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ORIGINAL PAPER

GEOGRAPHICAL VARIATIONS IN ELEMENTAL COMPOSITIONS OF TWO PESTICIDAL PLANTS FROM THREE AGRO-ECOSYSTEMS IN NIGERIA AND THEIR WOOD PROTECTION POTENTIALITY

Funmilayo Sarah Eguakun[1], Gabriel Adetoye Adedeji[1*], Taiwo Olayemi Elufioye[2], Azuka Chinedum Egubogo[1]

[1]Department of Forestry and Wildlife Management
University of Port Harcourt, Nigeria
[2]Department of Pharmacognosy
University of Ibadan, Nigeria

Abstract

Lawsonia inermis and *Lagenaria breviflora* are important tropical pesticidal plants with some potential for industrial wood protection uses. However, little is known about their elemental composition of wood protection importance. In this study, three agro-ecosystems: Guinea savannah (A), Dry rainforest (B), and Fresh water swamp forest (C) were selected and from each zone *Lawsonia inermis* leaves and *Lagenaria breviflora* fruits were collected and extracted. Six most important elements: arsenic (As), boron (B), chromium (Cr), copper (Cu), lead (Pb) and zinc (Zn) used to formulate outlawed standard wood preservatives, were quantitatively analysed by the spectrophotometric method. Data were analysed using analysis of variance (ANOVA) and *t*-test at $\alpha_{0.05}$. All the elements were present in both plants, with chromium being most copious. Arsenic concentrations were in the range of 1.05±0.04 to 1.19±0.02 mg kg^{-1} for *L. inermis* and 1.16±0.05 to 1.34±0.10 mg kg^{-1} for *L. breviflora*. Boron ranged from 1.59±0.09 to 1.75±0.06 mg kg^{-1} for *L. inermis* and 2.15±0.24 to 3.00±0.14 mg kg^{-1} for *L. breviflora*. Chromium ranged from 28.94±0.21 to 44.15±0.13 mg kg^{-1} for *L. inermis* and 0.63±0.05 to 21.55±0.47 mg kg^{-1} for *L. breviflora*. Copper ranged from 2.55±0.17 to 11.35±0.17 mg kg^{-1} for *L. inermis* and 9.94±0.21 to 15.83±0.17 mg kg^{-1} for *L. breviflora*. Lead ranged from 21.36±0.44 to 22.86±0.11 mg kg^{-1} for *L. inermis* and 19.41±0.33 to 32.50±0.47 mg kg^{-1} for *L. breviflora*. Zinc ranged from 2.35±0.19 to 21.85±0.19 mg kg^{-1} for *L. inermis* and 6.18±0.10 to 7.10±0.14 mg kg^{-1} for *L. breviflora. Lawsonia inermis* and *Lagenaria breviflora* from Dry rainforest had significantly high pesticidally relevant elements, producing extracts that could be best explored as bio-preservatives for wood protection. Further research covering all the agro-ecosystems with individual and extract synergising tests against wood degrading agents are suggested.

Keywords: bio-preservatives, *Lagenaria breviflora* fruits*, Lawsonia inermis* leaves*,* pesticidal plant species, preservative elements.

* Corresponding Author: +2348060709698, gabriel.adedeji@uniport.edu.ng

INTRODUCTION

The recent growing demand for components of nature such as plants to produce environmental friendly biocides has stimulated interest in many plants potentially capable of protecting woods globally. For many years, wood protection across the globe has relied on Chromated Copper Arsenate (CCA) and other closely related elemental formulations to control degradation agents. However, due to the environmental concern over the use of these chemicals, finding wood protecting alternatives of organic base have been the priority for the wood preservation industry worldwide. *Lawsonia inermis* and *Lagenaria breviflora* are cultivated shrub and weed plants, respectively, and have widely been used for a vast array of pesticidal conditions in traditional societies, especially in African and Asian communities (Adesina, Akinwusi 1984, Chaudhary et al. 2010, Chandra et al. 2011, Semwal et al. 2014). These societies use extracts from the above plants for multiple pest control techniques, ranging from wounds healing to prevention of microbial and insects growth (Ajayi et al. 2002, Yasuyuki et al. 2005, Yusuf et al. 2011). Studies have shown that both plants possess multiple pesticidal activities against: insects (Suleiman et al. 2012, Jose, Adesina 2014, Emerhi et al. 2015), bacteria (Adesina, Akinwusi 1984, Tomori et al. 2007, Kawo, Kwa 2011, Alsaimary 2014,) as well as other form of pests, including fungi (Ajayi et al. 2002, Satish et al. 2010, Yusuf et al. 2011, Sherifa et al. 2015). Several investigations have reported an array of bioactive ingredients responsible for their varying pesticidal properties (Elujoba et al. 1990, Mikhaeil et al. 2004, Babili et al. 2013, Oridupa et al. 2013).

In Nigeria, pesticidal plant species are abundant but few have been investigated for wood preservative values. *L. inermis* and *L. breviflora* are unique among important indigenous pesticidal raw materials used virtually by every community in diverse ways. Historically, the plants have been an integral part of livelihood and health care lifestyle in Nigeria (Oridupa et al. 2013, Jose, Adesina 2014, Aiyeloja et al. 2015). Specifically, extracts from *Lawsonia inermis* leaves are renowned as cosmetic agents for beautifying, and as agents preserving resources from degradation (Chaudhary et al. 2010, Adedeji 2016), while *Lagenaria breviflora* fruit extracts are notable as depilatory and preservative agents for hygienic production and protection of food and musical items (Aiyeloja et al. 2015). The potentials of *L. inermis* leaf and *L. breviflora* fruit extracts as wood preservatives against termites and fungi have been explored (Emerhi et al. 2015, Adedeji 2016). While many plants extracts that have pesticidal potential, including wood protection, owe it to their chemical composition, most phytochemical investigations have focused on isolation and characterisation of some specific secondary metabolites, while little is known about the quantification of elements that are of wood protection importance.

Type C of Chromated Copper Arsenate (CCA-C), developed in the 1930s, has been the most widely used water-borne wood preservative across the globe for many years (Nico et al. 2004, Nair 2006). Subsequently, many other standard elemental-based chemicals have been designed. While analysing the standard CCA components, copper is the primary fungicide, arsenic is a secondary fungicide and an insecticide, and chromium is a fixative agent which also imparts ultraviolet (UV) light resistance (Pizzi 1981, Nair 2006). In particular, *L. inermis* extract has been found to possess chromium related fixative/stain actions on lignocellulosic materials (Jan et al. 2011, Yusuf et al. 2011, Adedeji 2016) that could be commercially explored for safer degradation agents' control. Despite the long-established relevance of some elements in the formulations of outlawed standard pesticides, quantifications of concentrations of such bio-preservative elements in plant extracts are relatively scarcely studied. There is need for advance in this area of inquiry by quantifying elements in pesticidal plants and to advocate the explicit demonstration of some specific plants as potentially important wood protecting agents. Elementology as a recently emerging aspect of natural sciences should give priority to elementological studies on metals and trace elements of wood protective value other than nutri-therapeutic benefits.

Quantifications of plants' chemical elements such as arsenic (As), boron (B), chromium (Cr), copper (Cu), lead (Pb) and zinc (Zn), which were components of now banned inorganic chemicals, are important to provide baselines for possible pesticidal effects including wood protection activity and to inform on potential formulations development. *Lawsonia inermis* and *Lagenaria breviflora* are important pesticidal plants with some potential for industrial wood protection uses. With the global importance of bio-preservatives and usefulness of elemental compounds in wood protection industry, the formulation of plant-based biocides requires understanding of the influence of ecological variants in the composition of elements. In this study, elemental compositions of *L. inermis* and *L. breviflora* were quantified and their concentrations compared across three agro-ecosystems of southern Nigeria, with a view to identifying under which ecosystem(s) the plants could be grown to best fit the control of wood degradation. *Lawsonia inermis* and *Lagenaria breviflora* are widely distributed and highly valued for their biological characteristics thus representing potential natural sources for developing globally much needed biocides to limiting wood fungi and termites.

MATERIAL AND METHODS

Study locations

Fresh *L. inermis* leaves and *L. breviflora* fruits were collected from three habitats or locations (Imeko, Ibadan, and Port Harcourt) representing three different agro-ecosystems of Southern Nigeria at latitude 4°00′ and 7°55′ N and longitude 2°09′ and 6°59′ E (Figure 1). The climate in this region is tropical humid with rainfall ranging between 1300 and 2308 mm (Ige et al.

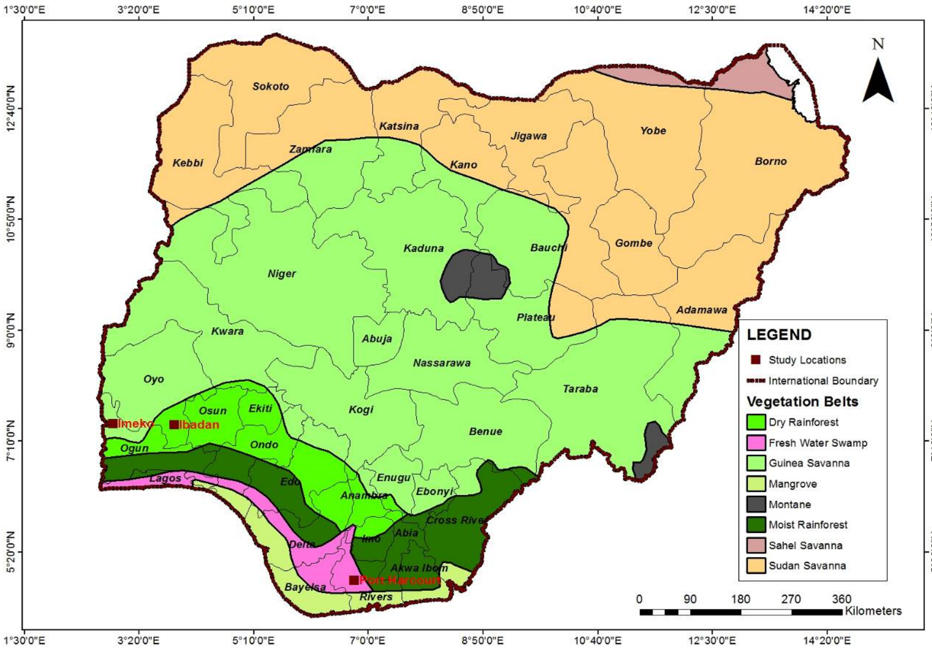

Fig. 1. Map of Nigeria showing locations (Imeko, Ibadan, and Port Harcourt) where the plant samples were collected

2008, ADEJUWON 2012). The soil type is diversified, ranging from Precambrian Basement Complex in Imeko and Ibadan (GBADEGESIN, OLABODE 2000, IGE et al. 2008), to Coastal Plain of the Eastern Niger Delta (NGAH, ABAM 2014). At Imeko, the plant parts were collected around Nazareth High School. At Ibadan, they were collected around the University of Ibadan. At Port Harcourt, they were collected on the campus of the University of Port Harcourt, Nigeria. The three locations were free of effluents or waste disposal landfills.

Plant samples collection

Stands of *L. inermis* were pollarded in January 2016, two months prior to leaf collection, in order to obtain fresh samples and perhaps to reduce possible influence of age variations. Fresh leaves were collected from three regrowths of pollarded plants, cleaned, air-dried and kept in air-tight Ziploc nylon bags. Unblemished *L. breviflora* fruits were collected from three stands in April 2016 and kept under room conditions until May, when the elemental analyses were performed. The plant specimens were identified and authenticated by dr A. T. Oladele (ethno-botanist) at the Herbarium Unit of the Department of Forestry and Wildlife Management, University of Port Harcourt, Nigeria, where voucher number AGA001 – *Lawsonia inermis* and AGA002 – *Lagenaria breviflora* are deposited. Dried leaves of *L. inermis* packed into Ziploc nylon bags and fruits of *L. breviflora* were transported for analyses to the Analytical Laboratory Unit of the Department of Agronomy, University of Ibadan, Nigeria.

Preparation of extracts and elemental analysis

The dried leaf samples were milled to powder while the fruit samples were sliced, oven-dried and milled to powder as well. Elemental compositions were quantified following the method described by ZAFAR et al (2010) with slight modification. Samples of 0.5 g each from the powdered materials was sequentially weighed into beakers and 10 mL of an acid mixture of nitric acid and perchloric acid in the 2:1 ratio was added. The beakers were covered with tops, placed on a heating mantle at 105°C for 30 min under a fume cupboard until the contents became colourless. The digest was then allowed to cool and made up to 25 mL mark with distilled water. The 25 mL digest was used to quantify in mg kg^{-1} the selected wood preservative reference elements using a Buck Scientific Atomic Absorption Spectrophotometer (model 210/211 VGP) at various wavelengths for each element. All the samples were quantified in quadruplicate.

Statistical analysis

Results were expressed as mean of four quantifications ± standard deviation (SD). The elements quantified were analysed by analysis of variance (ANOVA) in a completely randomised design (CRD) to compare data among the three agro-ecosystems within each species, while *t*-test were performed to compare the data between the two plants in the three agro-ecosystems and differences between the means were established using the Duncan's multiple range test at α 0.05 ($p < 0.05$).

RESULTS

Results showed that *L. inermis* and *L. breviflora* used traditionally as pesticides contained major elements of wood protection importance. The elemental compositions of each species considerably varied in the context of agro-ecosystems influence, as presented in Tables 1 and 2, and expectedly greatly differed between the two plant species within each agro-ecosystem, as shown in Table 3. It was found that all the elements were present in both plant species, with chromium being most abundant. Their total concentrations significantly varied in different agro-ecosystems between 0.63±0.05 and 44.15±0.13 mg kg^{-1}, and chromium in *L. inermis* from Dry rainforest was by far the highest. The decreasing trend of the elements in plants across the ecosystems is presented in Table 4.

Table 1

Comparison of agro-ecosystems elemental compositions of *Lawsonia inermis*

Species	Agro-ecosystems*	Elements (mg kg^{-1}), mean ± SD, n = 4					
		As	B	Cr	Cu	Pb	Zn
Lawsonia inermis	A	1.15 ± 0.03^{b}	1.65 ± 0.04^{ab}	38.44 ± 0.39^{b}	4.55 ± 0.07^{b}	21.36 ± 0.44^{a}	3.34 ± 0.38^{b}
	B	1.19 ± 0.02^{b}	1.75 ± 0.06^{b}	44.15 ± 0.13^{c}	11.35 ± 0.17^{c}	22.55 ± 0.44^{b}	21.85 ± 0.19^{c}
	C	1.05 ± 0.04^{a}	1.59 ± 0.09^{a}	28.94 ± 0.21^{a}	2.55 ± 0.17^{a}	22.86 ± 0.11^{b}	2.35 ± 0.19^{a}
Average		1.13	1.66	37.18	6.08	22.26	9.18

A – Imeko (Guinea Savannah), B – Ibadan (Dry rainforest), C – Port Harcourt (Fresh Water Forest);
Means with the same superscript in the same column are not significantly different from each other at $\alpha = 0.05$.

Table 2

Comparison of agro-ecosystems elemental compositions of *Lagenaria breviflora*

Species	Agro-ecosystems	Elements (mg kg^{-1}), mean ± SD, n = 4					
		As	B	Cr	Cu	Pb	Zn
Lagenaria breviflora	A	1.16 ± 0.05^{a}	2.15 ± 0.24^{a}	21.55 ± 0.47^{c}	13.76 ± 0.21^{b}	19.41 ± 0.33^{a}	6.93 ± 0.18^{b}
	B	1.34 ± 0.10^{b}	3.00 ± 0.14^{b}	8.60 ± 0.39^{b}	9.94 ± 0.21^{a}	32.50 ± 0.47^{c}	6.18 ± 0.10^{a}
	C	1.19 ± 0.02^{a}	2.79 ± 0.06^{b}	0.63 ± 0.05^{a}	15.83 ± 0.17^{c}	28.98 ± 0.14^{b}	7.10 ± 0.14^{b}
Average		1.23	2.65	10.26	13.18	26.96	6.74

Means with the same superscript in the same column are not significantly different from each other at $\alpha = 0.05$.
A, B, C – see Table 1.

Table 3

Comparison of elemental composition between the two plant species among the three agro-ecosystems

Elements	Agro-ecosystems	Plant species elements (mg kg^{-1}), mean ± SD, n = 4		t
		Lawsonia inermis	*Lagenaria breviflora*	
As	A	1.15±0.03	1.16±0.05	0.463
	B	1.19±0.02	1.34±0.10	3.426*
	C	1.05±0.04	1.19±0.02	8.684*
B	A	1.65±0.04	2.15±0.24	-4.140*
	B	1.75±0.06	3.00±0.14	25.000*
	C	1.59±0.09	2.79±0.06	26.291*
Cr	A	38.44±0.39	21.55±0.47	-133.551*
	B	44.15±0.13	8.60±0.39	-172.443*
	C	28.94±0.21	0.63±0.05	-342.762*
Cu	A	4.55±0.07	13.76±0.21	79.907*
	B	11.35±0.17	9.94±0.21	-12.556*
	C	2.55±0.17	15.83±0.17	223.065*
Pb	A	21.36±0.44	19.41±0.33	-10.550*
	B	22.55±0.44	32.50±0.48	199.000*
	C	22.86±0.11	28.98±0.14	49.650*
Zn	A	3.34±0.28	6.93±0.18	17.286*
	B	21.85±19	6.18±0.10	-249.145*
	C	2.35±0.19	7.10±0.14	164.545*

* P – value is significant at a = 0.05 (P < 0.05)

Table 4

Decreasing trend of the elements in the plants across the eco-systems

Species	Agro-ecosystems	Elements decreasing order					
Lawsonia inermis	A	Cr >	Pb >	Cu >	Zn >	B >	As >
	B	Cr >	Pb >	Zn >	Cu >	B >	As >
	C	Cr >	Pb >	Cu >	Zn >	B >	As >
Lagenaria breviflora	A	Cr >	Pb >	Cu >	Zn >	B >	As >
	B	Pb >	Cu >	Cr >	Zn >	B >	As >
	C	Pb >	Cu >	Zn >	B >	As >	Cr >

DISCUSSION

An idea that natural products from plants represent a huge potential for replacing conventional wood preservative chemicals (Tiilikkala et al. 2010) is becoming a reality. *Lawsonia inermis* and *Lagenaria breviflora* are of interest for development of wood phyto-protective ingredients because of their eco-friendly characteristics, traditional history of successful performance as natural pesticides, and abundant bioavailability. Existing elemental compositions studies on many different plants worldwide are often profiling the chemical characteristics and nutri-medicinal values. As wood preservation practice is becoming increasingly less inorganic, the presence of elements such as: As, B, Cr, Cu, Pb and Zn in *L. inermis* and *L. breviflora* is a biological indicator that these plants could be good sources of safe wood preservative formulations. Internalisation of organic elements through plant tissues extractions into wood for protection is hitherto in tandem with the environmental friendly methods of recovery and safe utilisation of metals.

Arsenic (As) in inorganic forms is one of the foremost important elements that were used to formulate industrial wood preservatives, which are now banned. It is the most toxic of the three elements in CCA-treated wood and its role is to deter insects (Dawson et al. 1991, Stilwell, Gorny 1997, Ko et al. 2007). Arsenic has been documented to have no known bio-importance in human biochemistry, physiology and nutrition, and as such a zero average level is required (Duruibe et al. 2007). The As average concentrations range between 1.05±0.04 and 1.34±0.10 mg kg^{-1} found in this study implied that extracts from the two plants possess insecticidal properties. *L. breviflora* contained significantly slightly higher concentrations of As compared to *L. inermis* across the agro-ecosystems except at Guinea savannah. The difference between the two plants within each eco-system could be ascribed to inter-species trophic habit specificity or genetic control factor variation, and the variation in plant parts used across the eco-systems could be likely related to a wide spectrum of edaphic associated factors. The results of this investigation were relatively higher than the reported value of <0.01 mg kg^{-1} from Malaysian native leaf (Ling et al. 2010), suggesting that Nigerian native *L. inermis* could be a better bio-preservative source for wood protection against insects. For *L. breviflora*, several studies have been performed in Nigeria (Elujoba et al. 1991, Ajayi et al. 2002, Tomori et al. 2007, Onasanwo et al. 2011, Oridupa et al. 2011, Ajani et al. 2015), however none performed elemental analyses of the plant tissues and no information is available elsewhere for comparison except a Bangladeshian report of 0.02 mg kg^{-1} in *Lagenaria siceraria* leaves (Islam, Hoque 2014).

Boron (B) and boron-based compounds have high insecticidal, fungicidal (Ahmed et al. 2004, Freeman et al. 2009) and fire retarding (Tsunoda 2001) effectiveness on wood and wood-based composites. The increasing role of boron-based compounds in wood preservation worldwide, in particular since the banning of CCA in 2004, was the result of its lower human toxicity (Thevenon et al. 2010). The B concentrations range of 1.59±0.09 and 3.0±0.14 mg kg^{-1} obtained in this study, with *L. breviflora* containing significantly higher quantity across the three eco-systems could be a cofactor responsible for the wide pesticidal uses of the two plants in Nigeria.

Chromium (Cr) is perhaps a prime chemical element for wood protection owing to its co-elements playing multiple fixative roles. Pizzi (1981) reported that Cr fixes irreversibly to lignin of wood and is weakly bound on the cellulose surface, implying that the amount of potential chemicals to be leached was dependent on the proportion of cellulose in the wood. Earlier studies documented 0.57 - 0.60 mg kg^{-1} for Sudanese leaf and henna made cosmetic products sold on Sudanese markets (Ebrahim et al. 2012, 2014), 0.31 - 26.07 mg kg^{-1}, for henna product sold on Saudi Arabian markets (Shaheem et al. 2014, Issa et al. 2016), 1.9 mg kg^{-1}, for Pakistan *L. inermis* leaf (Nigha, Nazeer 2016), and 0.31 - 26.07 mg kg^{-1} for henna made cosmetic samples sold on Egyptian markets (Ibrahim et al. 2016, Issa et al. 2016). In this study, the higher content of Cr obtained was an indication that Cr in *L. inermis* from Nigeria could have a comparative advantage for wood protection. While *L. inermis* has been researched for its preservative properties and fixative actions on lignocellulosic materials (Yusuf et al. 2011, Adedeji 2016), Lawsone (2-hydroxy-1, 4-napthaquinone) with the molecular formula $C_{10}H_6O_3$ (Chaudhary et al. 2010, Jain et al. 2010) was chiefly reported to be responsible for the dyeing and colorant properties of the leaf (Jain et al. 2010, Borade et al. 2011). The significant concentrations of Cr in this plant suggest that *L. inermis* exerts its previously reported fixative role and that the colour fastness is regulated by the action of Cr embedded in the leaf. As expected, *L. breviflora* contained relatively less Cr than *L. inermis* across the eco-systems, but a high concentration of Cr from Guinea savannah could be of synergical use to enhance “the locking in” of co-elements into wood fibril. Although no information is available on the Cr content of *L. breviflora*, its amount of 0.19 mg kg^{-1} from Bangladeshian congener *Lagenaria siceraria* leaf (Islam, Hoque 2014) is lower to the range found in this study.

Copper (Cu) is a primary preservative constituent in many compounds which deter fungi. The Cu content of 9.75 mg kg^{-1} (Mtui et al. 2008) reported from Tanzanian leaf was within the ranges achieved in this study, although 13 mg kg^{-1} (Nigha, Nazeer 2016) and 1729.4 mg kg^{-1} (Fahad et al. 2014) from Pakistan and Bangladesh, respectively, were above the results found in this study. The wider variation existing between our results and those of Fahad et al. (2014) could be due to some contamination, either in the growth site or during sample preparation. Cu was found to be relatively higher in *L. breviflora* than in *L. inermis*, except in Dry rainforest eco-system. No information on Cu was found either but the content of 10.42 mg kg^{-1} from Bangladeshian *Lagenaria siceraria* leaf (Islam, Hoque 2014) was within the ranges found in the study.

Lead (Pb), like arsenic, has no bio-importance in human nutrition and human biochemistry and can be toxic (Duruibe et al. 2007). The Pb concentration ranges in *L. inermis* found in this study were higher than those shown in other sources: 0.64 mg kg^{-1} (Ling et al. 2010) from Malaysia, 1.04 mg kg^{-1} (European Commission 2013) from henna made cosmetic products on European markets and 0.019 mg kg^{-1} (NIGHA, NAZEER 2016) from Pakistan. The quantity of Pb in *L. inermis* was comparatively lower than in *L. breviflora*, except Pb from Guinea eco-system. For *L. breviflora,* the results of this study are higher than those of 0.69 mg kg^{-1} (ISLAM, HOQUE 2014) from Bangladeshian *Lagenaria siceraria* leaf.

Zinc-based compounds have also been used extensively as preservatives to inhibit mould fungi, decay fungi and termites (KARTAL et al. 2009). The content of Zn obtained in this study for *L. inermis* is less than 47.48 mg kg^{-1} (MTUI et al. 2008) from Tanzania, 5441.5 mg kg^{-1} (FAHAD et al. 2014) from Bangladesh and 33 mg kg^{-1} (NIGHA, NAZEER 2016) from Pakistan. In *L. breviflora*, the results of this study were lower than 29.29 mg kg^{-1} (ISLAM, HOQUE 2014) from Bangladeshian *Lagenaria siceraria* leaf.

The trends observed for individual plant elements among the three eco-systems varied slightly. For *L. inermis*, Cr was consistently the highest while As was the lowest, and the same trend occurred in both Guinea savannah and Fresh water swamp forest, while there were slight variations in Dry rainforest. The high level of Cr in *L. inermis* was expected and this reflects the indigenous use of the plant for producing and fixing cosmetic on human body. Also, the presence of all the wood preservative elements in appreciable quantities further supports the popularity of the traditional pesticidal use of the plants. The trends were in agreement with the previous study documented by LING et al. (2010) but in contrast to findings reported by of MTUI et al. (2008), FAHAD et al. (2014) and NIGHA, NAZEER (2016). For *L. breviflora*, Cr in was the highest in Guinea savannah and the trend was similar to the trend detected for *L. inermis* in Guinea savannah and Fresh water swamp forest. Dry rainforest and Fresh water swamp forest demonstrated similar increasing trends, with Pb being the highest, followed by Cu, after which both had a contrasting trend with As being the least abundant in Dry rainforest while Cr was at the lowest in Fresh water swamp forest. These facts, taken together, are essential for the choice of wood phyto-protective measures.

Generally, elemental composition of plants related to their consumption, nutri-therapeutic and ecological aspects is widely researched and discussed. Toxicity levels are usually measured by quantity per body weight daily, weekly or monthly. In wood protection, evaluation of plants extract threshold levels against target organisms is usually based on the percentage concentration of the extract relative to the yield and the retention level in kg m^{-3} is the major parameter requirement for protection. The toxicity threshold of boron -based compound as low as 0.36 kg m^{-3} retention achieved 100% extermination of the wood beetle *Hylotrupes bajulus* (SCHOEMAN, LLOYD 1998). Exploring the elements combined in a single extract or synergic effects of both plants could hold tremendous promise for the development of wood protection formulations.

CONCLUSIONS

In this study, variations in the elemental concentrations between the two plants and within same species relative to geographical differences are a reflection of many parameters. The inherent useful elemental compositions, which are of excellent performance threshold requirements for protection, differed in relation to the type of plant species and geographical locations of growth. *L. inermis* leaves had higher concentrations of elements such as Cr and Zn while *L. breviflora* fruits had higher amounts of Pb, Cu Zn and As. Evidently, Cr had the maximum and minimum concentration in *L. inermis* from Dry rainforest and in *L. breviflora* from Fresh water swamp forest, respectively. To maximise the wood protection potential benefits of Cr, *L. inermis* from Dry rainforest is considered to be the best for exploration for wood pest control. Similarly, the highest concentration of Pb from Dry rainforest could be synergically explored but synergising *L. breviflora* fruits grown in Guinea savannah might be more effective for better elemental retention enhancement as they contained higher amounts of fixative agent (Cr). The bioaccumulation of wood phyto-protection elements in plants urgently requires further research by wood protectionists and environmentalists. More studies covering all the ecological zones with individual and extracts synergising tests against wood degrading agents are suggested.

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AUTHORSHIP

GAA and FSE conceived the idea. GAA and ACE designed the work and collected the plants' samples. TOE and ACE were responsible for the elemental analyses. FSE performed data analysis. GAA and ACE wrote the first draft and TOE proof-read. All Authors provided inputs to the drafting and final version of the manuscript.

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