

## EFFECT OF EXTRACTIVES ON HEATING VALUE OF *GMELINA ARBOREA*

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**FUWAPE, J.A. 1992. Effect of extractives on heating value of *Gmelina arborea*.** The difference in heating value of extractive-free wood and unextracted wood was used in determining the influence of extractives on the heating value of *Gmelina arborea*. Heartwood, sapwood, bark, terminal branches and leaves were extracted with benzene/ethanol solution, absolute ethanol and water. The heating values of extractive-free samples and the unextracted control were measured. The mean percentage contribution of extractives to heating values was 23.2, 20.1, 31.5, 17.0 and 22.1% for heartwood, sapwood, bark, terminal branch and leaves, respectively. Correlation matrix suggested that other chemical components of wood also influenced the variation in heating value.

Key words: *Gmelina arborea* - extractives - heating value

### Introduction

Extractives and other chemical components of wood affect its properties and use. Extractives are the components of the tree which can be removed by water and neutral organic solvents such as alcohols, benzene and ethyl ether. The proportion of extractives varies with different parts of the tree from 1 to 30% (Anderson 1962, Wang & Huffman 1982).

The extractive content in wood affects its specific gravity, durability and pulping characteristics. Research has also shown that combustion characteristics of trees are affected by the composition of extractives. Wang and Huffman (1982) reported that the contents of extractives of *Melaleuca guinguenervia* and *Eucalyptus grandis* had statistically significant effect on the heating value. The leaves of *M. guinguenervia* which contained 26.8% extractives had heating value of 12.29 MJ kg<sup>-1</sup> while the bark, terminal branch, heartwood and sapwood which contained 21.1, 9.1 and 2.7% extracts had heating values of 13.33, 10.96, 11.01 and 10.83 MJ kg<sup>-1</sup>, respectively. The trend followed by *E. grandis* was different. The bark that contained 15.0% extractives had heating value that was less than that of the heartwood which contained 5.1% extractives; this was attributed to the high ash content of the bark.

Lucas and Fuwape (1982) reported variation in heating value of different parts of *Gmelina arborea* but no study has been carried out on the relationship between its combustion characteristics and extractive composition. The aim of this study was to determine the proportion of extractives in different parts of *G. arborea* and its influence on the heating value.

## Materials and methods

The materials for the study were collected from the *G. arborea* plantation in J4, Omo Forest Reserve, Ogun State; the Jebba pulpwood plantation, Kwara State; and the Awi plantation in Oban Forest Reserve, Akwa Ibom State. Nine trees were randomly selected from 7-y-old compartments in the plantations. Discs were cut from each tree at four levels (3, 30, 60 and 90%) of height. Samples of bark, sapwood and heartwood were also collected from each disc. Specimens were also randomly selected from terminal branches and leaves. The samples were pulverized and the fraction that passed through a 60-mesh screen but was retained on a 80-mesh screen was extracted according to ASTM D1105-56 in a Soxhlet apparatus with ethanol/benzene solution, followed by 95% ethanol and distilled water.

Compounds in the extractives were isolated using paper chromatography, thin layer chromatography (T.L.C.) and column chromatography according to standard method (Vogel 1973, Giwa 1975, Okogun 1983). Attempts to identify the compounds in the extractives were made by spraying the T.L.C. plates and paper chromatogram with diazotised sulphanilic acid solution (D.S.A.) to identify the presence of phenolic compounds and 2,4 dinitrophenylhydrazine reagent (2,4 DNPH) to detect the presence of carbonyl compounds, aldehydes, ketones and esters. On spraying the T.L.C. plates with 2,4 DNPH, presence of carbonyl compounds resulted in yellow colouration while esters gave purple spots when the plates were warmed. Development of purple colour when chromplates were sprayed with D.S.A. indicated possibility of the presence of phenolic compounds.

Infra-red (I.R.) spectroscopy and N.M.R. spectroscopy test on eluates and functional group tests for carboxylic acids and phenols were also carried out. Determination of heating value was carried out according to ASTM 2015 standard. The loss in heating value due to removal of extractives from wood was used to determine the effect of extractives on the heat of combustion.

## Results and discussion

There were variations in the extractive composition and heating values of different parts of *G. arborea* as indicated in Table 1. The variations in the extractive content of the heartwood, sapwood, bark, terminal branch and leaves on a tree, and between trees on the same and different sites were statistically significant at 5% level. Significant differences also occurred in combustion characteristics of extractive-free and unextracted materials from heartwood, sapwood, bark, terminal branch and leaves.

The influence of extractives on heating value was likely due to the type of compounds in the extracts. Attempts made to identify the compounds in the extracts revealed that extracts removed by benzene/ethanol solution gave higher RF(0.59). This suggested that most of the non-polar compounds like esters, fats, carotenoids and lipids were likely extracted by benzene/ethanol solution while comparatively low RF values by ethanol extraction indicated the possibility of the presence of more polar compounds like phenols, catechols and tannins. The

**Table 1.** Percentage contribution of extractives to heating values of *Gmelina arborea*

Source of sample	Extractive contents %	Heating value of unextracted material <i>MJ kg<sup>-1</sup></i>	Heating value of extractive-free material <i>MJ kg<sup>-1</sup></i>	Additional heat due to extractive <i>MJ kg<sup>-1</sup></i>	% contribution of extractives to heating value
<b>J4 OMO</b>					
Heartwood	5.1	25.23	19.63	6.62	25.93
Sapwood	5.7	24.93	21.11	5.04	19.85
Bark	15.8	26.06	19.37	9.80	37.52
Terminal branch	9.7	24.90	21.82	5.15	20.66
Leaves	14.1	25.29	22.51	5.98	23.46
<b>JEBBA</b>					
Heartwood	12.4	27.03	22.92	6.99	25.89
Sapwood	11.7	26.60	22.18	7.02	26.32
Bark	23.3	23.24	20.29	7.66	32.98
Terminal branch	10.0	25.56	22.59	5.26	20.59
Leaves	12.0	24.88	21.36	6.08	24.45
<b>AWI</b>					
Heartwood	9.8	22.64	20.66	3.99	17.74
Sapwood	7.8	22.61	21.07	3.17	14.11
Bark	21.6	22.84	22.10	5.54	24.25
Terminal branch	9.3	24.81	23.66	3.37	13.61
Leaves	16.0	23.99	23.16	4.53	18.53

developed chromatogram of extractives from wood and bark of *G. arborea* gave resolution into four layers: greenish yellow, yellow, light brown and brown. The extract from the leaves gave resolution into a yellowish green (chlorophyll-b), bluish green (chlorophyll-a), yellow (xanthophyll and carotene) and brown (phenolic compounds) layers. Presence of phenolic compounds in the brown eluate was confirmed by the solubility of the eluate in 5% sodium hydroxide and 5% sodium bicarbonate solutions, the brown eluates also gave red colouration when 0.05 g of it was dissolved in ferric chloride.

The infra-red (I.R.) spectra and the results of compound analysis showed that the wood extracts contained fats, carboxylic acids and phenolic compounds. The bark contained more phenolic compounds than the wood or any other part of the tree while the branch contained comparatively a lower quantity of extractives than the bark and wood.

The average heating value of extractive-free and unextracted material and the calculated contribution of total extractives to heat of combustion of samples indicated in Table 1 suggest that the presence of extractives positively contributed to the heating value of extractive-free and unextracted materials. Results of correlation analysis showed that there were statistically significant correlations between average heating value of extractive-free material and additional heat due to the presence of extractives at 5% level of test.

The average percentage contribution of extractives to heating value of bark (31.5%) was greater than those of heartwood (23.2%), sapwood (20.1%), leaves (22.1%) and terminal branch (17.04%) as indicated in Table 2. These differences in percentage contribution of extractives to heating value are due to differences in compounds in the extractives and the possible effect of other chemical components such as lignin, cellulose, hemicellulose and ash-forming minerals.

**Table 2.** Mean heating values of extractive-free and unextracted material from *Gmelina arborea*

	Heartwood	Sapwood	Bark	Branch	Leaves
Mean heating value of unextracted wood $MJ\ kg^{-1}$	25.54 ± 0.6	24.7 ± 0.7	23.71 ± 0.7	25.1 ± 0.3	24.51 ± 0.4
Mean heating value of extractive-free material $MJ\ kg^{-1}$	21.07 ± 0.59	19.1 ± 0.8	18.6 ± 0.8	22.95 ± 0.4	22.29 ± 0.5
Mean % extractives	9.1 ± 1.2	8.4 ± 1.4	21.0 ± 1.4	8.9 ± 0.7	14.0 ± 0.9
% Contribution of extractives to heating value	23.2 ± 3.0	20.1 ± 3.0	31.5 ± 2	17.0 ± 2.3	22.1 ± 1.7

Although the average contribution of extractives to the heating value of the bark was 31.5%, the bark had a heating value (on dry basis) that was not significantly different from those of other parts of the tree (at 5% level of test) because it contained a high ash content. This result is similar to previous reports that the tree bark contains more ash-forming minerals than wood and terminal branch (Chow & Rolfe 1989, Fuwape 1989) and that ash in fuel material reduces its heating value (Harris *et al.* 1986). High composition of lipids and terpenoid hydrocarbons in the leaves and branch may be responsible for their greater heating values. Lipids and terpenoid hydrocarbons, containing mainly carbon and hydrogen, produce more heat energy when combusted than phenolic compounds which contain several hydroxyl groups (Wang & Huffman 1982).

### Conclusion

The extractives of the heartwood, sapwood, bark, branch and leaves of *Gmelina arborea* positively contributed to the heating value; removal of the extractives caused reduction in the heat of combustion. Though the bark had the highest extractive content, its heating value was not significantly different from those of other parts of the tree due to differences in the chemical components of the extractives.

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