Pak. J. Chem. 3(3): 123-128, 2013
ISSN (Print): 2220-2625
ISSN (Online): 2222-307X
Full Paper
DOI: 10.15228/2013.v03.i03.p05

Efficacy of *Erythropleum Suaveolens* Water Extractives on the Durability of Ghanaian *Antiaris toxicaria* and *Aanarium schweinfurthii*

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ABSTRACT
In an effort to find new preservatives which are less hazardous, the efficacy of branch bark, leaf, and heartwood water extractives of Erythropleum suaveolens (Potrodom), a highly durable timber species, was tested on *Antiaris toxicaria* (Chenchen) and *Canarium schweinfurthii* (Bediwonua) of low natural durability by presssure impregnation. Impregnated Chenchen and Bediwonua were exposed in the field for 6 months in accordance with a modified EN 252. Durability ratings, hardness and mass losses were measured in assessing their field performance. Though Bediwonua and Chenchen retained branch bark water extractives minimally, it conferred the highest resistance to deterioration**.** Branch bark water extractives represent a potential source of wood preservative.

Keywords: branch, eco-friendly, bio-deterioration, preservatives

1. INTRODUCTION
Although conventional wood preservatives are very effective against wood destroying organisms, they are also hazardous to the environment, animals and human beings[5-15] because they have very long bio-degrading lives. Even CCA which was previously thought to be stable in wood has now been found not to be. Thus, Governments and industry embarked on a wholesale changeover, including a voluntary phase-out of CCA in exchange for other chemicals for preserving wood. Nonetheless, when it comes to preservatives powerful enough to deter or kill wood destroying organisms, options that are less hazardous are limited. One readily accessible less hazardous option is the treatment of low durability timbers with extractives from highly durable ones, most of which are quickly bio-degradable. Extractives from the heartwood of highly durable timbers are mostly used[7-14] while those from other parts of trees like leaves, bark, root, needles and seeds are seldomly used. However,the fraction of extractive compounds in stem bark is four to five times that of bark free wood, and needles have seven to eight times that of bark free wood[13]. The stem-bark of *Erythropleum guineense*, a close realative of *E. Suaveolens* (Potrodom) contains alkaloids, tannins, saponins and glycosides (Adeoye and Oyedapo, 2004) which are combinedly responsible for its toxicity which could be explored for preservation of wood. Hence, the need to test the efficacy of branch bark, leaf, heartwood water extractives of *E. suaveolens* at a concentration of 0.5 g/ml on *Antiaris toxicaria* (Chenchen) and *Canarium schweinfurthii* (Bediwonua) of low natural durability. Impregnated Chenchen and Bediwonua were exposed in the field for 6 months in accordance with a modified EN 252. Durability ratings, hardness and mass losses were measured in assessing their field performance.

2. MATERIALS AND METHODS

2.1 *Identification, selection and provenance of test species*
Antiaris toxicaria and *Canarium schweinfurthii* 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, and with the help of an identification expert and a local farmer from an area of 4 km² falling 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*
Sound Chenchen and Bediwonua beams were selected regardless of whether they were true heartwood or sapwood from a freshly cut tree and air-dreid to about 25-30% moisture content. Beams were sawn into stakes of 250×10×50 mm. Seven stakes each of Chenchen and Bediwonua were impregnated with 0.5 g/ml leaf, 0.5 g/ml heartwood and 0.5 g /ml bark water extractives. A separate 7 stakes each of Chenchen and Bediwonua were left untreated as controls. In all fifty six stakes were prepared for exposure in the field. Each stake was then weighed 3 times. Hardness of stakes were taken 3 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 penetration (lowest hardness)]. Durability of stakes were visually rated on a scale of 0 to 4. Zero (0) showing no termite attack, 1: sight attack, 2: moderate attack, 3: severe attack and 4: failure. Dimensions of stakes were taken with a veneer caliper at 3 diffent points. Efficacy of branch bark, leaf, heartwood water extracts of *E. suaveolens* was tested in the Complete Randomised Design (CRD) where visual durability ratings, percentage hardness loss or percentage mass loss was a single-factor (efficacy

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Received 30th January 2011, Accepted 24th August 2013

response) with its corresponding control and bark-extractive-treated, leaf-extractive-treated and heartwood-extractive-treated values as treatments (levels of each single-factor).

2.3 *Preparation of extractives*

Potrodom leaves, bark and heartwood were air-dried to about 25-30% and milled to 40-60 mesh granules. Mixtures were made from equal weights of 1120g of granules from each part in equal volumes of 11200ml 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 from each part was kept in a conditioning room to maintain concentration. Mass concentration of extractives was determined by taking two separate 3ml portions of each and evaporating water to complete dryness in crucibles on a water bath. Mass concentrations obtained were: 0.7 g/ml for leaves, 0.6 g/ml for bark and 0.7 g/ml for wood extractives each of which was diluted to 0.5g/ml.

2.4 *Impregnation of stakes*

Stakes were impregnated at a maximum temperature of 123ºC, pressure of 1.0135 x10^5 Pa. and for duration of 90 minutes. Impregnation process did not use an initial vacuum nor a final vacuum as many typical full cell processes do as a modification of EN 252. Seven stakes of either Chenchen or Bediwonua were impregnated at a time in every 2000ml of extractives. After each impgrenation, used extractives was discarded. Retention of extractives (g/mm³) 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 spread in the laboratory for drying for 5 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 spread in the laboratory for drying for 5 days after fixation of extractives. After drying, weight and hardness of stakes were taken as before.

2.5 *Burial of stakes*

Impregnated stakes were buried at random on a 1 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 every month for 6 months at a time when moisture content was above fibre saturation. After removal, stakes were dried for 5 days as before and weighed, pilodyned and visually rated. Percentage mass losses of stakes were calculated on air-dried mass instead of oven-dry mass of stakes (Kumi-Woode, 1996) as Mass Loss $(\%) = [(I - R)/I] \times 100\%$ …(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 Hardness Loss $(\%) = [(Ih - Rh)/Ih] \times 100\%$ … (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*

Generally, retention was higher in Chenchen than in Bediwonua. In decreasing order, Chenchen retained bark extractives highest, followed by heartwood extractives and in turn by leaf extractives as shown in Figure 1. Bediwonua retained leaf extractives highest, followed by heartwood extractives and in turn by bark extractives as shown in Figure 2. Chenchen retained extractives moderately because it has cell inclusions (Fordjour, 2004; http://insidewood.lib.nscu.ed and http://database.prota.org/search) which obstruct the flow of fluids and render it less treatable as was observed by Ofori and Bamfo (1994).

3.2 *Percentage mass loss*

Bediwonua and Chenchen treated with leaf extractives lost the highest mass, followed by those treated with heartwood extractives and in turn by those treated with bark extractives (Fig.3 and Fig. 4). From Figure 3, Chenchen treated with bark extractives with mass loss of 25.32% resisted deterioration about more than two times that treated with leaf extractives with mass loss of 73.32%. From Figure 4, Bediwonua treated with bark extractives with mass loss of 40% resisted deterioration about more than one time that treated with leaf extractives with mass loss of 70%. This is expected because according to Onuorah (2000), bark of Potrodom contains the toxic alkaloid, erythrophleine as well as many others and their derivatives including cassaine horscassaidine and homophleine which could be responsible for the high deterioration resistance of Bediwonua treated with bark extractives, even at minimal retention.

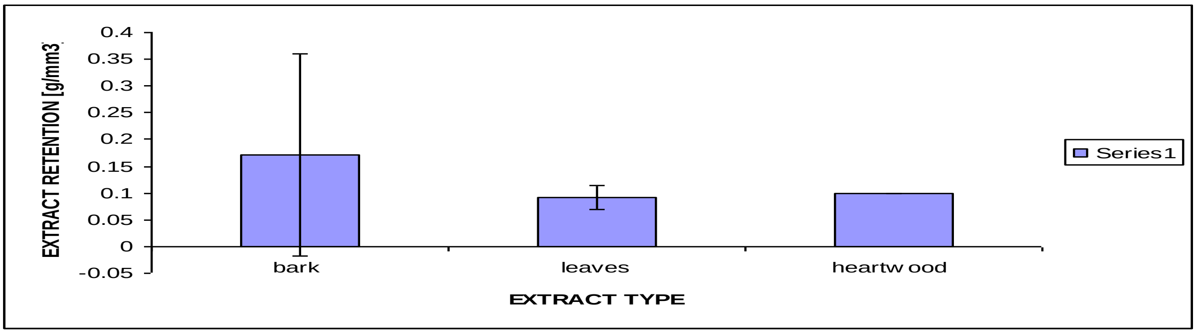

Fig-1: Retention of Potrodom branch bark, heartwood and leaf water extractives at 0.5 g/ml in Chechen after impregnation. N=7, P=0.02, α=5%, F= 3.82.

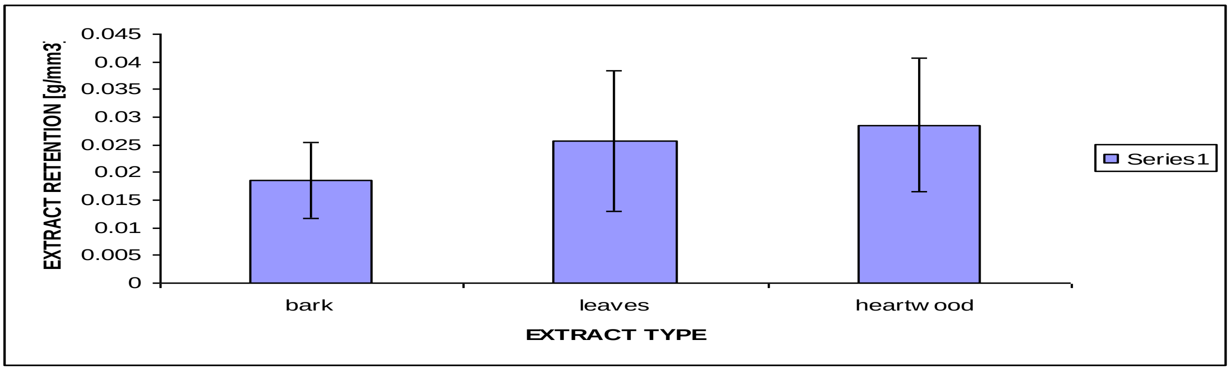

Fig-2: Retention of Potrodom branch bark, heartwood and leaf water extractives at 0.5 g/ml in Bediwonua after impregnation. N=7, P=3.12E-5, α=5%, F= 12.94.

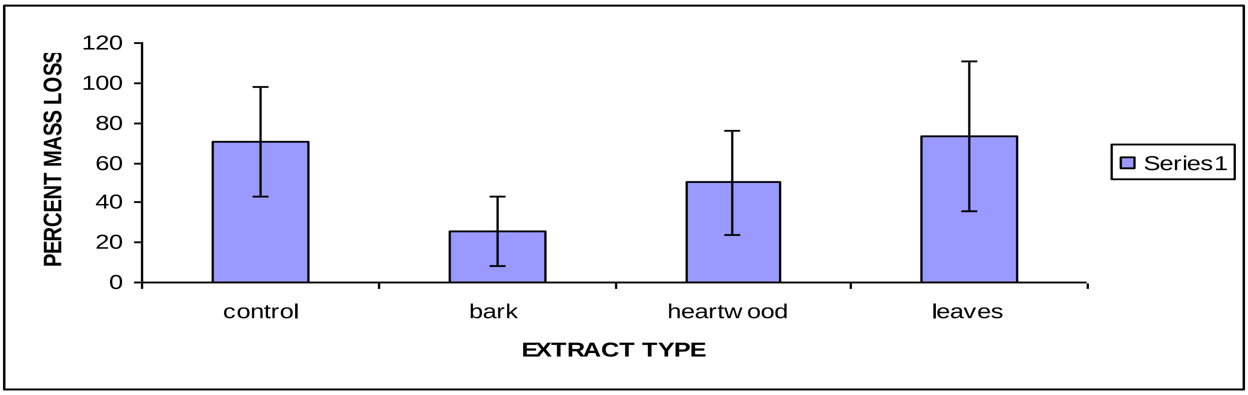

Fig-3: Percent mass loss of Chenchen treated with Potrodom branch bark, heartwood and leaf water extractives at 0.5 g/ml after field exposure for 6 months. N=7, P=0.01, α=5%, F=4.41.

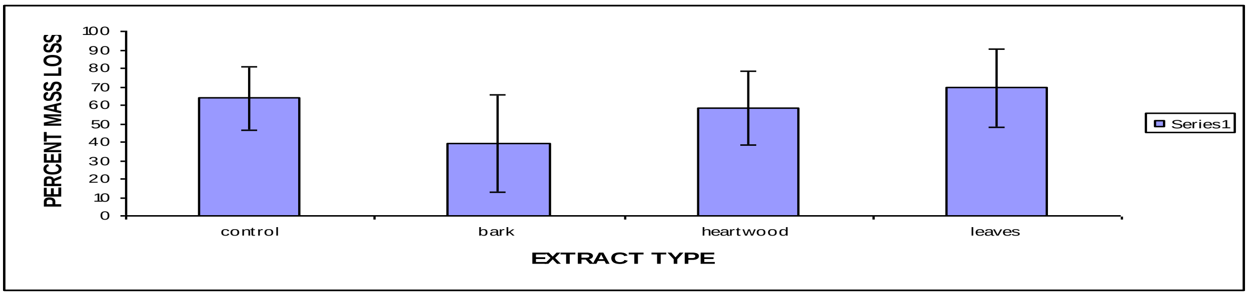

Fig-4: Percent mass loss of Bediwonua treated with Potrodom branch bark, heartwood and leaf water extractives at 0.5 g/ml after field exposure for 6 months. N=7, P=0.08, α=5%, F= 2.58

3.3 *Percentage hardness loss*

Chenchen treated with bark extractives lost hardness highest (least deterioration resistance), followed by that treated with heartwood extractives and in turn by that treated with leaf extractives (Fig. 5). Bediwonua treated with heartwood extractives lost hardness highest, followed by that treated with leaf extractives and in turn by that treated with bark extractives (Fig. 6). Chenchen and Bediwonua treated with bark extractives increase in hardness, hence their negative values of -27.57% and -15.75% respectively as illustrated in Figures 5 and 6. This was expected because according to Bever (1982), a catechuic tannin, a saponin, a flavonoides and a wax (with high proportion of hexacosonol) have been isolated from the bark of Potrodom which are capable of hardening and possibly closing the pores of treated Chenchen and Bediwonua.

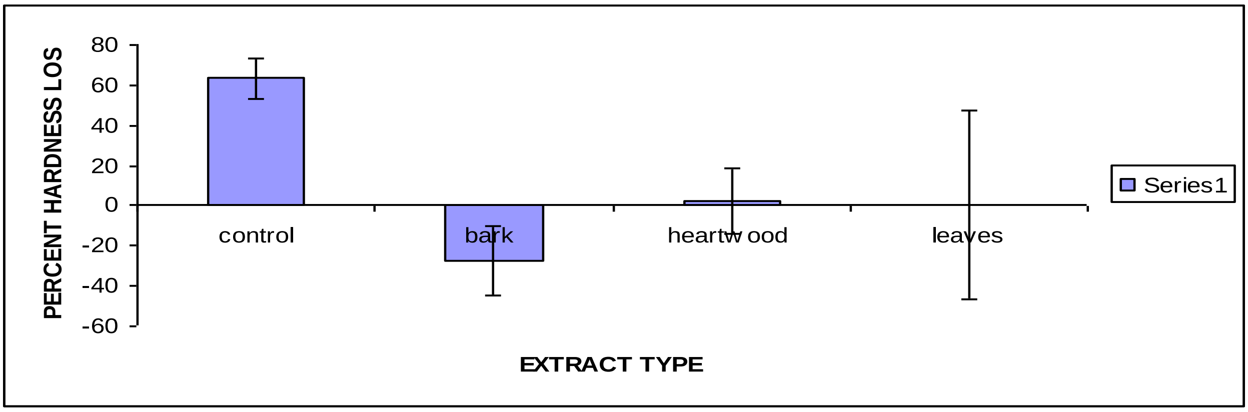

Fig-5: Percent hardness loss of Chenchen treated with Potrodom branch bark, heartwood and leaf water extractives at 0.5 g/ml after field exposure for 6 months. N=7, P=1.58E-5, α=5%, F=14.20

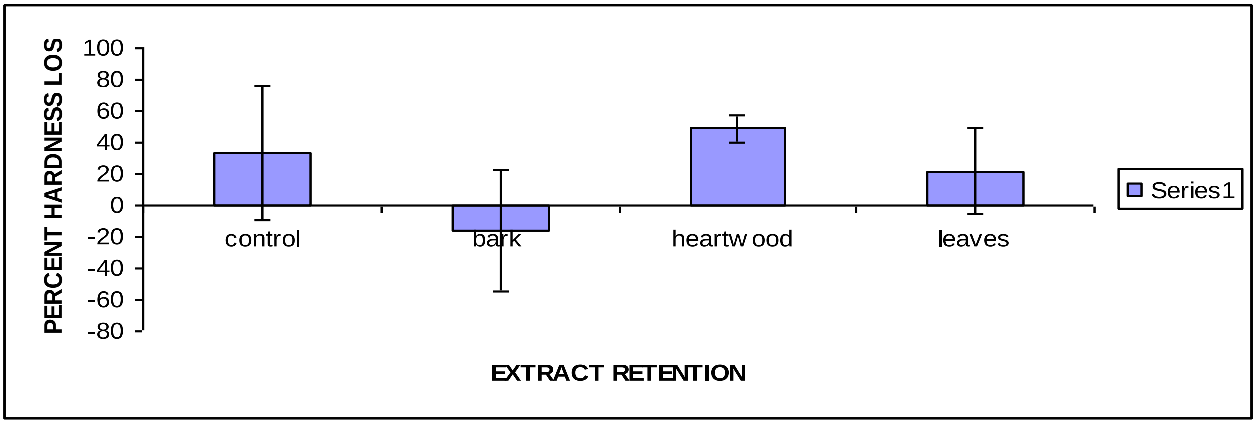

Fig-6: Percent hardness loss of Bediwonua treated with Potrodom branch bark, heartwood and leaf water extractives at 0.5 g/ml after field exposure for 6 months. N=7, P=0.01, α=5%, F=5.06

3.4 *Durability Ratings*

Chenchen treated with heartwood extractives rated highest visually (least deterioration resistance), followed by that treated with leaf extractives and in turn by that treated with bark extractives (Fig. 7). Bediwonua treated with leaf extractives rated highest visually, followed by that treated with heartwood extractives and in turn by that treated with bark extractives (Fig. 8). Bediwonua and Chenchen treated with bark extractives resisted deterioration highest with visual durability rating of 0.4 and 0.7 respectively. This may be explained by the same reason as above.

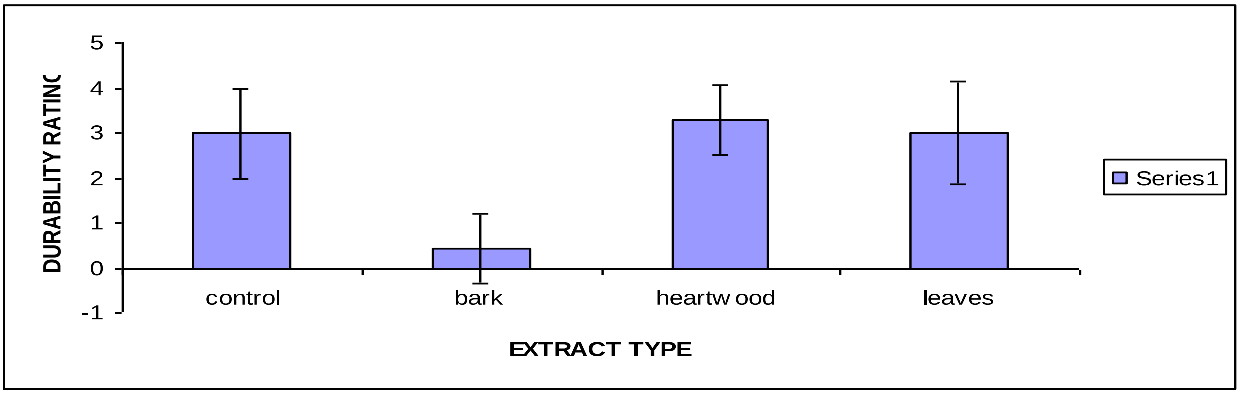

Fig-7: Visual durability ratings of Chenchen treated with Potrodom branch bark, heartwood and leaf water extractives at 0.5 g/ml after field exposure for 6 months. N=7, P=1.52E-5, α=5%, F=14.27

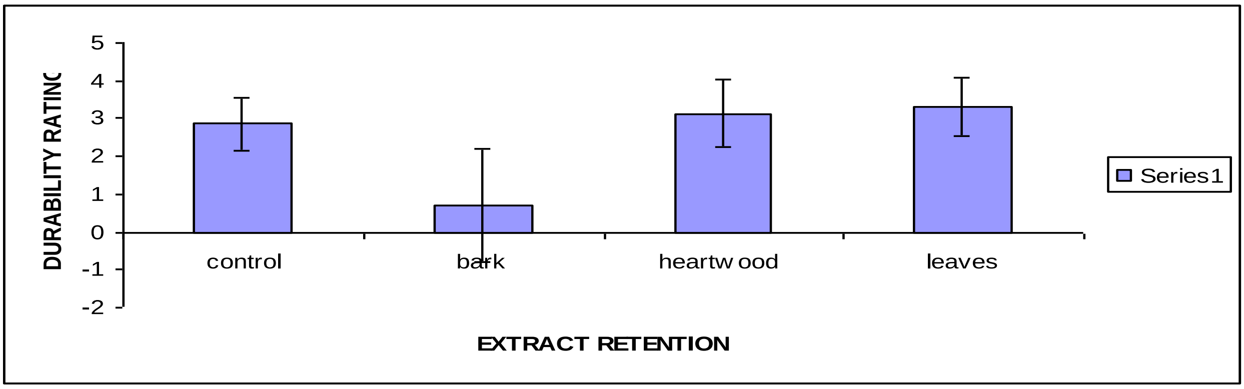

Fig-8: Visual durability ratings of Bediwonua treated with Potrodom branch bark, heartwood and leaf water extractives at 0.5 g/ml after field exposure for 6 months. N=7, P=1.95E-4, α=5%, F=9.91

3.5 *Durability Classification*

From Table 1, bark extractives conferred a durability class of 'durable' on treated Chenchen and Bediwonua as opposed to a class of 'very durable' reported (Onuorah, 2000) for heartwood of native Potrodom where extractives are intrinsically accumulated. Leaching of extractives, low extractives concentration as well as low extractives retention could have accounted for their reduced effect in Chenchen and Bediwonua. Nonetheless, Potrodom bark extract with the lowest x values resists deterioration best.

Table-1: Durability classification of Bediwonua and Chenchen impregnated with heartwood, bark and leaf water extractives of Potrodom after 6 months field exposure

Species	Treatment	X Values	Durability Class
Chenchen	Bark	0.41	Durable
	Wood	0.81	Durable
	Leaf	1.20	Moderately Durable
Bediwonua	Bark	0.63	Durable
	Wood	0.63	Durable
	Leaf	1.09	Moderately Durable

X value → mean mass loss of treatment/mean mass loss of control

4. CONCLUSION

Bediwonua is more pervious than Chenchen, and thus retained more of extractives. Though Bediwonua and Chenchen retained branch bark water extractives quite minimally, it conferred the highest resistance to deterioration**.** Bediwonua and Chenchen are both low durability timbers but Bediwonua is more durable. Though extractives showed reduced efficacy over time, indications were that extractives from parts of tropical timber species as that of Potrodom could be employed to preserve their low durability counterparts. The use of Potrodom as a botanical extractives is promising if it will be deeply researched.

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