

NATURAL DURABILITY OF KHAYA GRANDIFOLIOLA STEM AND BRANCHWOOD AGAINST TERMITE INFESTATION

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Abstract:

The decay of wood results in weight loss which was used as a measure of durability level. The approach assumed that weight loss is directly related to natural durability. This study was therefore carried out to compare the wood quality of stemwood of Khaya grandifoliola to its branchwood with emphasis on its natural durability. The study followed a field test in accordance with the method developed by Lenz et al, 2003. Wood samples for the study were obtained from a harvested single tree of Khaya grandifoliola and converted in to different dimensions for wood properties determination. Moisture content and specific gravity were determined. Termites' resistance test (field test) was carried out in a secured location for a period of 20 weeks. The experiment was laid out in a 3³ factorial in a completely randomized design. Data obtained were subjected to analysis of variance and descriptive statistics at $\alpha = 0.05$. Result revealed that stem wood had the highest mean specific gravity, followed by primary branchwood and the least specific gravity from secondary branchwood. Although variations exist among wood types, the SG of stemwood and primary branchwood were not significantly different. Result also showed that Stemwood had least percentage weight loss of 4.67% compared to primary branchwood and secondary branchwood against termite's attack. Based on visual rating of wood, stemwood obtained a visual rating of 1 (slight attack) while primary and secondary branchwood obtained a visual rating of 2 (moderately attack). Both stem and branchwoods were classified respectively as very durable and durable against termite's resistance. This indicates that branchwoods have similar service life to their stemwood irrespective of the difference in the durability status of stem and branchwood of this species, it could be proposed that where the stemwood is applicable in terms of durability requirements, the branchwood could also be used as supplement.

Key words: natural durability; branchwood utilization; stemwood; wood decay resistance; Khaya grandifoliola, percentage weight loss; specific gravity.

INTRODUCTION

Nigeria has extensive community forests which produce a diverse range of wood species. However, most of the wood species from the community forests are highly vulnerable to wood-destroying organisms such as insects and fungal decay. It has been reported that of more than 6,000 wood species in Nigeria, most of them (80–85%) are regarded as poor quality due to their low natural durability. Furthermore, there is a profound lack of knowledge on their characteristics and uses. Outdoor utilisation of wood is limited due to its susceptibility to biodegradation. It is a common practice among wood users to purchase wood and use directly for construction work without knowing the durability characteristics of such species or a preservative treatment process (Owoyemi and Olaniran 2014). This could be as a result of lack of knowledge about the

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natural durability status of some of the Nigerian wood species, users only rely on experience acquired over the years, but which is no longer reliable because of dwindling supply of mature timber from the forest.

Natural durability is the inherent ability of wood species to resist biological deterioration or withstand attack by wood destroying organisms such as bacteria, fungi, insects and marine borers without preservative treatment (Tsunoda 1990; Highley 1999, Cartwright and Findlay 1958). Wood as a natural polymer consists primarily of cellulose, hemicelluloses, lignin and extractives in a matrix that provides structural support to the living tree and some resistance against microbial attack. Cellulose, because of its partial crystallinity, is somewhat resistant to microbial attack. Lignin is a heterogeneous polymer of phenyl propane units and is extremely resistant to some decay fungi. Natural durability varies between wood species and is explained mainly by the composition and amount of wood extractives. Extractive deposits formed during the conversion of sapwood to heartwood often make the heartwood of some species more durable since generally higher heartwood extractive content imparts higher decay resistance of wood species (Onuorah 2000; Pometti *et al.* 2010). Lignin content adds to the natural durability as found in birch and pine. Knowledge about natural durability is obtained by field and laboratory tests as well as by practical experience of the end users (Willeitner and Peek 1997; Gierlinger *et al.* 2003). Moisture has great impact on wood durability and service life because it is a prerequisite of vital importance for the wood destroying organisms. On the other hand, the most realistic description of microbiological deterioration is the monitoring of specific gravity changes by weight loss and decrease of some strength characteristics. The unity of specific gravity, strength and wood durability is even standardized (EN 113 and EN 252) to give a comprehensive description of wood behaviour.

The importance of forest trees in a nation's economy cannot be over-emphasized. Increasing market demand of timber species both locally and internationally have resulted in their overexploitation, thereby rendering some species like *Khaya grandifoliola* endangered (Poku *et al.* 2001). The forest situation in Africa poses enormous challenges to its economic development agenda. On account of decreasing raw material supply and the environmental concerns about the depletion of the tropical forests, industrial utilisation of branches and roots has been a subject of interest to researchers and industry. In the estimation of Hilton (2001), branch wood represents 25-30% of the total wood volume. Even though branchwood represents a secondary resource its potential utilisation has less been investigated therefore it is essential that this be carried out to ensure sustainable production of durable timber to wood users. Increasing the added value of branches indicates finding alternative uses other than firewood or particleboard for wood-based panels (Gurua *et al.* 2008) and this will make more wood available for construction once its technical properties are ascertained.

Branchwood could potentially serve as a substitute for stem wood if its qualities (natural durability, specific gravity; physical and mechanical properties) are known and understood (Cionca *et al.* 2006). Knowledge of durability of wood and its properties allows for better optimization, minimal use of raw material and characterisation of their behaviour in different end-use applications (Van de Kuilen and Blass 2005). However, since information on the wood properties of *Khaya grandifoliola* branchwood is limited, particularly with respect to its utilisation, therefore in an effort to promote branchwood utilisation, it is imperative that the natural durability of the species be investigated as such study will provide useful information towards its utilisation potentials. It has been reported that *Entandrophragma cylindricum* and *Khaya* species have branches of about 25 and 64%, respectively per tree volumes (Dadzie 2013), which could be used as supplements to their stemwood in new value-added products, like garden furniture. Due to the foreseen consequential threat of wood raw material extinction to the future of wood and construction related industries in particular, human activities and livelihood in general, researchers are exploring the use of branchwood of tropical hardwood as supplements to their stemwood. This study was conducted to assess the natural durability of branchwood of *Khaya* compared to their stemwood to ascertain whether the branchwood can supplement their respective stemwood in any application in terms of durability.

MATERIALS AND METHODS

Study Site

Wood samples for the study were collected from a harvested 50 years old *Khaya grandifoliola* tree within the, University of Ibadan, Oyo State, Nigeria. It is located north of Ibadan along Oyo road at approximately latitude 7.44°N and longitude 3.89°E in an altitude of 249m above sea level. It falls within the humid region which is characterized by wet and dry season. The vegetation pattern of Oyo State is that of rain forest in the South and guinea savannah in the North.

Data Collection and Sampling Procedure

Logs were converted in-situ, and promptly transported to the wood workshop unit of the Department of Forest Resources Management, University of Ibadan. Harvested logs were sectioned into main bole (stem), primary branches and secondary branches. A 60cm length billets were obtained from the base, middle and

top of the stem wood, two primary branches and four secondary branches, given a total of 21 billets. Central plank was also obtained from each billet from top, middle and base of stem wood and branches and were partitioned into inner wood, middle wood and outer wood for further conversion to test samples.

Preparation of wood blocks samples for Natural durability and Specific gravity test

Wood samples of 2cmx2cmx 60cm were obtained from each central plank and were further converted into dimensions of 2cmx2cmx6cm and 2cmx2cmx2cm samples which were used for natural durability and specific gravity determination respectively. Wood samples of 2cmx2cmx6cm were selected from each radial zone (inner, outer and middle) and axial position (base, middle and top) of stemwood, two primary branches and four secondary branches for natural durability test. The samples were replicated 5 times making a total of 315 wood samples as shown in Table 1.

Determination of specific gravity

Specific gravity (SG) of *Khaya grandifoliola* wood samples was obtained using cubes wood of 2cmx2cmx2cm. Wood samples were subjected to a gravimetric procedure developed by Smith (1954) in which test specimen were completely saturated with water by boiling. Each cube was removed from water, blotted to remove excess water, weighed (W_s) and oven-dried (W_o) to a constant weight at $103\pm 2^\circ\text{C}$. Specific gravity was determined using Equation 1.

$$G = \frac{1}{\frac{W_s - W_o}{W_o} + 1.53} \quad 1$$

where: G = Specific gravity;
 W_s = Saturated weight of wood;
 W_o = Oven dry weight of wood;
 1.53 = Actual weight of wood substance.

Table 1

Preparation of wood blocks samples for natural durability test (field test)

Wood Type	Axial Direction	Radial Direction	No.	Replicates	Total number of Samples	
Stemwood	Base	1	Outer, Middle and Inner wood	3	5	15
	Middle	1	Outer, Middle and Inner wood	3	5	15
	Top	1	Outer, Middle and Inner wood	3	5	15
	Total samples for stem			9		45
Primary branch wood	Base	2	Outer, Middle and Inner wood	6	5	30
	Middle	2	Outer, Middle and Inner wood	6	5	30
	Top	2	Outer, Middle and Inner wood	6	5	30
	Total samples for primary branches			18		90
Secondary branch wood	4 Secondary branches					
	Base	4	Outer, Middle and Inner wood	12	5	60
	Middle	4	Outer, Middle and Inner wood	12	5	60
	Top	4	Outer, Middle and Inner wood	12	5	60
Total samples for primary branches			36		180	
Total samples for this experiment					315	

Natural durability

The natural durability of stemwood and branchwood of *Khaya grandifoliola* was assessed by applying the below ground exposure method (field test) in accordance with Lenz *et al.* (2003) and European Standards EN 113 (1996) for 20 weeks' period. Quartey *et al.* (2008) and Quartey (2009) have acceptably evaluated the natural durability of some lesser-known Ghanaian hardwood species within 6 months based on the standard EN 252 (1989). The study measured natural durability in terms of percentage weight losses (%WL) and visual rating of the extent of destruction/attack by biological agents. Weight loss was quantitatively measured on a 4-point percentage scale (Eaton and Hale 1993), while the extent of attack was qualitatively measured on a 5-point visual rating scale according to EN 252 (1989) as shown in Table 2. The test site used for this study has medium to fine texture soil with pore spaces and it is home to a lot of termite mounds and is generally a very high decay hazard zone.

Table 2

Natural durability classes of wood to termite attack using tests based in accordance with Eaton and Hale (1993)

Weight loss (%)	Durability Level
0-5 % loss	Very durable
6-10 % loss	Durable
11-40 % loss	Moderately durable
41-100 % loss	Slightly durable /non-durable

Visual rating scale in accordance with EN 252 (1989)

Level of Attack	Visual Rating
No attack	0
Slight attack	1
Moderate attack	2
Severe attack	3
Failure (completely destroyed)	4

Field Test

Below ground exposure method, according to Lenz *et al.* (2003) was adopted for evaluating the in-ground termite's resistance of stem and branch wood block samples. Five replicates of wood samples (2cmx2cmx6cm) from each axial and radial zone of stemwood and branchwood were oven dried at 103±2°C for 22 hours to constant weight, conditioned and weighed as W_1 . The initial weights (W_1) of the samples were first taken and recorded using sensitive balance before taken to the field. A total of 315 wood blocks from axial and radial direction of stem and branchwood of the specie were buried using below ground method on an agricultural soil situated in a secured location in Kurumi area of the campus at 0.5m apart for twenty weeks with evidence of infestation by termite. At the expiry of 20 weeks, wood samples were carefully exhumed from the ground, washed to remove soil particles, and dried at room temperature and finally oven dried to a constant weight at 103±2°C for 22 hours, conditioned, and re-weighed to a final weight W_2 (Arora 2006; Sarker *et al.* 2006). The Percentage weight loss was determined using Equation 2.

$$W = \frac{W_1 - W_2}{W_1} \quad 2$$

where: W= Wood block weight loss (%);
 W_1 = Oven-dry weight before decay exposure test;
 W_2 = Oven dry weight after decay test.

Experimental design

Experimental design adopted for specific gravity and natural durability test was a 3x3 factorial experiment (3 factors with 3 levels) in a Completely Randomized Design with five replicates for each test sample. Data obtained were analyzed using both inferential and descriptive statistic. Analysis of variance was employed to assess variation patterns in percentage weight loss. The means and standard deviations of the data were subsequently determined. ANOVA was also used to determine significant differences in percentage weight loss among wood types. Where significant difference was detected, the means were separated using Duncan's New Multiple Range Test (DNMRT) at 0.05 level of probability. Charts, tables and graphs were used to present the result of descriptive analyses.

RESULTS AND DISCUSSION

Specific gravity

The mean specific gravity (SG) values for the sampled wood types along axial and radial position was 0.709±0.005 (Table 3) at 10±2% moisture content (MC). The result revealed that stem wood had the highest mean specific gravity of 0.711, followed by primary branchwood 0.710 and the least specific gravity of 0.707 from secondary branchwood. Although variations exist among wood types, the SG of stemwood and primary branchwood were insignificantly different.

The result of this study (Table 3) is in line with the work of Donkor (1997), who reported that specific gravity of *Khaya grandifoliola* varied from 0.60 to 0.70 with mean specific gravity of 0.68 at 12% MC. It is also in agreement with the report of Lavers (1969) on mechanical properties of four *Khaya* species, where he recorded mean specific gravity of 0.73 at 12% MC for same species. The result of this study also contradicts the findings of Hidayat and Williams (1994) who reported mean S.G of same species to be 0.54 at 54% MC.

The observed difference could be as a result of tree age, moisture content, growth rate and environmental conditions, since age and MC have strong influence on specific gravity.

The result also showed that wood types are significantly different while insignificant difference exists within the interactions (Table 4). Although variations exist among the wood types, Duncan Multiple Range Test (Table 5) showed that stemwood and primary branchwood were not significantly different from each other. The result also agrees with the findings of Dadzie and Amoah (2015) who reported that higher specific gravity in branch wood does not translate into significant higher strength and durability class. Moreover, branchwood (primary branch) having a specific gravity value (0.710) that is almost same value with stemwood (0.711) can be compared with previous studies of Okai 2002; Amoah *et al.* 2012; Dadzie and Amoah 2015 where they recorded marginally higher values in branchwoods to its stemwood. This result also confirms the report of Antwi *et al.* (2022) where they recorded high basic density in branchwood of *Nesogordonia papaverifera* (721 kgm⁻³) to that of its stemwood (712kgm⁻³), with no statistically significant difference. Researchers have offered various reasons to explain the relatively high specific gravity values in branchwood compared to stemwood (Fegel 1941; Patel 1970; Haygreen and Bowyer 1996). It has been reported that generally branchwoods grow more slowly and this makes them have shorter cells with thick cell walls that subsequently make them as heavy as or heavier than stemwood (Bannan 1965; Fegel 1941; Patel 1970). Additionally, branchwood is known to contain reaction wood which could also contribute to specific gravity as high as those of stemwood (Tsoumis 1991).

Table 3

Mean Specific gravity of *Khaya grandifoliola* wood types along axial and radial direction

Wood Type	Radial Position	Sampling Height (Radial Position)			Pooled Mean \pm SD
		Base	Middle	Top	
Stemwood	Outerwood	0.716 \pm 0.001	0.711 \pm 0.005	0.711 \pm 0.009	0.713 \pm 0.006
	Middlewood	0.713 \pm 0.009	0.710 \pm 0.005	0.707 \pm 0.003	0.710 \pm 0.006
	Innerwood	0.712 \pm 0.003	0.708 \pm 0.005	0.706 \pm 0.004	0.709 \pm 0.004
Pooled Mean \pm SD		0.714 \pm 0.005	0.710 \pm 0.005	0.708 \pm 0.006	0.711 \pm 0.006^a
Primary branchwood	Outerwood	0.712 \pm 0.004	0.708 \pm 0.005	0.709 \pm 0.007	0.710 \pm 0.005
	Middlewood	0.712 \pm 0.005	0.712 \pm 0.004	0.710 \pm 0.006	0.711 \pm 0.005
	Innerwood	0.709 \pm 0.006	0.709 \pm 0.003	0.707 \pm 0.005	0.708 \pm 0.004
Pooled Mean \pm SD		0.711 \pm 0.005	0.710 \pm 0.004	0.709 \pm 0.006	0.710 \pm 0.005^a
Secondary branchwood	Outerwood	0.711 \pm 0.004	0.709 \pm 0.001	0.705 \pm 0.006	0.708 \pm 0.004
	Middlewood	0.708 \pm 0.007	0.708 \pm 0.001	0.708 \pm 0.004	0.708 \pm 0.004
	Innerwood	0.707 \pm 0.002	0.706 \pm 0.001	0.705 \pm 0.003	0.706 \pm 0.002
Pooled Mean \pm SD		0.709 \pm 0.004	0.708 \pm 0.002	0.706 \pm 0.004	0.707 \pm 0.004^b
Overall Pooled Mean \pm SD		0.711 \pm 0.005^c	0.709 \pm 0.004^d	0.708 \pm 0.005^d	0.709 \pm 0.005

Table 4

Analysis of variance (ANOVA) for specific gravity of *Khaya grandifoliola* wood samples

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-cal.	Sig. level
Wood	2	0.000	0.000	4.679	0.011*
Axial	2	0.000	0.000	5.469	0.005*
Radial	2	0.000	0.00009080	3.374	0.038*
Wood*Axial	4	0.00009141	0.00002285	0.849	0.497 ^{ns}
Wood*Radial	4	0.00008514	0.00002129	0.791	0.533 ^{ns}
Axial*Radial	4	0.00003398	0.000008495	0.316	0.867 ^{ns}
Wood*Axial*Radial	8	0.00007700	0.000009625	0.358	0.940 ^{ns}
Error	108	0.003	0.00002691		
Total	134	0.004			

Values with "*" are significantly different at 5% probability level while values with ns are not significantly different at 5% probability level.

Table 5

Duncan Multiple Range Test (DMRT) for S.G on wood types, axial and radial positions of *Khaya grandifoliola*

Wood type	Subset	
	1	2
Secondary branchwood	0.7076 ^a	
Primary branchwood		0.7103 ^b
Stemwood		0.7106 ^b
Sig.	1.000	0.782
Axial position (sampling height)		
Top	0.70788 ^a	
Middle	0.70927 ^a	
Base		0.71146 ^b
Sig.	0.206	1.000
Radial direction		
Inner	0.70792 ^a	
Middle		0.710129 ^c
Outer		0.710571 ^c
Sig.	1.000	0.686

*Means with same letters in same column are not significantly different ($p > 0.05$) while means with different letters in same column are significantly different ($p < 0.05$).

Natural resistance of *Khaya grandifoliola* wood to termites

The percentage weight loss for wood types significantly ranged from 3.84% in stemwood to 11.64% in secondary branchwood with mean value of 5.79% (Table 6). Stemwood had least percentage weight loss of 4.67%, while primary and secondary branchwood had percentage weight loss of 6.21% and 6.50%, respectively (Fig. 1). *Amitermes evuncifer*, *Macrotermes bellicosus*, *Odontotermes spp.* were the common termite's species identified in the study area degrading the wood samples and filling the voids created with clay materials. Fungal activity was observed on the wood species in the test yard. This could be as a result of prevalent high atmospheric moisture and abundance of soil moisture in the study area. Based on the durability classes of wood to termite's attack in accordance with Eaton and hale (1993) as shown in Table 2, weight loss of 4.67% after 20 weeks of exposure indicates that stemwood of *Khaya grandifoliola* is highly resistance (very durable) against termite's attack while the branchwoods with 6.21% and 6.50% weight loss were considered as resistance (durable) against termite's attack. The result of this study also revealed that the percentage weight loss of wood samples increased insignificantly from base to top along the axial position while it increases from pith to the bark along the radial direction in stemwood and secondary branchwood except in primary branchwood where inconsistent pattern of variation was observed. The fact that branchwoods are reaction wood could be attributed to this inconsistent variation, some characteristics of tension woods deposited in branchwood makes them behave differently from normal wood.

Based on visual rating of wood to termite's attack in accordance with EN 252 (1989), stemwood obtained a visual rating of 1 (slight attack) while primary and secondary branchwood obtained a visual rating of 2 (moderately attack) as shown in Table 7. Both stem and branchwoods were classified as very durable and durable under durability classes. This indicates that branchwoods have similar service life to their stemwood irrespective of the difference in the durability status of stem and branchwood of this species, it

could be proposed that where the stemwood is applicable in terms of durability requirements, the branchwood could also be used as supplement. In stemwood evidence of colour changes were observed while in branchwoods clear changes to a moderate attack were observed with evidence of colour changes. The result of analysis of variance showed that percentage weight loss of wood types and their interactions are significantly different while Duncan multiple range test revealed that primary and secondary branch woods are not significantly different but are significantly different from stemwood (Table 8, Table 9). This difference does not indicate that branchwood of *Khaya grandifoliola* is not a good substitute to its stemwood since both stem and branchwoods were classified as very durable and durable respectively under durability classes.

This result corroborates with findings from literature that the decay resistance may vary among tree species, among individual trees, and within individual trees. Also decay resistance can vary according to the position in the heartwood region. The result also confirms a similar work carried out by Dadzie and Amoah (2015), who reported that *Entandrophragma cylindricum* (sapele), appeared to exhibit better natural durability than its branchwood while *Khaya ivorensis* branchwood appeared comparable to its stemwood in terms of natural durability. Meanwhile, the durability descriptions obtained in the present study for the species appear to agree with previous studies from literature that generally, *Khaya grandifoliola* wood is durable and highly resistance to termite attack (Lemmens 2008; Pleydell 1994). The result of this study contradicts the findings of Owoyemi and Olaniran (2014) who recorded percentage weight loss of 18.60% (moderately durable) in *Khaya grandifoliola* after six months of exposure to termites. The observed difference in durability could be attributed to duration of exposure, tree age, climatic condition and moisture content of the wood samples at the point of exposure. According to the report of Malloch (1997), he stated that the rate and extent of decay that affects properties of timber depends on duration, climatic conditions, moisture content as well as the type of timber and particular types of wood degrading organisms endemic to a specific geographical area which interact to influence the natural durability of wood species. Furthermore, Francis and Norton (2006) reported that in ground contact field test result, the durability of wooden stakes differs between temperate and tropical regions due to temperature and water availability producing diverse rates of biodegradation despite having the same durability classes. The result of this study also contradicts the findings of Chudnoff (1984) who reported that *Khaya grandifoliola* had been classified as moderately durable with no information on test methodology. It must be noted that assigning classes of decay resistance to various species entailed the use of several criteria. The assessments could either use the results of laboratory pure culture decay test or field test but the results cannot be compared since they are not exposed to same environmental conditions and no test methodology was recorded by Chudnoff (1984).

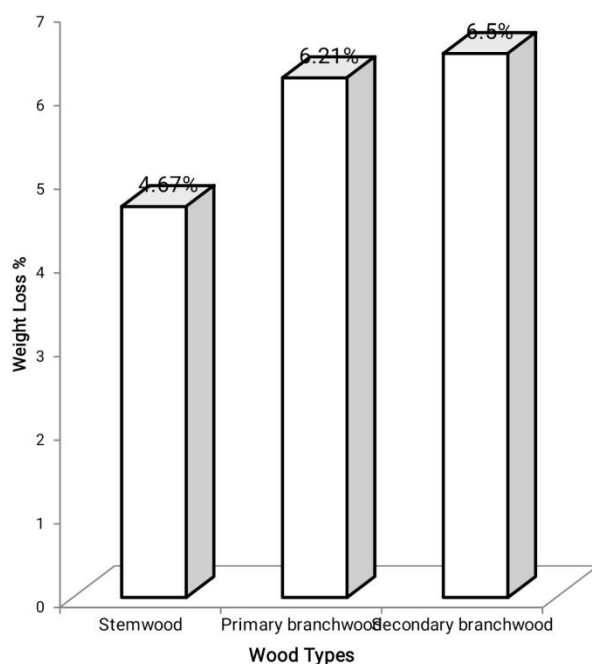


Fig. 1.
Mean percentage weight loss of wood types against termites' attack.

Table 6

Mean weight loss (%) of *Khaya grandifoliola* wood types against termite's attack along axial and radial direction

Wood Type	Radial Position	Sampling Height (Radial Position)			Pooled Mean ± SD
		Base	Middle	Top	
Stemwood	Outerwood	4.695 ± 1.812	4.468 ± 0.894	6.418 ± 2.721	5.194 ± 2.023
	Middlewood				
	Innerwood	3.949 ± 1.543	4.820 ± 0.714	4.523 ± 0.677	4.431 ± 1.047
Pooled Mean±SD		5.077 ± 0.848	4.263 ± 0.303	3.837 ± 0.912	4.392 ± 0.868
		4.574 ± 1.435	4.517 ± 0.676	4.926 ± 1.939	4.672 ± 1.425^a
Primary branchwood	Outerwood	5.289 ± 0.767	6.316 ± 1.738	5.923 ± 1.284	5.843 ± 1.106
	Middlewood				
	Innerwood	5.943 ± 0.244	7.853 ± 2.939	6.184 ± 0.822	6.660 ± 1.857
Pooled Mean±SD		6.884 ± 1.234	5.900 ± 1.909	5.595 ± 0.750	6.127 ± 1.400
		6.039 ± 1.039	6.689 ± 2.158	5.901 ± 0.942	6.210 ± 1.493^b
Secondary branchwood	Outerwood	6.708 ± 0.558	6.874 ± 0.783	11.641 ± 1.629	8.407 ± 2.574
	Middlewood				
	Innerwood	4.161 ± 0.367	4.894 ± 0.989	6.709 ± 0.853	5.255 ± 1.325
Pooled Mean±SD		5.573 ± 0.702	5.658 ± 0.985	6.297 ± 0.544	5.843 ± 0.784
		5.481 ± 1.196	5.808 ± 1.202	8.216 ± 2.713	6.502 ± 2.186^b
Overall Pooled Mean ±SD		5.365 ± 1.35	5.672 ± 1.70	6.348 ± 2.40	5.795 ± 1.90

*Mean value with same letter in same column are not significantly different (p>0.05)

Table 7

Result of percentage weight loss and visual rating of stemwood and branchwood of *K. grandifoliola* against termite's attack in accordance with the model proposed by Eaton and Hale 1993 and EN 252 1989 respectively

Wood type	Weight loss % mean (SD)	Durability description according to %WL	Visual rating based on level of termite's attack
Stemwood	4.67 ± 1.425 ^a	Very Durable	1
Primary branchwood	6.21 ± 1.493 ^b	Durable	2
Secondary branchwood	6.50 ± 2.186 ^b	Durable	2

*Mean values with the same letters are not significantly different (p>0.05)

Table 8

Analysis of variance (ANOVA) for weight loss caused by termites

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-cal.	Sig. level
Wood	2	86.929	43.465	27.679	0.000*
Axial	2	22.764	11.382	7.248	0.001*
Radial	2	31.839	15.919	10.137	0.000*
Wood*Axial	4	50.933	12.733	8.109	0.000*
Wood*Radial	4	63.771	15.943	10.152	0.000*
Axial*Radial	4	46.095	11.524	7.338	0.000*
Wood*Axial*Radial	8	12.776	1.597	1.017	0.428 ^{ns}
Error	108	169.597	1.570		
Total	134	484.704			

* = Significantly different at 5% level of probability. ns = Not significantly different at 5% level of probability

Table 9

*Duncan Multiple Range Test (DMRT) for % weight loss on wood type, axial and radial direction of *Khaya grandifoliola**

Wood type	Subset	
	1	2
Stemwood	4.672728 ^a	
Secondary branchwood		6.501996 ^b
Primary branchwood		6.210234 ^b
Sig.	1.000	0.272
Axial position		
Base	5.364840 ^a	
Middle	5.672177 ^a	
Top		6.347950 ^b
Sig.	0.247	1.000
Radial direction		
Inner	5.448878 ^a	
Middle	5.454316 ^a	
Outer		6.481772 ^c
Sig.	0.984	1.000

*Means with different alphabets in same column are significantly different ($p < 0.05$) while means with same alphabets in same column are not significantly different ($p > 0.05$).

CONCLUSION

Specific gravity and natural durability of stem and branch wood of *Khaya grandifoliola* (mahogany) were assessed to ascertain the potential utilization of branchwood of the species as a supplement to their stemwood. Stemwood of the species exhibited high specific gravity which is relatively same with specific gravity of their branchwood counterparts which was consistent with previous studies. Based on %WL, the natural durability of both the stemwood and branchwood of *Khaya grandifoliola* were rated very durable and durable respectively. This indicates that branchwoods have similar service life to their stemwood irrespective of the difference in the durability status of stem and branchwood of this species. Therefore, it could be proposed that where the stemwood is applicable in terms of durability requirements, the branchwood could also be used as supplement.

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