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# Efficacy of Tectona grandis (Teak) and Distemonanthus benthamianus (Bonsamdua) Water Extractives on the Durability of Five Selected Ghanaian Less Used Timber Species

*A. Asamoah, K. Frimpong-Mensah and C. Antwi-Boasiako
Department of Wood Science and Technology,
Kwame Nkrumah University of Science and Technology,
Kumasi, Ghana
Email: *asamoah38@yahoo.com

## ABSTRACT
Conventional wood preservatives are not only toxic to target bio-deterioration organisms but also to man, other organisms and the environment. In an effort to find preservatives that are less or non- toxic to man, other organisms and the environment, efficacy of heartwood water extractives (0.65g/ml) of Tectona grandis (teak) and Distemonanthus benthamianus (bonsamdua) was tested on five selected less used timer species (LUS): Sterculiaoblonga (ohaa), Antiaristoxicaria (kyenkyen), Canariumschweinfurthii (bediwonua), Celtiszenkeri (esa-kokoo) and Colagigantea (watapuo) by brushing and immersion and exposed to the ground for 8 months following a modified EN 252. Regardless of extract retention in selected LUS, Bonsamdua extract improved their durability more than that of Teak. Improved durability of selected LUS was ranked as follows: Sterculiaoblonga>Colagigantea>Celtiszenkeri>Antiaristoxicaria>Canariumschweinfurthii. Though extracts showed reduced efficacy with time, indications were that they could be employed to control wood pests.

**Keywords:** conventional, preservatives, eco-friendly, percentage, visual

## 1. INTRODUCTION
Although conventional wood preservatives are very effective against wood destroying organisms, they are hazardous to environment, animals and human beings[5-9] because they have very long bio-degradable lives. Even CCA which was previously thought to be stable in wood has now been found not to be. Thus, the need for Governments and industry to replace harzardous conventional wood preservatives with other chemicals. Nonetheless, when it comes to preservatives powerful enough to deter or kill wood destroying organisms, options that are less hazardous are limited. One contemporary less hazardous option is the treatment of low durability timbers with extractives from high durability ones, most of which are quickly bio-degradable.Teak wood has excellently proved to resist bio-deterioration due to sufficient presence of tectoquinones[1-3].Aiyegoro et al[4], found aqueous extracts from bonsamdua stem bark to contain tannins, steroids, saponins and alkaloids, while Nguelefack et al[5]. found ethyl acetate extracts from bonsamdua stem bark to contain flavonoids, phenolic compounds, sterols, triterpenes and alkaloids.Hence, the need to test the efficacy of heartwood water extractives(0.65g/ml) of Tectona grandis (teak) and Distemonanthus benthamianus (bonsamdua) on five selected less used timer species (LUS): Sterculia oblonga (ohaa), Antiaris toxicaria (kyenkyen), Canarium schweinfurthii (bediwonua), Celtis zenkeri (esa-kokoo) and Cola gigantea (watapuo), and exposed to the ground for 8 months following a modified EN 252. Durability ratings, hardness and mass losses were measured in assessing their field performance.

## 2. EXPERIMENTAL

### 2.1 Identification, selection and provenance of less used timber species
Five LUS were selected based on their relative distribution & abundance, utilization, minimum felling diameter and durability, and were identified and felled following William Hawthorne`s Field Guide to the Forest Trees of Ghana with the help of an identification expert, and a local farmer from an area of 4 km²falling within Fenaso No. 1 Junction, Fenaso No. 2 and Aboagyekrom localities of Dunkwa-On-Offin of the Central Region of Ghana (latitude 06º 43´ North and longitude 01º 36´ West).

### 2.2 Preparation of stakes and experimental design
True heartwood and sapwood beams were selected from freshly felled trees of LUS and later air-dreid to about 25-30 % moisture content. Beams were sawn into stakes of 60mm x 25mm x 12.5 mm. Four heartwood and four sapwood stakes from each LUS was selected for immersion in teak and bonsamdua extracts; the same number were similarly selected for brushing with teak and bonsamdua extracts. Four heartwood and four sapwood stakes of each LUS were selected for controls.An inert, long-lasting thermosetting plastic was used to label each stake. Each stake was then weighed three times. Hardness of stakes were taken three times along the grain through the 10×50 mm cross section on a scale of 0-40mm pilodyn needle penetration [0 being no penetration (highest hardness) and 40, the deepest

*Corresponding Author
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penetration (lowest hardness)]. Durability of stakes were visually rated on a scale of zero to four. Zero showing no termite attack, one: sight attack, two: moderate attack, three: severe attack and four: failure. Dimensions of stakes were taken with a veneer caliper at three diffent points.Efficacy of heartwood water extractives of teak and bonsamdua was tested in the Complete Randomised Design (CRD) where visual durability ratings, percentage hardness loss or percentage mass loss was a single-factor (efficacy response) with its corresponding control and non-extract-treated, teak-extract-treated and bonsamdua-extract-treated values as treatments (levels of each single-factor).

### 2.3 Preaparation of water extractives

Teak and dahoma heartwood were air-dried to about 25-30% and milled 40-60 mesh granules. Mixtures were made from equal weights of 200g of granules from each part in equal volumes of 5000ml cold distilled water in plastic buckets. Buckets were covered after to prevent evaporation of volatile components of Mixtures. Mixtures were left to stand for 24 hours, after which their solid residues were sieved off. Extractives were kept in a conditioning room to maintain concentration.Stockmassconcentration of water extractives was determined by taking two separate 3ml portions of each water extract and drying in crucibles on a water bath.Stock mass concentration of water extracts finally used for impregnation was 0.65 g/ml.

### 2.4 Impregnation of stakes

Each series of four stakes of selected LUS were immersed in 2500ml of extract from bonsamdua and teak for one week on room conditions (pressure & temperature). Liberal amounts of extract from teak and bonsamdua were brushed on each series of four stakes three successive times with a day's drying intervals on room conditions (pressure & temperature). After each immersion, used extract was discarded. Retention of extract ($g/mm^3$) in each stake (R1) was determined as [ $R1 = (q2 - q1)/v$ ](Asamoah, Antwi-Boasiako and Frimpong-Mensah, 2008) where q1 is the mass of air-dried untreated stake, q2 is the mass of air-dried treated stake and v is the volume of air-dried untreated stake. Consequently, mean retention (Rn) was determined as [ $Rn = (R1 + R2 + R3..Rn)/n$ ]where Rn is the nth treated stake in a charge, and n is the number of stakes in a charge. Stakes were then close-stacked and kept wrapped for two hours to avoid rapid drying and to enable extractives fix in stakes. Stakes were lined on polyethylene sheets in the laboratory for drying for five days under the ventilation of ceiling fans after fixation of extractives to bring them to a moisture content of 25-30% .After drying, weight and hardness of stakes were taken.Impregnated stakes were close-stacked and kept wrapped for two hours to avoid rapid drying to fix extractives in stakes. Stakes were lined on polyethelene sheets in the laboratory for drying for five days after fixation of extractives. After drying, weight and hardness of stakes were taken in the same way as before.

### 2.5 Burial of stakes

Impregnated stakes were buried at random on a 9 $m^2$ land area within a 30 x 30cm grid to half their lengths. Surrounding soil was pressed tight to each stake to make good contact with the surfaces so that each stake was firm in the ground.

### 2.6 Collection of data and analysis

Impregnated stakes were removed after eight months exposure in the ground, and at a time when moisture content was above fibre saturation. After removal, stakes were weighed, pilodyned and visually rated after drying for five days as before. Percentage mass losses of stakes were calculated on air-dried mass instead of oven-dry mass of stakes (Kumi-Woode, 1996) as $\text{Mass Loss}(\%) = [(I - R)/I\ ]\text{x}100\%$ …(1), where I is initial mass of stakes and R is the final air-dried mass of stakes. Percentage hardness losses of stakes were calculated on air-dried hardness instead of oven-dry hardness of stakes as $\text{Hardness Loss}(\%) = [(Ih - Rh)/Ih]\text{x}100\%$… (2), where Ih is initial hardness of stakes and Rh is final air-dried hardness of stakes. Differences between treatment means were determined using one-way ANOVA with the aid of Excel 2003.

## 3. RESULTS AND DISCUSSION

### 3.1 Retention

From Table-1, sapwood of selected LUS treated by immersion retained more of both teak and bonsamdua extracts than that treated by brushing. Sapwoods and heartwoods of selected LUS retained more of bonsamdua extract than teak extract in both immersion and brushing (Tab. 1).Brushed and immersed LUS retained extracts dissimilarly.

From grand cumulative areas under treatments of 3348.41 and 3231.48 for teak and bonsamdua extracts respectively (Table-2), bonsambua extract improved the durability of LUS more than that of teak. Improved durability of immersed and brushed selected LUS was ranked as follows: C. gigantea>C. zenkeri>S. oblonga>A. toxicaria =C. schweinfurthi (Table-3).

**Table-1:**Retentions [g/mm3] x 103 of extracts in heartwoods and sapwoods of LUS

| Impregnation | Teak. Heart | Teak. Sap | Bon. Heart | Bon. Sap | Sum |
|---|---|---|---|---|---|
| Immersion | 1.17100 | 1.3700 | 2.5260 | 1.3690 | 6.4360 |
| Brushing | 0.11167 | 0.0933 | 0.1260 | 0.1547 | 0.4907 |
| Sum | 1.28770 teak extract | | 4.1757 bonsamdua extract | | |

**Table-2:** Cumulative area under treatments

| | Heartwood | Sapwood | Sum |
|---|---|---|---|
| | visual durability rating | | |
| Teak | 29.63 | 28.88 | 58.51 |
| Bonsamdua | 29.63 | 28.25 | 57.88 |
| | percentage hardness loss | | |
| Teak | 1009.20 | 1025.50 | 2034.70 |
| Bonsamdua | 1021.30 | 0955.20 | 1976.50 |
| | percentage mass loss | | |
| Teak | 644.70 | 610.50 | 1255.20 |
| Bonsamdua | 628.50 | 568.60 | 1197.10 |
| Sum | 3024.36 | 3188.66 | |

**Table-3:** Durability ranking of LUS impregnated with extracts

| | | | | | Heartwood | Sapwood | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Extract | CS | CG | CZ | AT | SO | CS | CG | CZ | AT | SO | sum |
| | | | | | Visual durability rating | | | | | | |
| Teak | 4 | 2 | 3 | 4 | 1 | 4 | 3 | 1 | 4 | 2 | 28 |
| Bonsamdua | 4 | 3 | 2 | 4 | 1 | 4 | 2 | 1 | 4 | 3 | 28 |
| | | | | | Percentage hardness loss | | | | | | |
| Teak | 4 | 1 | 5 | 3 | 2 | 4 | 2 | 1 | 5 | 3 | 30 |
| Bonsamdua | 4 | 1 | 5 | 3 | 2 | 3 | 2 | 1 | 4 | 5 | 30 |
| | | | | | Percentage mass loss | | | | | | |
| Teak | 4 | 2 | 3 | 5 | 1 | 5 | 3 | 1 | 4 | 2 | 30 |
| Bonsamdua | 5 | 3 | 2 | 4 | 1 | 3 | 2 | 1 | 4 | 5 | 30 |
| Sum | 25 | 10 | 20 | 23 | 8 | 23 | 14 | 6 | 25 | 20 | |
| Durability (Sapwood+heartwood) | CS=48 | | CG=24 | | CZ=26 | | AT=48 | | SO=28 | | |

## 3.2 Discussion

Sapwood of selected LUS treated by immersion retained more of both teak and bonsamdua extracts than that treated by brushing because sapwood has less extractive than heartwood, and thus can contain more extracts. Sapwoods and heartwoods of selected LUS retained more of bonsamdua extract than teak extract in both immersion and brushing because extractives of bonsamdua must have bonded better with the extractives and walls of selected LUS than that of teak. Brushed and immersed LUS retained extracts dissimilarly because they are of varying anatomy. Altogether, immersed and brushed heartwoods and sapwoods of LUS retained bonsamdua extract (4.1757) more than teak extract (1.28770) possibly because bonsamdua extract components may have bonded very well in large amounts with the extractives of impregnated LUS, a phenomenon Lui[3] and Hyvonenet al[7]. have reported. Bonsamdua extract improved the durability of LUS more than that of teak because bonsamdua extractives were more bio-active than that of teak to the extent that even possible denaturing and degradation of some proportion of it still left enough to protect impregnated LUS.

## 4. CONCLUSION

Extractives of tropical timber species as that of bonsamdua could be employed to preserve their low durability counterparts. The use of botanical extracts is promising if it will be deeply researched.

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