PERFORMANCE EVALUATION OF CHARCOAL SAMPLES FROM DIFFERENT WOOD SPECIES IN IBADAN, NIGERIA

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ABSTRACT: *The performance evaluation of charcoal samples produced from wood offcuts of some selected tropical wood species (Iroko, Obeche, Oak, Afara, and Mahogany) was carried out. The woods offcuts were collected from different saw-mills in Ibadan metropolis, Nigeria, and were converted into charcoal using a portable steel kiln. In evaluating the performance of different tropical charcoal samples, three test conditions were considered: water boiling, burn rate of charcoal in cook stove and cooking duration tests. Values obtained as burn rates and water boiling durations were 0.51 kg/hr and 28minutes for Iroko specie, 0.58 kg/hr and 24 minutes for Obeche specie, 0.55 kg/hr and 26 minutes for Oak specie, 0.60 kg/hr and 22 minutes for Afara specie and 0.54 kg/hr and 28minutes for Mahogany specie. In a Comparative cooking test conducted with the different charcoal samples using beans as food item, the fastest cook time was recorded with Afara charcoal samples in cook stove; it spent 45 minutes to cook beans. Time spent using other charcoal samples in cook stove varied: Obeche specie spent 48 minutes to cook, Oak specie spent 52 minutes to cook and Mahogany specie spent 55 minutes to cook while Iroko charcoal sample took the longest time of 58 minutes to cook beans.*

Keywords: Evaluation, Charcoal, Burn rate, Duration

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INTRODUCTION

It is obvious that most of the world's energy demand is not met by fossil fuel mainly coal, crude oil, and natural gas. Fossil fuel, which is non-renewable, provides about 80 % of man's energy sources now and this may start to depreciate in the next twenty to thirty years. This has been the major concern for the entire world especially developing nations like Nigeria, and the need to produce quality charcoal from wood offcuts in areas like Ibadan, Nigeria and other developing countries where the materials are locally available in large quantity, production cost is relatively low

and hence reduce dependence on purchase of kerosene and gas.

There is need to have information on the particular wood specie that has the best combustion properties for charcoal production, this would provide useful data on how to improve on the quality and quantity of charcoal production from wood offcuts towards meeting energy needs in urban and rural communities.

METHODOLOGY

The performance evaluations of the charcoal samples were carried out in open-air to simulate the traditional cooking method commonly adopted in rural communities in Nigeria through. The rate of temperature rise of water, burn rate of charcoal and cooking duration were considered.

The evaluation of combustion properties of the various charcoal samples produced was carried out through water boiling test. The procedure used in the calculations of the parameters was based on the approach used by Ahuja, *et al* (1987) and Baldwin (1986).

Burn Rate (F)

The burn rates (F) corrected for moisture content of the various tropical wood charcoal in cook stove were calculated using the formula below:

$$\mathbf{F\ (kg/h)} = \frac{1}{t} \cdot \frac{100(W_i - W_f)}{(100 + M)} \qquad (1)$$

Where;

F = Burning Rate (kg/h)

W_i = Initial weight of the fuel before burning (kg)

W_f = Weight of fuel after burning (kg)

M = Moisture content of the fuel

t = Total time taken for burning fuel

Time Spent in Cooking Per Kilogram of Cooked Food

$$T_s = \frac{\text{Total time spent in cooking}}{\text{Total weight of cooked food}}\ \text{(hr/kg)} \qquad (2)$$

Where

T_s = Time spent

RESULT AND DISCUSSION

Boiling water on the cook stove loaded with charcoal from Afara wood had the fastest temperature increase among all the wood charcoal used, this was due to the combustion properties of charcoal from Afara wood species having the highest heating value and the least ash content while Mahogany in cook stove produced least heat and the rate of temperature rise of water in pot was slow, as shown in Table 1. This was due to the high production of ash in the cook stove, which is the non-combustible component of charcoal and the higher the fuel's ash content, the lower the heat value it produce and hence the longer time it takes in cooking activities i.e. water

boiling. (Loo and Koppejan, 2008). The rate of change of water temperature in pot when the cook stove was charged with various species of charcoal is shown in Figure 1.

Burning of charcoal in cook stove may be classified as controlled burning as distinguished from free burning in an open fire. The burn rates obtained from charcoal of various wood species (Iroko, Obeche, Oak, Afara and Mahogany) in cook stove, used for the experiment according to equation 2 were: 0.514 kg/hr, 0.575kg/hr, 0.554 kg/hr, 0.600 kg/hr and 0.536 kg/hr respectively. These results showed that charcoal from Afara wood had the highest burn rate in cook stove among all the charcoal samples used and was closely followed by those from Obeche wood which burned with little smoke due to its high volatile matter content. Charcoal from Iroko wood specie had the lowest burn rate out of all the charcoal samples used, this was due to the fact that it has the highest percentage ash content which lowered the rate of air circulation to the fuel bed of the cook stove used (Loo and Koppejan, 2008). All the charcoal samples used for the evaluations had similar burn rates in the cook stove used; this were also due to the high heating values of the charcoal samples used for the experiment. Kaoma and Kasali (1994) in their research work noted that burn rate is a function of the supply of air (oxygen) to the fuel bed in the stove and also on the prevailed temperature within the firebox (fuel bed). The results for the experiment are shown in Figure 2.

Beans, one of the food items that take a very long time to cook was chosen to test the time spent in cooking using different charcoal samples. The time spent in cooking per kilogram of cooked food was lowest with Afara charcoal samples in cook stove (1.59 hr/kg), followed by Obeche charcoal samples with 1.63 hr/kg while those of Oak, Mahogany and Iroko charcoal samples had 1.67 hr/kg, 1.70 hr/kg and 1.73 hr/kg respectively. These results have shown that all the charcoal samples used had good combustion properties with charcoal of Afara wood species having the fastest cooking duration. This was due to the high heating value obtained from Afara charcoal sample when compared to the heat values obtained from other charcoal samples used.

With these results, fuel recovered after the water boiling test when the stove was loaded at test intervals with 0.5 kg of charcoal of Iroko, Obeche, Oak, Afara and Mahogany woods were: 0.26 kg, 0.27 kg, 0.26 kg, 0.28 kg and 0.25 kg respectively. All the tropical wood charcoal used had

good combustion properties and burn rates in cook stove therefore, are ideal for cooking activities at home as alternative to non-renewable energy resources such as kerosene or liquefied gas.

CONCLUSION AND RECOMMENDATION

The results from the tests and evaluation of the charcoal sample used showed that the best charcoal sample were those produced from Afara wood specie which had the best combustion properties with the highest burn rate value, boiled water with the fastest time and had the fastest cooking duration. Although other tropical wood charcoal species investigated in this research work also had good combustion properties, they are environmental friendly, release lesser or no smoke to the atmosphere and can be applied as a clean and alternative source of energy to firewood for heating purposes.

The energy values and combustion characteristics or qualities of charcoal from different tropical wood species used in this study are sufficient enough to produce the required heat for domestic cooking and also for industrial application especially the energy requirement of small-scale industries. The chemical properties, especial the low toxic emissions (volatile matter content), make them to be environmental friendly and very safe for the users.

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Table (1): Mean Values of Density(gcm^{-3}); and Heating Values, HV ($kJkg^{-1}$) of Charcoal from some Tropical Wood Species.

Wood Species	Density (gcm^{-3})	HV (kJ/kg)
Iroko		

	0.5567 ± 0.042^{b}	$3.2149 \times 10^{4} \pm 248.974^{b}$
Obeche	0.6200 ± 0.046^{bc}	$3.3038 \times 10^{4} \pm 169.604^{a}$
Oak	0.5300 ± 0.035^{b}	$3.2956 \times 10^{4} \pm 430.128^{a}$
Afara	0.4533 ± 0.038^{a}	$3.3236 \times 10^{4} \pm 171.932^{a}$
Mahogany	0.4567 ± 0.032^{a}	$3.2230 \times 10^{4} \pm 337.0545^{b}$

• Values followed by the same superscript letters in each column are not significantly different at $\alpha = 0.05$ according to Duncan's multiple range tests.

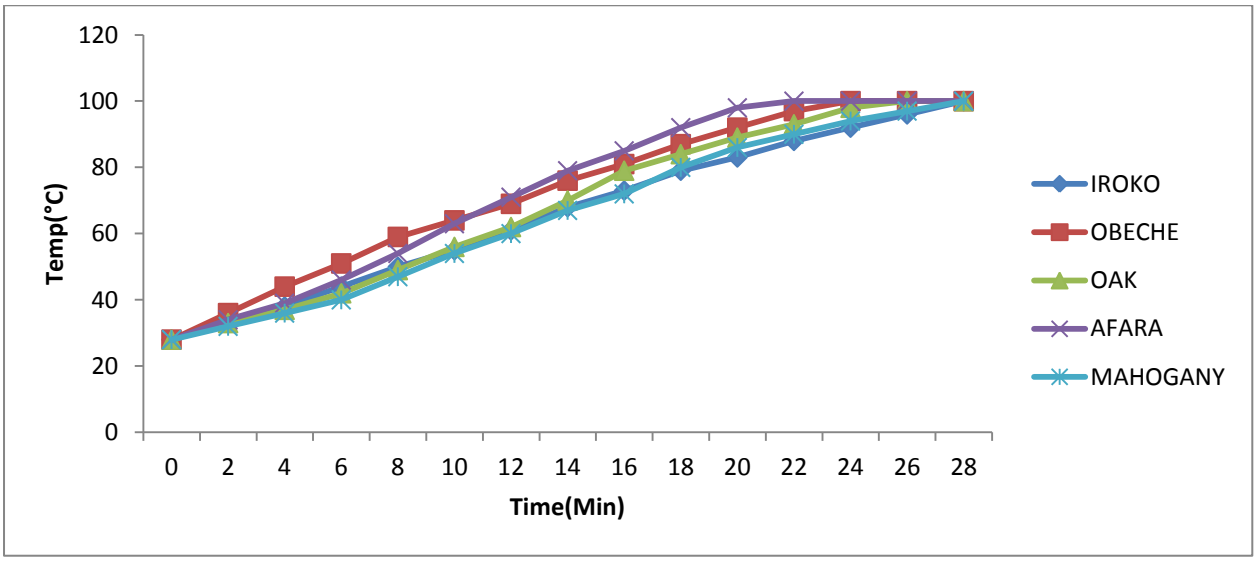

Figure 1: Line Graph Showing the Rate of Rise of Water Temperature Using Different Charcoal Samples in Cook Stove

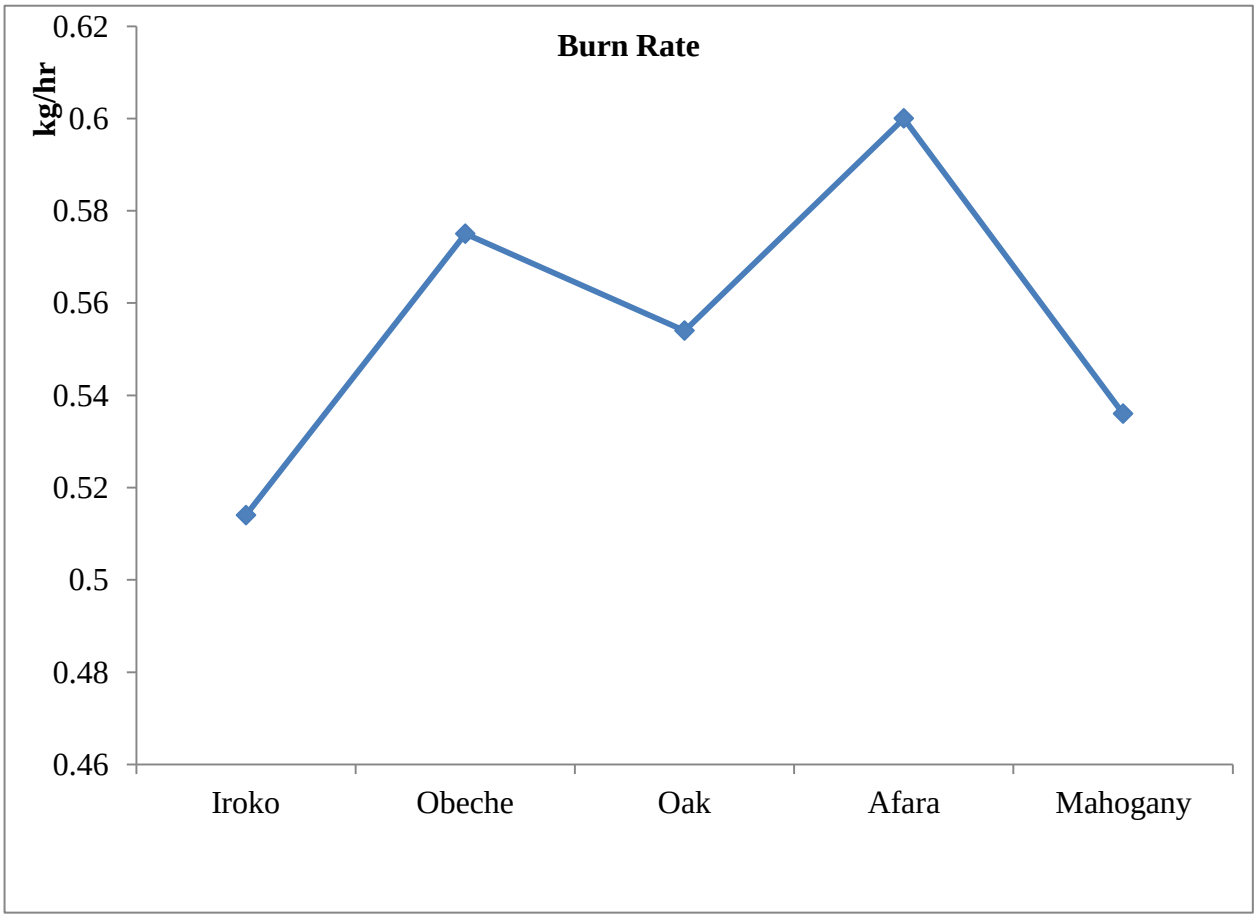

Figure 2: Burn Rates of Charcoal in Cook Stove

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