Comparative Evaluation of Moisture Content and Natural Durability within Two Borassus Aethipoum Mart. against Termites

J. Boakye Acheampong[1], A. Kwaku[2], E. Wenia Achana[3]

[1]Department of Wood Science and Technology, Kwame Nkrumah University of Science and Technology, Kumasi - Ghana.
[2]Department of Construction and Wood Technology Education, University of Education - Winneba, Ghana & Department of Wood Technology, Tamale Technical University, Tamale, Ghana
[3]Department of Construction and Wood Technology Education, University of Education - Winneba, Ghana

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ABSTRACT:- *The decline in traditional wood species necessitates research into alternative Non–Timber Forest Products (NTFPs). Efficient applications of NTFPs like Borassus aethiopum needs comprehensive research into the male and female varieties. Data on B. aethiopum varieties as substitute to wood species seem less documented regarding Moisture Content and natural durability. This study evaluated moisture content and mass loss relationships within B. aethiopum varieties on field test against termite. The specimens were taken from the axial and radial positions. The dry moisture content was assessed with oven-dry method while mass loss was determined after a year insertion of B. aethiopum stakes on experimental field. Data analysis using origin 8.5 and further Tukey's Honestly Significant Difference revealed linear moisture content increase along the bole of both varieties. The base peripheries from both varieties were more durable (0–5%), middle peripheries from both varieties and the base core from the male were durable (6 – 10%). The base core from the female was moderately durable (29.11%). The crown peripheries, middle and crown cores from both varieties were non-durable (41–100%). The results obviously identified the base and middle peripheries to have less MC and more resistance to termite degradation. Generally, the male variety was noted more resistance to termite degradation than the female. The cores from both varieties were easily susceptible to termites and further preservative treatment would be required for their potential applications.*

Keywords: *Borassus aethiopum,* Core, Degradation, Natural Durability, Periphery, Termites

1. INTRODUCTION

Wood utilization keeps on escalating, but primary wood species adversely dwindle annually due to the huge demand for various applications. Wood is considered the most essential natural forest biomaterial which is available, in use and versatile for constructional purposes globally [1]. Research into alternative Non-Timber Forest Products (NTFPs) like palms (*Borassus aethiopum*) which has potential applications to substitute primary wood species sound promising. Palm cultivation in tropical regions are increasing with the focus primarily on *Cocos nucifera, Phoenix dactilifera, Elaeis guineesis*, but *B. aethiopum* which is native to Indian sub-continent, parts of southeast Asia and Africa are cultivated for its fruit, sap, edible sprouts, and foliage [2]. The structure of *B. aethiopum* as monocot are entirely different from traditional dicots and effective applications of *B. aethiopum* wood as an alternative require comprehensive assessment of its properties like moisture content (MC) and natural durability against termites.

Natural durability of wood signifies its resistance to attacks by biodeteriogens. This resistance against biological degradation and moisture permeability for long period of time is known as natural durability of wood [3]. Wood species are biologically attack by termites, fungi and other microorganisms due to the amount of cellulose and MC which serve as nutrients and threaten the service life of wood [4]. Effective and engineered wood applications need better evaluation of their durability properties in relation to MC to ascertain the appropriate end utilizations and the need for possible preservation treatment against termites [5]. Wood expose to MC above Fibre Saturation Point (FSP) are favorable to bio-deteriorating agents like termites and often decompose rapidly. Termites resistance to wood are essential to potential wood users and makes it necessary in determining the natural durability characteristics of *B. aethiopum* to detect its main utilizations regarding various positions along the bole.

B. aethiopum mart has multipurpose and multifunctional applications including stakes, shelter, thatching, composites, food supply, economic enhancement as well as biodiversity protection [6]. They have been classified into male and female varieties with their stems consisting periphery, core and pith along the bole. The English names for *B. aethiopum* include Giant Africa Palmyra Palm, African fan palm, Deleb palm, Ron palm, Elephant palm and others [7]

Wood is hygroscopic, and its MC varies with temperature as well as Relative Humidity (RH) of its surroundings [8]. Moisture in wood has been an essential element for all biological agents attacking wood. Virtually, wooden elements eventually develop some moisture related issues due to their exposure to environment resulting in biodegradation [9]. Termites are extremely aggressive and usually built their colonies to severely attack treated and untreated wood in service. Moisture exclusion or reduction has essential role in limiting termite attacks in wood. Termite susceptibility to wood often result from proportional differences of sapwood and heartwood in dicots, periphery and core in monocots, but are minimized by lowering MC. Insects such as termites and other bio-degraders usually attack wood whenever is in contact with ground as well as excessive moisture [10]. Adequate knowledge about wood durability provide series of information on possible applications and aid in predicting the service life [11]. Woods species differ in their susceptibility to termite attacks but natural durability of wood in direct ground contact depends on differences in heartwood and sapwood distribution, climatic conditions, density, MC and chemistries within and among wood species.

Wood from palms are traditionally regarded as non-durable which require preservative treatment especially for exterior applications [12]. This research sought to evaluate MC and natural durability variations among *B. aethiopum* varieties to termite resistance on field trial. Field tests can be costive and time consuming but reliable means of predicting the service life of wood species to ascertain the most resistant positions along and across the boles as well as their suitability for various applications [13]

2 Materials and methods

2.1 Wood selection and MC evaluation

The two *B. aethiopum* varieties of about fourty years were harvested from Kobriso (Semi-arid forest zone in the Offinso North District of Ashanti Region) in Ghana. Their diameter range were between 0.20 m to 0.50 m at the breast height of 1.5m above ground level with a height range of 15 –20m. Each specimen (110cm) was taken from three main positions: 2.4m of the base, 10.6m from the middle and 18.8m of the crown from the ground. The boles were sawn radially (periphery and core) from the axial (base, middle and crown) positions. Ten replicates each from the radial and axial (20 x 20 x 20 mm) positions were used for dry MC determination using oven-dry method [14]. The sawn discs were oven–dried at 103 ± 2 °C, cooled in desiccators until constant weight were attained. Dry MC of the specimens were expressed as the percentage of the oven-dried weight of the specimens:

$$MC\ (\%) = \frac{W_1 - W_0}{W_0}\ X\ 100 \quad (1)$$

W_1 = Initial weight of specimens (g).

W_0 = Oven–dried weight of specimens (g).

2.2 Preparation and insertion of *B. aethiopum* stakes for natural durability evaluation

Defect free dry boles were sawn into billets in two main directions (Radial and axial). The specimens were taken from the periphery and the core along the bole and critically examined to ensure that they were free from natural and artificial defects. The specimens were further ripped, crosscut and planed measuring 25 × 50 × 500 mm (radial × tangential × longitudinal) and air-dried for the natural durability evaluation [15]. Ten specimens each from the periphery, core of the base, middle and crown were weighed before and after tagging to determine their weights before insertion in the experimental test field. The test field had neither been cultivated or had agrochemical application previously. The stakes were vertically inserted randomly with one-third length in the soil as displayed in Figure 1.

Figure 1: *B. aethiopum* stakes inserted in the test field for natural durability evaluation at FRNR (KNUST) Experimental Field.

During the field test, it was visually observed that termites colonized the core portions where vascular bundles was less but with more MC excessively than the peripheral zones with enough embedded vascular bundles but less MC. The specimens were visually inspected and rated monthly for a year to identify signs of termite attack in their respective positions in accordance with [15] as displayed in Table 1 and Figure 2.

Table 1: Visual natural durability rating of *B. aethiopum*

Rating	Descriptions	Features
0	No attack	No evidence of attack
1	Slight attack	Limited evidence of attack
2	Moderate attack	Significant evidence of attack
3	Severely attack	Strong evidence of attacks
4	Failure	Total failure or destruction of specimens

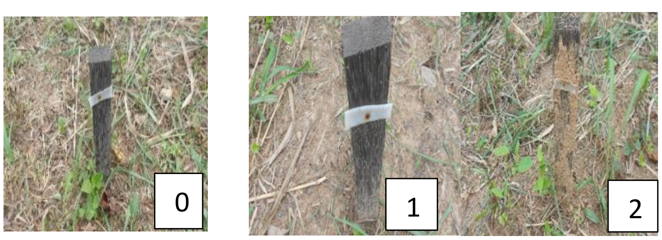

Fig. 2a **Fig. 2b** **Fig 2c**

Fig. 2d **Fig. 2e**

Figure 2: Termites attack rating of stakes during field test at KNUST

2.3 Mass loss evaluation of *B. aethiopum* stakes

The stakes were exhumed after a year, dried for 72 hours after which the soil particles were brushed off. The stakes were weighed and oven-dried at 103±2ºC for 24 hours and reweighed. Mass loss were determined after equilibrated moisture levels of the stakes. The corrected oven-dried (M_1) was determined by the formula:

Corrected oven dry weight

$$M_1 = \frac{100 - M2}{100 + \%\,MC}\ X\ 100 \qquad (2)$$

M_2 = Weight before insertion

%MC = Percentage moisture content after insertion

The percentage mass loss of each stake after insertion was also determined as:

$$\text{Mass loss } (\%) = \frac{M1 - Mf}{M1}\ X\ 100 \qquad (3)$$

Where:

M_1 = The corrected oven – dried weight

Mf = The final oven –dried weight

The percentage mass loss of stakes was rated as very durable (0–5%), durable (6–10 %), moderately durable (11–40%) and non-durable (41–100%) [16].

2.4 Statistical analysis

Single Factor One-way Analysis of Variance (ANOVA) using Origin 8.5 was employed to assess the significant difference ($P<0.05$) between the specimens within each bole. Turkey's Honestly Significant Difference Multiple Comparison Test was used to test the statistical significances of each pair of means from each variety. The mean values with standard deviations in brackets are listed in Table 2. Values in the same column with same letter are not significantly different ($P<0.05$).

3. Results and discussion

3.1 Dry MC between and within stem positions of *B. aethiopum*

The amount of moisture within wood species play significant role in assessing durability resistance to termites and strength properties of wood are often associated with MC [17]. Several research findings including [18] – [19] on palm trunks revealed a gradual increase in MC along the bole and towards the central regions, with the periphery and base portions having far less MC than the core and crown portions. Higher MC is susceptible to termite colonization and severe attacks until the wood is approximately below FSP [20]. Results from this study confirmed these findings with the dry MC around equilibrium moisture content (12%) as indicated in Figure 3 with dash lines showing linear increase from the base to the crown for both peripheries and cores along the bole of both *B. aethiopum*.

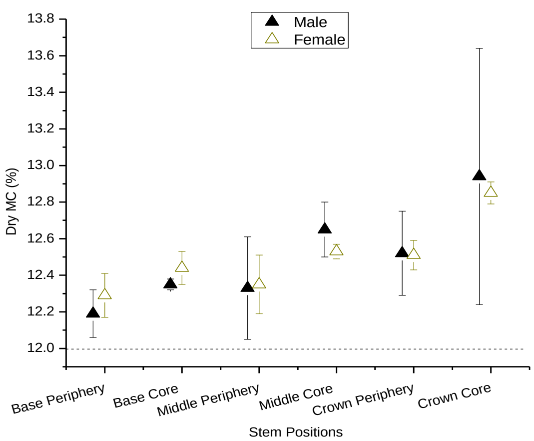

Figure 3: Dry MC within two varieties of *B. aethiopum*

The peripheries in general had least MC along the bole. The male variety recorded least MC between base and middle peripheries but contrary to between middle and crown cores of the two studied varieties. This trend imply positions with less MC could have minimal dimensional changes, greater densities, superior termite resistance than where MC is higher. Thus, the lower the wood MC, the longer it will last against biological agents as dry wood has prolong service life than partly dry or unseasoned wood when exposed to identical hazardous environments. This contributing factor could enhance termite resistance and greater strength properties as portions with less MC (peripheries) may be more durable than the cores with higher MC.

3.2 Mass Loss between and within stem positions of *B. aethiopum*

The percentage mass loss had steady axial increase from the base through the middle to the crown for both varieties. The requirements of mass loss for natural durability evaluation set out by [16] include very durable (0–5%) and durable (6–10%) which are represented by red and black dashed lines respectively as benchmark values displayed in Figure 4.

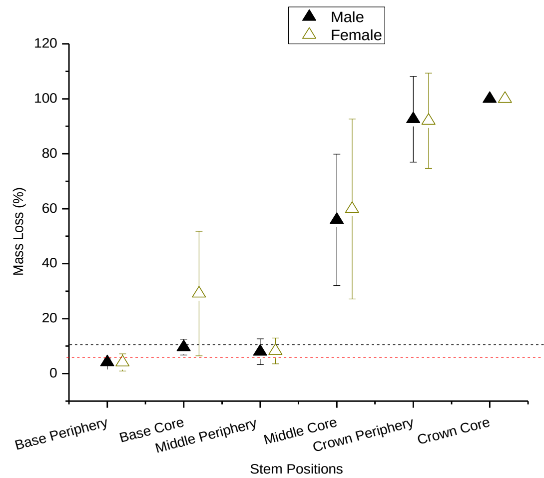

Figure 4: Mass loss among two varieties of *B. aethiopum*

Radially, mass loss also increased along the bole from periphery to the core for the two varieties. This explains that termites extremely attacked the cores but could not devour the peripheries which affirms [21] findings that, natural durability of most tropical wood species varies radially. The minimal mass loss of the peripheries in relation to termite resistance could be ascribed to the higher inherent chemical extractives, hardness, embedded vascular bundles, lignin, as well as less MC and ash content of the wood [22] – [23]. The linear increase in natural durability along the boles could further be associated with both radial and axial differences, woody tissue density as well as sugar and starch content [24] – [12]. The two *B. aethiopum* varieties had less than 5% and 10% mass loss for the base and middle peripheries respectively which show their extreme durability characteristics than their core counterparts. The more resistance of these peripheries to termites could also be ascribed to the embedded vascular bundle at the peripheral positions along the bole. The excessive degradation of the core portions among both varieties by termites occur when cellulose cell walls are broken which result in mass loss around 80% of its dry weight and value. These cellulose components serve as wood carbohydrates which make wood mostly susceptible to termite degradation [25]. These affirm variations in the natural durability between and among wood species [26] – [27].

3.3 Relationship between MC and mass loss in natural durability evaluation

The natural durability of wood species is related to its ability to maintain a low level of MC [28]. MC often exceeding 20% result in biological attacks of wood components (hemicellulose, cellulose and lignin) which lead to mass loss and subsequent degradation by termites, fungi and other microorganisms [29] – [30]. Findings from this study displayed in Figure 5 is in consonance with previous studies on palms by [19] where less MC was found at the base and peripheral positions along the bole. This hinder excessive mass loss and enhance termite resistance at peripheral positions unlike the core and central portions. All cores within the two varieties had higher MC, mass loss and excessively devour by termites. This could be due to the linear increase in parenchyma tissue, sugar and starch, MC from peripheral to core positions and from the base to the crown along the bole which made palms more susceptible to excessive termite colonization as well as mass loss at the core positions.

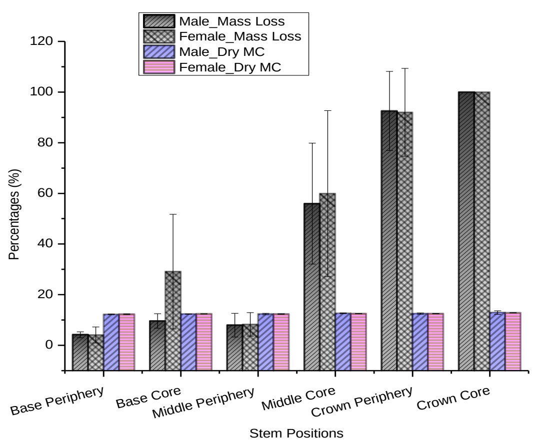

Figure 5: Relationship between MC and mass loss in natural durability evaluation

Table 2: Natural durability and Tukey's Honestly Significant Differences within *B. aethiopum* varieties

Properties	Stem positions		Varieties	
	Radial	Axial	Male	Female
Dry moisture content (%)	Periphery	Base	12.19^{d} (0.13)	12.29^{C} (0.12)
		Middle	12.33^{cd} (0.28)	12.35^{BC} (0.16)
		Crown	12.52^{bc} (0.23)	12.51^{AB} (0.08)
	Core	Base	12.35^{cd} (0.03)	12.44^{BC} (0.09)
		Middle	12.65^{ab} (0.15)	12.53^{A} (0.04)
		Crown	12.94^{a} (0.70)	12.85^{A} (0.06)
Mass loss (%)	Periphery	Base	4.17^{c} (1.19)	4.07^{D} (3.15)
		Middle	7.97^{c} (4.69)	8.26^{D} (4.67)
		Crown	92.56^{a} (15.70)	92.00^{A} (17.34)
	Core	Base	9.62^{c} (2.87)	29.11^{C} (22.66)
		Middle	55.95^{b} (23.90)	59.89^{B} (32.77)
		Crown	100.00^{a} (0)	100.00^{A} (0)

The peripheral specimens from both varieties typically showed superior natural durability characteristics irrespective of their positions along the bole compared to those from the cores except in few cases where the difference was insignificant. Although specimens from the core positions had inferior natural durability properties but preservative treatments could enhance them for probable applications exteriorly. Generally, all specimens from the base and middle peripheral positions irrespective of the *B. aethiopum* variety had better natural durability resistance.

4. CONCLUSIONS

Evaluation of natural termite resistance against wood species has become very essential due to the focus of finding alternative durable wood species for various applications.

- The peripheries at the base and middle from both varieties could be much useful in exterior and structural application such as roofing, decking and paneling without preservative treatment.
- The core portions especially from the middle and crown could be recommended for interior applications and light works like cork for bottling, pencils, and packaging due to their less natural durability properties.
- The peripheral base and middle of both *B. aethiopum* have the potential requirements as alternative to primary timber species.
- The outcome of this study suggests that the male variety is more durable than the female.

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BIOGRAPHIES

Mr. J.B. Acheampong holds B.ed Technology Education and MSc Wood Science. He is Ghanaian based writer and researcher in Technical Education and Wood Science and Technology

Dr. Kwaku Antwi is Ghanaian based university lecturer and researcher. He holds Bachelor's, masters and PhD in Wood Science and Technology and currently head of Wood Technology Dept. of Tamale Technical University, Ghana.

Mr. E. W. Achana is a holder of B.ed Technology Education and MPhil in Wood Science and Technology. He is Ghanaian educationist and District GNAT secretary.