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Production Technique and the Influence of Wood Species on the Properties of Charcoal in Nigeria, A Case Study of Oyo State

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Abstract: This study investigated the physical characteristics of the charcoal produced from selected wood species in a Local Government Area of Oyo State. The result showed that *Anogeissus leiocarpus* (Ayin) with 11.618 Kcal g^{-1} Calorific Value is the most preferred wood species for charcoal production in the study area; this may be the probable reason why it is mostly preferred to other available and selected wood species. The calorific value for other species tested ranged between 8.25 and 10.09 kcal g^{-1}. However the available of these species in the study area has being on a downward trend. On this basis it is recommended that Species like *Anogeissus leiocarpus* (Ayin), *Vitellaria paradoxum* (Emi), *Daniella oliveri* (Iya) and *Terminalia superba* (Afara) with high calorific values should be established in plantations to ensure regular supply of the species to the charcoal producers among other uses.

Key words: Production technique, charcoal, wood properties

INTRODUCTION

The primary sources of energy include; electricity, coal (coke), kerosene, gas, fuel wood (biomass) and solar energy in recent times. In developing countries the predominant traditional sources of energy are fuelwood and charcoal, which are used primarily for cooking and heating homes[1]. Most fuel users prefer charcoal to firewood because it does not produce much smoke, it can be ignited easily, it emits heat for a longer period of time and most importantly it is relatively cheap. Charcoal is the solid residue remaining when wood is carbonized or pyrolised under controlled conditions in a closed space such as charcoal kiln. Charcoal can be obtained from other organic substances such as coconut shell and bones, which provide very important and valuable charcoal for specialized uses[2], but wood is the most frequently used in developing countries. The physical and chemical properties of charcoal depend partly on the carbonization process. In Nigeria, charcoal has a multipurpose value as it can be used for cooking, roasting, dyeing and as the major source of energy for Goldsmith and Blacksmith workers.

The production of charcoal could either be by modern technology or traditional method. However for any method used, the wood should either be allowed to dry up naturally or be artificially dried before being carbonized.

The modern techniques of charcoal production are divided into four broad groups.

- Kiln-basically of the portable or fixed groups.
- Retorts
- Partial retorts
- Furnaces

The traditional technique of charcoal production: The production technique used is the Traditional earth mound kiln. Charcoal producers go into nearby forest to fletch wood or collect already declaimed trees from timber fellers. The woods (sticks) are usually stacked in a rectangular manner with a height of about 4ft, length of about 10 to 12ft and breadth of about 5 to 6ft. Three large woods or logs are used as a platform for the arrangement. The woods are arranged according to sizes starting from the largest at the base and the smallest at the top then a large quantity of dry grasses is used to cover the entire stacked wood, which is in turn covered with soil or layer of earth. A hole of about 10 cm in diameter is made at a position where the initial ignition of the stacked wood will be effected. Two holes each are made on both sides of the stacked wood and one more at the end to allow in limited amount of air thereby given room for an incomplete combustion of the stock. Several small holes are made on the top for the outlet of smoke. These ventilated holes are

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often covered at intervals to regulate the burning of the wood into charcoal. After a section of the stacked wood might have burnt to produce charcoal (about 3-4 days) the fire is put off and the burning continues at the other section. This act may require about 2 to 3 people depending on the quantity of wood to be converted per time. It takes about 8 to 9 days for a stacked wood of about 4ft high, 10 to 12ft in length and 5 to 6ft in breadth to completely burn into charcoal and it is left for 24 to 48 days to effectively cool and ready for bagging. A total of 25 to 30 bags could be obtained from the above-mentioned dimension.

Flow Chart of Charcoal Production

Collection of fuel wood
↓
Cutting and sorting (sizing)
↓
Drying of wood
↓
Stacking and arrangement of woods
↓
Covering with dry grasses and earth layer
↓
Making of ventilated holes
↓
Igniting the stock with fire
↓
Quenching of fire by stamping
↓
Conditioning of charcoal
↓
Sorting of charcoal
↓
Bagging and loading
↓
Charcoal users.

Determination of moisture content: Samples of charcoal from selected wood species were taken for moisture content determination. The samples were cut to a size of 2x2x2 cm. The samples were weighed to determine the initial weight. The samples were taken into the oven, which was regulated to a temperature of about 100°C. The samples were taken out of the oven every 6 h and reweighed until a constant weight was attained (i.e., final dry weight). The values derived were used in determining the moisture content by the following calculation.

$$\text{Moisture content} = \frac{\text{Initial wt} - \text{Final wt}}{\text{Final wt}} \times 100$$

Determination of calorific values: 0.2 g of dry sample was weighted into the steel capsule of the calorimeter. 10 cm cotton thread was attached to the thermo couple to touch the sample inside the capsule. The bomb was closed and charged with oxygen gas up to 30 atmosphere. The bomb was fired by depressing the ignite switch to burn the sample in an excess oxygen. The maximum temperature use in the bomb was measured with the thermo-couple and galvanometer device.

The same process was carried out for 0.2 g of Benzoic acid of known calorific value. The calorific value (Gross energy) of sample was calculated by the following steps.

Mass of Benzoic acid	= W_1 gm
Calorific value of 1gm Benzoic acid	= 6.32 x kcal g^{-1}
Heat released by Benzoic acid	= $6.32xW_1$Kcal
Galvanometer deflection of Benzoic acid	= X
Calibration constant	$\frac{6.32\times W_1}{X} = Y$
If the galvanometer deflection of sample	= Z
Then calorific value of sample	= $\frac{Z\times Y}{0.2}$

Note: Calorific value is the gross energy.
Gross energy can be defined as the energy liberation as heat

Statistical analysis of result: The sources of variation considered in carrying out the analysis of this project are: Wood species, Calorific value, Moisture content.

Completely Randomized Design (CRD): The design was used to estimate the variations in the treatment employed. The main effect was wood species. The design is one way Analysis of Variance (ANOVA) in a completely randomized design.

The mathematical model employed for the analysis

Yij = Individual
U = General mean
Ti = Effect of the treatment
Σij = Experimental error

Table 1: Analysis showing the mean calorific value and the moisture content of the test sample

Parameter	Species	Replicate	Mean	Std. Deviation	Std. Error
Calorific value	Ayin	3	11.62	0.188	0.109
(k Cal g^{-1})	Emin	3	10.09	0.326	0.188
	Iya	3	8.90	0.188	0.108
	Afara	3	8.25	0.188	0.108
Total	mean	12	9.718	1.353	0.391
Moisture	Ayin	3	5.12	0.466	0.269
content (%)	Emin	3	5.60	0.361	0.208
	Iya	3	7.53	0.127	0.073
	Afara	3	5.28	0.028	0.017
	Total	12	5.88	1.040	0.3004

Table 2: Summary of ANOVA for the tested parameters

Parameter	Sum of square	Df	Mean square	F	Sig.
Calorific value (Kcal g^{-1})					
Between group	19.0704	3	6.568	128.818	0.000**
Within group	0.727	8	0.053		
Total	20.128	11			
Moisture content (%)					
Between group	11.179	3	3.726	40.928	0.000*
Within group	0.728	8	0.0911		
Total	11.908	11			

** = highly significant p<0.05

RESULTS AND DISCUSSION

The result showed that the grand mean for the calorific value of the 4 tested charcoal samples from the 4 selected wood species is 9.718 Kcal g^{-1}. *Anogeissus leiocarpus (*Ayin) was found to have the highest calorific value of (11.63 kcal g^{-1}), Emi (10.09 kcal g^{-1}), *Daniella oliveri* (Iya) (8.90 kcal g^{-1}) and the least was *Terminalia superba* (Afara) (8.25 kcal g^{-1}). The average moisture content of all the test samples was 5.88%. *Daniella oliveri* (Iya) had the highest moisture content of 7.53%, followed by Emin (5.60%), *Terminalia superba* (Afara) (5.28%) and lastly *Anogeissus leiocarpus (*Ayin) (5.12%) Table 1.

The result of the one way analysis of variance showed that there are significant differences in the calorific values of the test sample both between and within the four selected wood species (p<0.05). There are also significant differences in moisture content of the samples both between and within the selected wood species (p<0.05) Table 2.

Table 3: Summary of the duncan multiple range test (DMRT) for the tested parameters

Parameter	Species	Replicate	Separated mean
Calorific value	*Terminalia superba (*Afara)	3	8.250a
(Kcal g^{-1})	*Daniella oliveri (*Iya)	3	8.904b
	*Vitellaria paradoxum (*Emi)	3	10.098c
	*Anogeissus leiocarpus (*Ayin)	3	11.618d
Moisture	*Anogeissus leiocarpus (*Ayin)	3	5.123a
content (%)	*Terminalia superba (*Afara)	3	5.277a
	*Vitellaria paradoxum (*Emi)	3	5.600a
	*Daniella oliveri (*Iya)	3	7.527a

*Mean with the same alphabet are not significantly different (p<0.05)

Table 4: List of species used in charcoal production in the study area

Scientific name	Local name	Status
Anogeissus leiocarpus	Ayin	*
Vitellaria paradoxum	Emi	**
Terminalia superba	Afara	**
Afzelia africana	Apa	***
Daniella oliveri	Iya	***
Afzelia bipindensis	Ayan	*
Hallea ciliata	Abura	*
Melicia excelsa	Iroko	*
Afromorsia laxiflora	shedun	
Triplochiton scleroxylon	Arere	**
Cylicodiscus gabunensis	Okan	**
Lovoa trichilioides	Asala	***
Tectona grandis	Teak	*
Nauclea diderrichii	Opepe	***

Source: Field survey 2005, *Rarely available, **Available, ***Readily available

CONCLUSION

Anogeissus leiocarpus (Ayin) is the most preferred wood species for charcoal production in the study area. With 11.618 kcal g^{-1} Calorific Value, as obtained from laboratory analysis; this may be the probable reason why it is mostly preferred to other available and selected wood species shown in Table 3. However, it is now relatively scarce in the study area. On this basis it is recommended that Species like *Anogeissus leiocarpus* (Ayin), *Vitellaria paradoxum* (Emi), *Daniella oliveri* (Iya) and *Terminalia superba* (Afara) with high calorific values should be established in plantations to ensure regular supply of the species to the charcoal producers show in Table 4.

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