VARIATION IN QUANTITY OF HEAT PRODUCED FROM CHARCOAL OF *PROSOPIS AFRICANA, TECTONA GRANDIS, AND BURKEA AFRICANA* WOOD SPECIES.

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ABSTRACT

Variation in the quantity of heat produced from the charcoal of Prosopis africana, Tectona grandis, and Burkea africana wood species was investigated. This was done to determine whether differences in the species and parts of the trees have significant effect on quantity of heat from their charcoal samples. Data were collected using the copper calorimeter, a thermometer, an air tight burner and a weight balance. The results showed a gradual decrease in the quantity of heat produced as combustion time increased from 10 40 minutes in all wood species. Significant differences ($p<0.05$) in the quantity of heat produced both within and between the charcoal of all the wood species were also observed. Further investigation revealed that the base of all the samples produced more heat ($p<0.05$) within species followed by the bole and the crown. The between wood species showed that Prosopis africana produced more heat followed by Burkea africana and Tectona grandis which may be attributed to the impact of density as it is more concentrated at the base than any other part of the wood.

INTRODUCTION

The emergence and development of civilization has been closely associated with the increase in the per capital consumption of energy by mankind (Foley1986, Hibajene and Kalumiana 1994). The simplest method of up grading the value of wood as a fuel is to convert it to charcoal. Charcoal is produced as a result of the chemical reduction of organic matter under controlled conditions. It is commonly used as a secondary energy source and as a chemical agent in industries. For those countries with sufficient man power and forest resources, charcoal has special significance for development (Prins and Ptasinski 2006). Charcoal for industrial use and for activation usually has to meet precise specifications. This can be fulfilled only if the end product has been made from suitable species. Adjustment of the carbonization process has being carried out, and appropriate methods of analysis have been used to ensure quality control during production.

Most charcoal is made from wood although there are other less abundant materials like coconut shell and bone which provide very important and valuable charcoals for specialized uses. The two most important raw material sources for charcoal production are round woods and wood residues, the former being the most abundant. Accordingly Anderson and Robert (1985) reported that dry wood usually produces greater yield of charcoal than wet wood and the time needed for carbonization is shorter.

The main processes of wood conversion into charcoal include; drying and resizing where wood is cut and split into smaller sizes,

gasification involving the breakdown of solid biomass fuels (e.g. wood, charcoal) by the use of heat to produce a combustible gas, known as producer gas and water gas which consists of carbon monoxide and nitrogen in a strongly exothermic reaction (Hall and Mao 1994) and; densification to convert the bulky nature of wood into smokeless briquettes (Antal and Grønli 2003).

This research therefore aims at identifying the species and the parts of the trees among those sampled that produces the highest quantity of heat when converted to charcoal.

MATERIALS AND METHODS

Agan plantation which is the study area is located within the Southern Guinea savanna zone between latitude 7° N and 8° N and longitude 8° E and 9° E. The study area is located 8km along Makurdi / Lafia highway. The area was gazzetted on 22nd June, 1961 as a Native Authority Makurdi Forest Reserve. In 1973, the reserve was renamed Agan Forest plantation with management objective of ameliorating shortage of fire wood, poles, and sawn timber.The wood samples used for data collection included three (3) matured hard wood species namely *Prosopis africana, Tectona grandis and Burkea africana.* Equipments include; an axe, a hand saw a copper calorimeter, a thermometer, weigh balance and a 15m x 15m constructed burner.The species were felled and cut to the equal sizes of $20cm^2$ each of Base, Bole and Branch with the aid of an axe/hand saw and dried. The calorimeter was filled to 2/3 volume with water and the initial temperature of the water was recorded using the thermometer. The 3 wood samples were heated in limited air using the 15m x 15m constructed burner to produce quality charcoal. The heated charcoals were immersed into the calorimeter for combustion time of 10, 20, 30, and 40 minutes for all the wood samples and readings of the final temperatures of water were recorded. The Quantity of heat evolved by each species was calculated using the formula Q= MCT where Q: quantity of heat evolved in Joules, C: the specific heat capacity of charcoal (0.241) and T: the temperature difference in degree Celsius. The Randomized Complete Block Design (RCBD) was used for statistical analysis of data.

RESULTS AND DISCUSSION

Effect of combustion time on *Prosopis africana* charcoal samples.

Analyses of variance indicated significant differences ($p<0.05$) in quantity of heat produced from 10, 20, 30 and 40 minutes combustion time among the BASE, BOLE and BRANCH (Fig 1.0). The mean values for BASE, BOLE and BRANCH in joules were; 0.253125, 0.222075, 0.160625; 0.139450, 0.211375, 0.158175; 0.138750, 0.118875, 0.184850 and 0.115025, 0.096100, 0.075525 respectively for 10, 20, 30 and 40 minutes of combustion time. The differences in the degrees of cell wall density from base to branches of samples may be responsible for the observed variation in quantity of heat produced with time, which agrees similar studies of (Larson, 1963), (Denn and Dodd, 1980) and (Delenze and Honiller 1996).

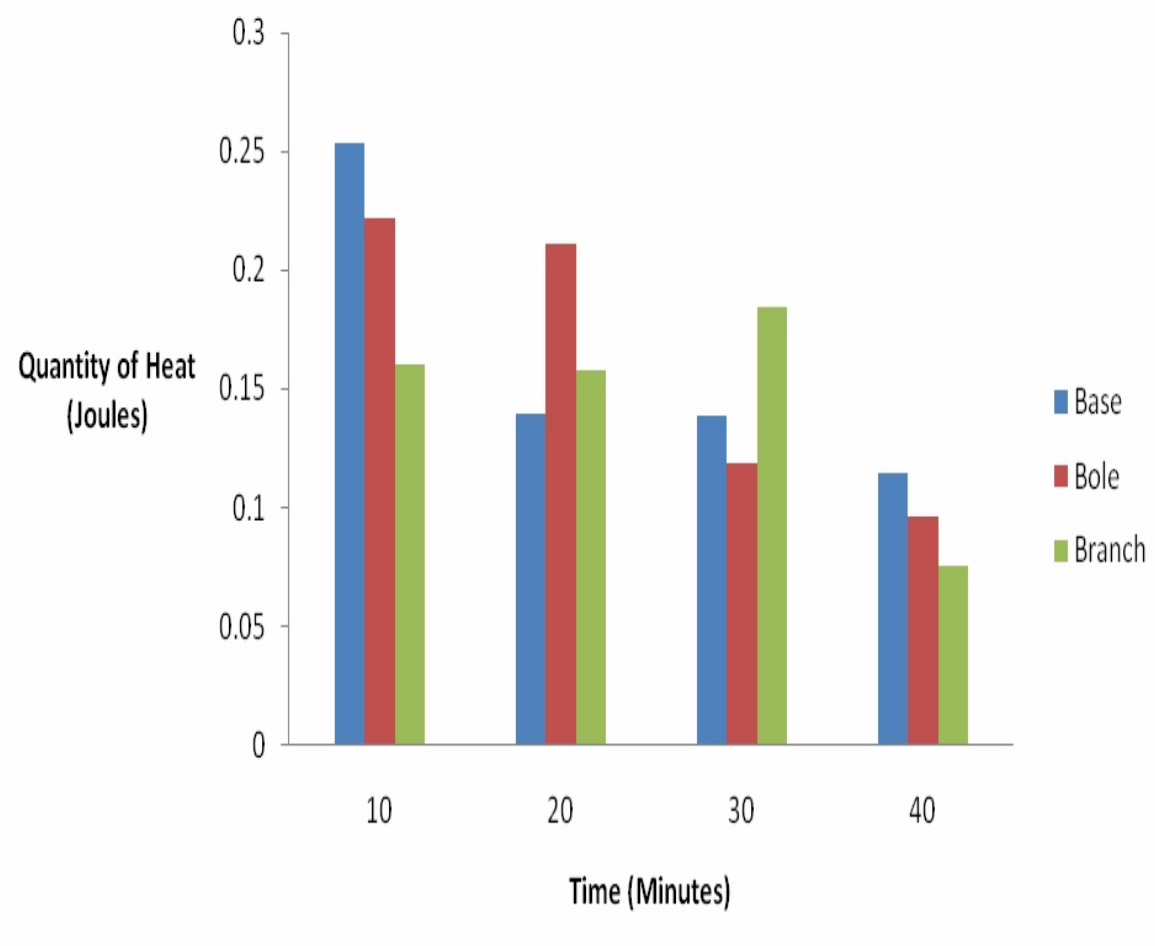

Fig.1.0 Quantity of heat produced (in joules)from *prosopis africana* charcoal samples with time.

Effect of combustion time within *Tectona grandis* charcoal samples.

From the analyses of variance, significant differences in heat exist within 10, 20, 30 and 40 minutes of combustion time within charcoal samples of *Tectona grandis* at the base, bole and branch. The mean quantity of heat produced with time from 10, 20, 30 and 40 minutes include;0.193250, 0.158925, 0.115850; 0.136475,0.128125,0.060425; 0.091075,0.078150, 0.053175, 0.074600, 0.052825 and 0.035250 joules respectively for base, bole and branches. This shows that the base retained more heat than the bole and branch among the samples (Fig 2.0). Reasons may be due to the variation in density as it decreases from base to bole and to branch of most tree species. This agrees with previous investigations including (Feinstein and Robert 1991) and (Delenze and Honiller 1996

Fig.2.Quantity of heat produced (in joules) from *Tectona grandis* charcoal samples with time.

Effect of combustion time on *Burkea africana* charcoal samples.

Result from analyses of variance showed that significant differences in heat existed with combustion time on charcoal samples of *Burkea africana*. This differences lies between base

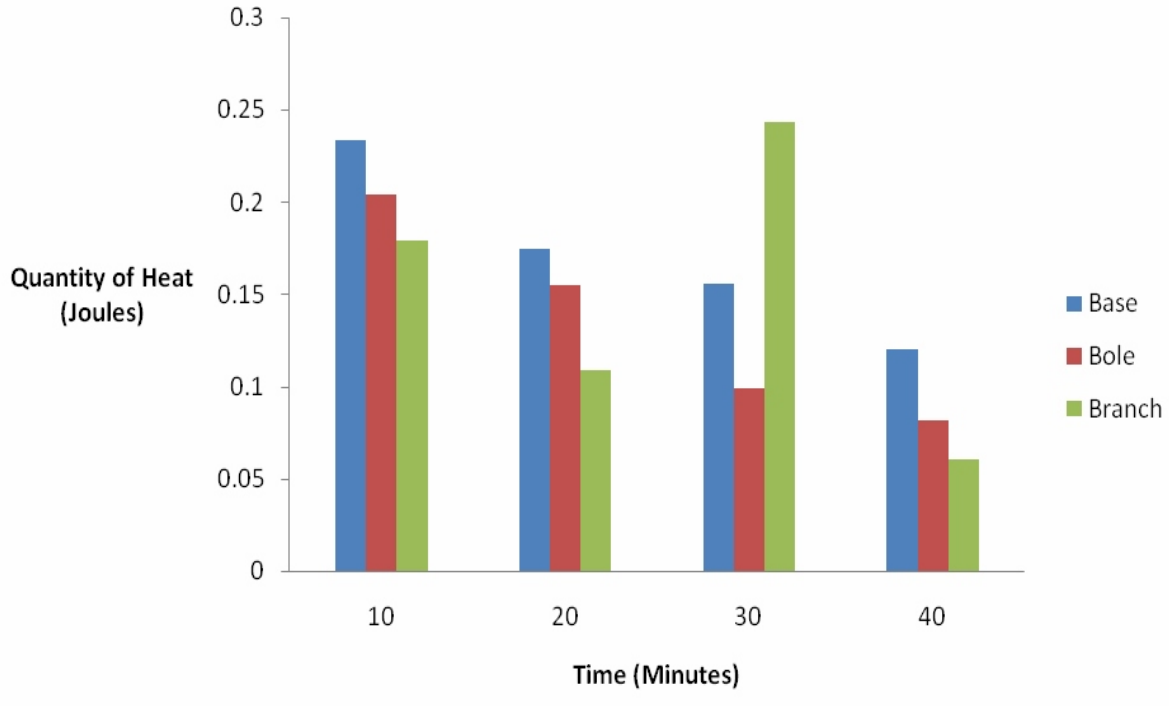

Fig 3.0 Quantity of heat produced (in joules) from *Burkea africana* charcoal samples with time.

and
boles, and branches (Fig 3.0). The variation in quantity of heat retained with combustion time of 10, 20, 30 and 40 minutes in joules from the base, boles and branches respectively was as follows; 0.2335875, 0.203725, 0.178800; 0.174625, 0.154750, 0.108975; 0.155650, 0.099275, 0.243675; 0.120125, 0.081600 and 0.060800. This indicates that the wood at the base has more density than any other parts of the tree as previously reported by other authors including Denne and Dodd (1980).

Comparing the variation quantity of heat among charcoal samples of *Prosopis africana*, *Tectona grandis* and *Burkea africana* species.

Variation in quantity of heat from charcoal at the BASE of wood species.

Results from analyses of variance indicated significant differences ($p<0.05$) in quantity of heat between charcoal samples at the base of *Prosopis africana, Tectona grandis* and *Burkea africana* species. Further investigation shows significant differences ($p<0.05$) existing between *Prosopis africana* and *Tectona grandis*, *Tectona grandis* and *Burkea africana* but non ($p>0.05$) existed between *Prosopis africana* and *Burkea* Africana (Fig 4.0).The reason may be due to genetic constitution of cell wall samples or environmental factors (Delenze and Honiller 1996) and (Antal and Grønli, 2003).

Variation in quantity of heat from charcoal from BOLES of wood species.

Analyses of variance result showed significant differences ($p<0.05$) in quantity of heat existing between charcoal samples in the boles of the three species. The quantity of heat existing between *Prosopis africana* and *Tectona grandis* was significant ($p<0.05$), but not significant ($p>0.05$) between *Prosopis africana* and *Burkea africana,* and *Burkea africana* and *Tectona grandis.*(Fig 4.0). Environmental factors may be responsible for the observed variation (Antal and Grønli, 2003).

Variation in quantity of heat from charcoal from BRANCHES of wood spesies.

Results obtained from statistical analysis shows that significant differences($p<0.05$) exist in quantity of heat between charcoal from branches of *Prosopis africana , Tectona grandis* and *Burkea africana* species. The differences were further observed between *Burkea africana and Tectona grandis* but non($p>0.05$) between *Prosopis africana and Burkea africana*, and *Prosopis africana and Tectona grandis*(Fig 4.0). This may also be related to environmental factors of growth (Hall and Mao 1994) and (Antal and Grønli, 2003).

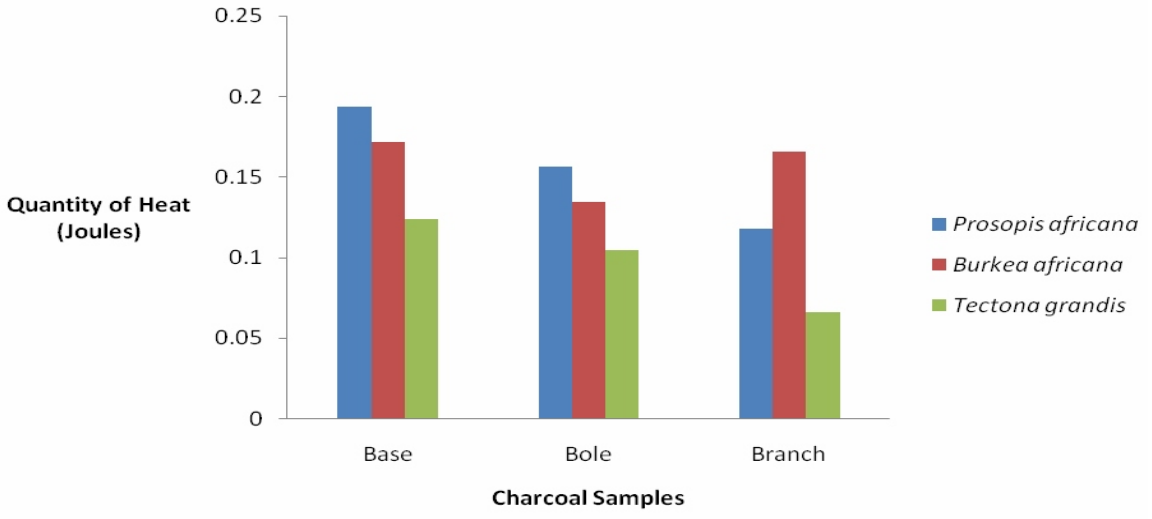

Fig.4.0 The quantity of heat produced (in joules) between charcoal samples.

Legend p = *Prosopis africana* b = *Burkea africana* t = *Tectona grandis*

CONCLUSION

The investigation showed that *Prosopis africana* produced the highest quantity of heat followed by *Burkea africana* and *Tectona grandis.* Also the bases of the wood species produced the highest heat content in all combustion regimes indicating the impact of cell wall density and accumulation of more latewood in the bases than the boles and branches of the tree species.

REFERENCES

Anderson, D and Robert F.(1985) Fuelwood consumption and Deforestation in African Countries, World Bank Staff Working Paper 704, Washington, DC.

Antal, M. J. jr. and Grønli, M. (2003) The art, science, and technology of charcoal production, Industrial, Engineering and Chemical Resources 42, 1619-1640.

Delenze, C and Honiller,F (1996) Xylem growth model to describe micro density profiles. IAWA journal 17(2):105 106.

Denne, M. P. and Dodd, R . S (1980) Control of variation in wood quality within Hardwood and softwood trees. IUFRO Division 5 conference Oxford UK: 1 5.

Foley, G.(1986) Charcoal Making in Developing Countries, Earthscan, London, UK.

Hall, D.O. and Mao, Y.S. (1994) Biomass Energy and Coal in Africa, AFREPREN, London.

Hibajene, S.H. and Kalumiana O.S.(1994) Manual for Charcoal Production in Earth Kilns in Zambia,Department of Energy, Ministry of Energy and Water Development and Stockholm Environment Institute, Lusaka, Zambia.

Larson, P. R (1963) Microscopic wood characteristic and their variation with tree growth. Proceedings of International Union of Forest Resources Organization. Madison, Wiscon. Section 41:45-57.

Prins, M.J and Ptasinski (2006), "Torrefaction of wood: "Journal of Analytical and Applied Pyrolysis 77 (1): 35-40..