-way analysis of variance and the means were separated using Multiple Range test at 5% probability level.

Result and discussion

Table 1: Physical properties of *Parkia biglobosa*

Table 1 showed the average values of physical properties of *Parkia biglobosa*. The Length ranged from (8.17 - 12.23) cm. The volume of the species ranged from (118.13 - 171.73) cm³, while the density ranged from (0.18 - 0.61) g/ cm³.

Table 1: Physical Properties of *Parkia biglobosa*

Samples	Length (cm)	Outer diameter (cm)	Inner diameter (cm)	D=d ₂ -d ₁ (cm)	Volume (cm ³)	Density(kg/cm ³)
1	12.23±0.86 ^b	6.30±0.44 ^a	1.83±0.35 ^a	4.47±0.15 ^{ab}	171.73±14.52 ^b	0.61±0.34 ^b
2	12.00±1.51 ^b	6.07±0.17 ^a	1.80±0.01 ^a	4.20±0.01 ^{ab}	168.03±22.13 ^b	0.64±0.46 ^a
3	11.30±1.00 ^b	5.81±0.60 ^a	1.87±0.31 ^a	3.95±0.44 ^a	123.39±9.12 ^a	0.22±0.79 ^a
4	8.17±0.22 ^a	6.52±0.43 ^a	1.93±0.12 ^a	4.60±0.35 ^b	118.13±11.18 ^a	0.18±0.06 ^a
5	11.58±0.41 ^b	5.87±0.17 ^a	1.80±0.01 ^a	4.07±0.01 ^{ab}	156.03±22.13 ^b	0.44±0.36 ^a

Values are means $\pm$ SD of three replicates. Different superscript in the same column indicate significant difference at $P < 0.05$

Table 2: The combustion Properties of *Parkia biglobosa*.

Table 2 showed the combustion properties of *Parkia biglobosa*. The ash content ranged from (1.48 $\pm$ 0.04 - 2.51 $\pm$ 0.08) %, volatile matter (12.19 $\pm$ 0.29 - 28.05 $\pm$ 0.23)%, fixed carbon (13.20 $\pm$ 0.17 - 18.25 $\pm$ 0.04)%. The Heating Value ranged from (3031.48 $\pm$ 12.23 - 6003.80 $\pm$ 42.35) kcal/kg , while the WBT ranged from (2.86 $\pm$ 0.27 - 8.45 $\pm$ 0.04) min/Sec.

Samples	Ash content (%)	Volatile matter (%)	Fixed carbon (%)	Heating Value (kcal/kg)	WBT (min/sec)
1	2.51 $\pm$ 0.08 ^c	22.53 $\pm$ 0.06 ^c	18.25 $\pm$ 0.04 ^d	3327.60 $\pm$ 69.50 ^c	5.00 $\pm$ 0.08 ^b
2	1.48 $\pm$ 0.04 ^b	10.19 $\pm$ 0.29 ^a	17.30 $\pm$ 0.03 ^c	6003.80 $\pm$ 42.35 ^d	2.86 $\pm$ 0.27 ^a
3	1.59 $\pm$ 0.03 ^b	28.05 $\pm$ 0.23 ^d	16.19 $\pm$ 0.05 ^b	3031.48 $\pm$ 12.23 ^a	8.45 $\pm$ 0.04 ^d
4	2.26 $\pm$ 0.04 ^a	15.53 $\pm$ 4.56 ^b	13.20 $\pm$ 0.17 ^a	5672.80 $\pm$ 17.41 ^b	5.28 $\pm$ 0.04 ^c
5	1.52 $\pm$ 0.03 ^b	12.19 $\pm$ 0.29 ^a	17.14 $\pm$ 0.05 ^b	5931.48 $\pm$ 12.23 ^a	8.35 $\pm$ 0.04 ^d

Values are means $\pm$ SD of three replicates. Different superscript in the same column indicate significant difference at $P < 0.05$

Table 3: Physical properties of *Tectona grandis*

Table 3 showed the average values of physical properties of *Tectona grandis*. The Length ranged from (10.87 - 11.57) cm. The volume of the species ranged from (160.09 -188.09) cm³ , while the density ranged from (0.20 - 0.35) g/ cm³.

Samples	Length (cm)	Outer diameter (cm)	Inner diameter (cm)	D= d ₂ -d ₁ (cm)	Volume (cm ³)	Density (g/cm ³)
1	10.87 $\pm$ 1.89 ^b	6.27 $\pm$ 0.46 ^a	1.80 $\pm$ 0.36 ^a	4.47 $\pm$ 0.15 ^a	170.00 $\pm$ 27.74 ^a	0.35 $\pm$ 0.81 ^a
2	11.13 $\pm$ 1.55 ^a	6.07 $\pm$ 0.16 ^b	1.63 $\pm$ 0.29 ^c	4.43 $\pm$ 0.25 ^a	168.46 $\pm$ 14.33 ^a	0.50 $\pm$ 0.13 ^b
3	10.37 $\pm$ 1.60 ^c	6.40 $\pm$ 0.53 ^a	1.87 $\pm$ 0.16 ^a	4.53 $\pm$ 0.42 ^a	160.09 $\pm$ 35.11 ^b	0.20 $\pm$ 0.66 ^c
4	11.20 $\pm$ 0.99 ^b	6.33 $\pm$ 0.40 ^b	1.80 $\pm$ 0.20 ^b	4.53 $\pm$ 0.25 ^a	188.09 $\pm$ 18.21 ^a	0.32 $\pm$ 0.15 ^a
5	11.57 $\pm$ 0.91 ^{ab}	6.53 $\pm$ 0.58 ^a	1.60 $\pm$ 0.35 ^c	4.53 $\pm$ 0.42 ^a	163.36 $\pm$ 26.44 ^b	0.30 $\pm$ 0.32 ^a

Values are means $\pm$ SD of three replicates. Different superscript in the same column indicate significant difference at $P < 0.05$

Table 4: The combustion properties of *Tectona grandis*.

Table 4 showed the combustion properties of *Tectona grandis*. The ash content ranged from (1.43 $\pm$ 0.60 - 2.67 $\pm$ 0.07) %, volatile matter (22.99 $\pm$ 0.54 - 29.28 $\pm$ 0.11)%,fixed carbon (16.18 $\pm$ 0.06 - 18.37 $\pm$ 0.11)%. The Heating Value ranged from (3489.14 $\pm$ 137.17 - 6006.20 $\pm$ 25.53) kcal/kg, while the WBT ranged from (3.02 $\pm$ 0.02- 5.18 $\pm$ 0.04)

Samples	Ash content (%)	Volatile matter (%)	Fixed carbon (%)	Heating Value (kcal/kg)	WBT (Min/Sec)
1	2.57 $\pm$ 0.60 ^a	22.99 $\pm$ 0.54 ^b	18.37 $\pm$ 0.11 ^c	3489.14 $\pm$ 137.17 ^b	5.18 $\pm$ 0.04 ^b
2	1.43 $\pm$ 0.02 ^b	28.23 $\pm$ 0.26 ^a	17.38 $\pm$ 0.10 ^b	5929.36 $\pm$ 21.22 ^c	3.09 $\pm$ 0.09 ^a
3	1.68 $\pm$ 0.06 ^b	19.36 $\pm$ 0.46 ^c	16.18 $\pm$ 0.06 ^c	6006.20 $\pm$ 25.53 ^c	8.50 $\pm$ 0.14 ^a

min/Sec.

4	2.67± 0.07 ^c	23.66±0.51 ^b	18.28±0.05 ^c	3068.66±292.52 ^b	5.22±0.02 ^b
5	1.74±0.03 ^b	29.28±0.11 ^c	17.24±0.01 ^b	3048.21 ± 0.93 ^c	3.02±0.02 ^a

Values are means ± SD of three replicates. Different superscript in the same column indicate significant difference at $P < 0.05$.

Discussion

The transformation of waste as a source of fuel is attractive because it reduces waste, forest depletion and by extension ameliorates the environment. It also reduces the increasing demand for non renewable fuel resources and improves local economy. Burning of loose biomass normally generates low thermal efficiency hence densification is essential. The use of sawdust waste of *Parkia biglobosa* and *Tectona grandis* for the production of briquettes is an effort for ensuring maximum utilization of the resources. According to Grover and Mishra (1994), many of the developing countries are producing large quantities of sawmill residues which are used inefficiently, causing extensive pollution to the environment. Also, cleanliness, great intensity of heat and convenience are notable advantages of briquettes are observed (Olorunnishola 2004). According to Kim *et al.* (2001), ash is the non-combustible component of biomass. The ash produced by burning briquettes may cause problems as briquettes normally produce increase in combustion remnant in the form of ash that lowers the heating value of briquettes and low ash content offers higher heating value for briquettes (Obi *et al.*, 2013). According to Gover *et al.*, (1994), ash deposit on heat transfer surfaces in boilers and internal surfaces in gasifiers accelerate corrosion of hot heat exchanging tubes and also reduce their efficiency, the maximum percentage ash content of 2.67± 0.07 was observed in *Tectona grandis* briquette while the highest heating value percentage 6006.20±25.5. The value in this study is in consonance with the recommended 0.7% by DIN 51731 and 6% according to the Austria ÖNORM M7135 as cited by Hahn, (2004). However, with the ash content, good heating value was obtained for *Tectona grandis* the high carbon content assisted in ensuring higher heating value. The report of Oladeji *et al.*, 2012 indicated that ash content has a great effect on heat transfer and oxygen dispersion to biomass fuel during combustion.

The least value of 19.36±0.46 recorded in this study was lower when compared with highly volatile coal dust, the lowest ignition energy of the low-volatile coal dust has a more significant impact on the explosion(Liu *et al.*,2014).However, result of this study could be crucial for quality briquette production, which is supported by Shukla *et al* 2015, who revealed that

briquettes with the lower volatile matter have good quality parameters including easy ignition and burning smoothly.

Conclusion

It can be concluded that briquettes produced from *Tectona grandis* as a biofuel can serve as a substitute to coal. Briquettes produced from *Tectona grandis* due to its burning characteristics could be used not only for domestic purposes but for industrial boilers.

Recommendation

From the result it can be, recommended that in order to fully understand the use of briquettes produced from *Tectona grandis*, effort should be geared towards creating awareness on its uses. Also, local entrepreneurs and NGOs should be mobilised for provision and establishment of community-level briquettes industries. Furthermore, indigenous briquettes technologies should be integrated into the curriculum of schools in Nigeria to inculcate sense of entrepreneurship to young students in the nation.

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