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Antibacterial Activity of Aqueous Extracts of Selected Chewing Sticks

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Abstract

The aim of this study was to determine the antibacterial activity in extracts obtained from various Nigerian chewing sticks. Aqueous extracts from seventeen chewing sticks and the fruit of *C. ferruginea*, one fruit used in oral hygiene in Nigeria, were screened for antibacterial activity against type cultures of *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, and *Pseudomonas aeruginosa*. Eleven of the test extracts showed activity against at least two of these referenced organisms. Minimum inhibitory concentrations (MIC) of these eleven extracts against clinical isolates from orofacial infection were determined. All the extracts demonstrated activity against Staphylococcal and Streptococcal isolates. Over half of the extracts were active against Enterobacteriaceae and obligate anaerobic isolates, including *Prevotella melaninogenica*, *Porphyromonas gigivalis*, *Fusobacterium nucleatum*, and *Peptostreptococcus prevotii*. Extracts of the *Vitellaria paradoxa* root, *Bridellia ferruginea* stem and twigs, *Garcinia cola* stem, *Terminalia glaucescens* root, *Morinda lucida* root, and *Cnestis ferruginea* fruit showed appreciable activity against all classes of bacterial isolates. The extracts of these plants may serve as sources for chemotherapeutic agents for the management of orofacial infections.

Keywords: Chewing sticks, aqueous extracts, antibacterial activity

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Introduction

In Nigeria, as in other developing countries, a very significant proportion of orofacial diseases are due to microbial infections.[1, 2] This being the case, there is widespread use of antibiotics in dental practice in these regions and this gives microorganisms enhanced opportunities for the development of resistance to a broad spectrum of antibiotics. Antibiotics are also widely used and misused in the management of other infections within the region.[3] The need to conserve antibiotics in order to prevent the selection of antibiotic resistant organisms has now been recognized[4] and there is, therefore, the need to look for non-antibiotic substances with proven antimicrobial activity, which can be used in the treatment of microbial infections, including those that are encountered in dental practice.

Chewing sticks are used very widely in Africa and Asia as a means of maintaining oral hygiene.[5, 6] They are made from the roots, twigs, or stem of a plant. The preferred part or parts are cleaned with water to remove dirt, cut to a convenient length which varies from 15-30 cm long, and tied into a bundle. The user holds one end directly in his mouth and chews it into a fibrous brush-like fringe, which is used to scrub the surfaces of the teeth. A combination of vertical and horizontal strokes of the "brush" on tooth surfaces removes plaque. The tongue is scrubbed as well. Cleansing movement is directed away from the gingival margin to avoid induced recession and undue damage to the gums. Chewing sticks are used in the mornings before breakfast and at night after supper for daily oral hygiene maintenance. About five minutes of complete devotion to this exercise is deemed adequate to achieve good cleansing. According to Sote and Wilson[7], chewing sticks obtained form a variety of selected plants are used as a traditional method of mechanical oral hygiene by up to 80–90% of Nigerians. Studies by Danielsen et al.[8], Van Palentstein Helderman et al.[9], Aderinokun et al.[10], and Almas and Al-Zeid[11] have demonstrated chewing sticks are at least as effective as toothbrushes in maintaining oral hygiene. Sathananthan et al.[12] reported Africans that use chewing sticks have fewer carious lesions than those that use toothbrushes, and their use has been encouraged by the World Health Organization.[13] Apart from their mechanical effects, many of these chewing sticks have been shown to have significant antimicrobial activity against a broad spectrum of microorganisms. In an early report Fadulu[14] described the activity of several plant extracts against *Streptococcus mutans*, a cariogenic organism. Since then several investigators including Akpata and Akinrimisi[15], Wolinsky and Sote[16, 17] as well as Rotimi et al.[18] have made similar reports of the antimicrobial activity of chewing stick extracts.

Recent interest in chewing sticks and their extracts has focused on their effects on organisms that are involved in oral infections. For example, Sote and Wilson[7] have reported extracts obtained from seven out of eight Nigerian chewing sticks included in their study demonstrated considerable *in vitro* activity against type cultures of oral pathogens. Li et al.[19] have reported the isolation of compounds active against aerobic and anaerobic periodontopathic bacteria from *Ceanothus americanus*, a plant employed by native Americans in the treatment of these conditions. Tauwi et al.[20] have also reported some Nigerian chewing sticks exhibited strong activities against a broad spectrum of bacteria including those that are involved in both medical and dental morbidity. This study also showed some of the chewing stick extracts demonstrated activity against antibiotic resistant organisms so they can be viewed as sources of novel lead substances with potential therapeutic or preventive applications. A recent trend in the management of periodontal infections is

to employ local antimicrobial delivery.[21] It is possible chewing sticks provide locally available antimicrobial agents in a manner similar to antimicrobial polymers and applications and could provide a suitable substitute therapy if they can be shown to be efficacious. Bioactivity guided fractionation of at least one chewing stick, the Namibian *Diospyros lycoides*, has yielded novel antimicrobial compounds with activity against organisms that cause periodontal disease.[22, 23]

The present study has been designed to identify antibacterial activity in extracts obtained from eighteen Nigerian chewing sticks against type cultures and organisms that were isolated form various orofacial infections.

Materials and Methods

Collection and Extraction of Plant Material

Whole roots, stem, and twigs of seventeen different plants used as chewing sticks as well as the fruit of *C. Ferruginea* were collected in the dry season (March 1996) from various parts of South-West Nigeria (Table 1). The specimens were identified in the Department of Botany, Obafemi Awolowo University, Ile-Ife. Voucher specimens of the plants were deposited in the herbarium of the Faculty of Pharmacy of the same university. The plant parts were all dried in an aerated oven at 45–50°C (Gallenkamp,Ltd. Loughborough, UK) following which they were pulverised in a mill (Christy Lab Mill, Christy and Noris Ltd; Process Engineers, Chelmsford, England). About 25 gm quantities of the dried plant parts and the fleshy part of the fruit were then covered with distilled water and thoroughly extracted during three days with occasional shaking and with two changes of the extractant. The combined filtrates obtained were then bulked and lyophilised to recover the residues as powder, or in a few cases, as sticky pastes, which were further dried in a desiccator. Aqueous extracts of the plants were employed in this study because the water was likely to extract the same principles as are extracted under in-use conditions. It has to be conceded, however, considerable maceration of the sticks occur during their use, and this is likely to lead to the release of slightly less polar constituents than were evaluated in the tests.


Anaerobic Jar

Bacterial Strains

Type cultures from four species were employed in the preliminary screening of the extracts: *Staph. Aureus* NCTC 6571, *E. Coli* NCTC 10418, *B. Subtilis* NCTC 8263, and *Pseud. Aeruginosa* ATCC 10145. Clinical isolates were recovered from patients with orofacial infection and identified by conventional biochemical techniques as described elsewhere.[24] The clinical isolates included Staphylococci (6 isolates), Streptococci (4 isolates), Enterobacteriacae (3 isolates) as well as obligate anaerobes belonging to the genera *Prevotella*, *Porphyromonas*, *Fusobacterium*, and *Peptostreptococcus* (11 isolates).

Microbiological methods: Fastidious Anaerobe Agar was obtained from Techlab®, Inc., Blacksburg, VA, USA. All other bacteriological media was obtained from Oxoid Limited, Basingstoke, UK and prepared in accordance with manufacturer's instructions. Aerobes and facultative aerobes were incubated under ambient atmospheric conditions at 37°C. Anaerobes were incubated at 37°C in anaerobic jars in an atmosphere of 1%O_2/8%CO_2 generated using commercial gas-generating kits (BBL, Cockleysville, USA).

Antimicrobial screening of extracts against type cultures: The hole in the plate method described by Lamikanra et al.[25] was used to screen the extracts. Aliquots of 50 mL molten and cooled nutrient agar inoculated with 500 µL of 18-hour nutrient broth cultures were poured into 14 cm petri dishes. Eight holes, equidistant

Table 1. Chewing sticks that were evaluated in the study.

No.	Botanical name	Part	Other names[1]
1	*Vitellaria paradoxa* Gaertn.f.(Sapotaceae)	Root	Emi, Emi-emi (Yor)
2	*Bridellia ferruginea* Benth (Euphorbiaceae)	Stem and twigs	Ira Odan (Yor)
3	*Phyllanthus muellerianus* (O.Ktze)(Euphorbiaceae)	Stem	Arunjeran (Yor)
4	*Massularia acuminata*(G.Don)Bullock ex Noyle(Rubiaceae)	Stem wood	Pako Ijebu (Yor)
5	*Clausena anisata*(Willd)Hook F.ex Benth(Rutaceae)	Stem and Twigs	Agbasa (Yor)
6	*Psidium guajava* Linn (Myrataceae)	Stem	Gooba (Yor)
7	*Garcinia kola* Heckel (Clusiaceae)	Stem and twigs	Orogbo (Yor)
8	*Vitex doniana* Sweet (Verbenaceae)	Stem	Ori (Yor)
9	*Paullinia pinnata* Linn (Sapindaceae)	Root	Kankansela (Yor)
10	*Rauwolfia vomitoria* Afzel (Apocynaceae)	Root	Oora Igbo (Yor)
11	*Vernonia amygdalina* Del (Asteraceae)	Root	Ewuro (Yor)
12	*Anogeissus leiocarpus* (DC) Guill et Perr (Combretaceae)	Root	Ayin (Yor)
13	*Terminalia glaucescens* Planch ex Benth (Combretaceae)	Root	Idi-odan (Yor)
14	Morinda *lucida* Benth (Rubiaceae)	Root	*M. citrifolia* (Syn); Oruwo (Yor)
15	*Citrus sinesis* Osbeck (Rutaceae)	Branch, branchlets	Orombo, osan(Yor)
16	*Xanthoxylum tessmannii* (Engl.) Ayafor (Rutaceae)	Root	Ata (Yor)
17	*Cnestis ferruginea* DC.(Connaraceae)	Fruit	Gboyin-gboyin (Yor)
18	*Cnestis ferruginea* DC.(Connaraceae)	Stem	Gboyin-gboyin (Yor)

[1] Yor: Yoruba; Syn: Synonym

from each other and the edge of the plate, were bored into the solidified seeded agar using sterile glass borers (8 mm in diameter). The plates were incubated at 37°C for 30 minutes before introducing 80 µL of each extract (at 40 and 20 mg/mL in 25% methanol) into each of two holes. Holes containing solvent alone and chlorocresol (BDH, England) (2 and 1 mg/mL) were included on each plate as controls. The plates were refrigerated at 4°C for 30 minutes to allow for diffusion before incubating at 37°C for 18 hours. All extracts that produced zones of inhibition at 40 and/or 20 mg/mL were considered active against the organisms screened.

Evaluation of the activity of chewing stick extracts against clinical isolates from oral infections: The Minimum Inhibitory Concentrations (MICs) of all the extracts that demonstrated activity against the type cultures were determined by the agar dilution method as described previously by Okeke et al.[26] A stock suspension of 200 mg/mL of extract in 25% methanol was prepared; from this, plate concentrations containing 40, 20, 10, 5, and 2.5 mg/mL of each extract were made. Plates containing chlorocresol 1, 0.5, 0.25, 0.125, 0.0625, 0.03125, and 0.015625 mg/mL were similarly prepared and employed as controls.

Aerobic bacteria were grown overnight in nutrient broth, diluted to a final density of 2 X 10^5 colony-forming units/ml in normal saline, and applied to the surface of nutrient agar plates containing dilutions of test extract, chlorocresol, or solvent alone employing a multi-point inoculator. Plates were incubated at 37°C for 48 hours. Anaerobic bacteria were grown in cooked meat medium for 72 hours, and dilutions were prepared in peptone water containing 0.1% sodium thioglycollate. The test was carried out on Fastidious Anaerobe Agar, and the plates were incubated anaerobically at 37°C for 72 hours. In all cases the lowest concentration at which there was no growth was recorded as the MIC.

Results

Extracts from 17 chewing sticks and the fruit of *C. ferruginea*, one fruit used in dental hygiene in Nigeria, were evaluated for antibacterial activity. Under the conditions employed in the study, 11 of the 18 extracts examined demonstrated some activity against type cultures used for preliminary screening. However, as shown in Table 2, only two of the extracts (*C. ferruginea* fruit and *T. gluacescens*) showed activity against all four-referenced organisms in the test. The other 9 extracts were only active against Gram-positive strains.

Further evaluation of the 11 extracts that demonstrated some activity in the primary screen revealed they varied considerably in their range and extent of activity against isolates from oral infections (Table 3). The majority of the extracts demonstrated appreciable activity against aerobic Staphylococci and Streptococci. Encapsulated *Staph. aureus* isolates were noticeably less susceptible to all the extracts than the non-encapsulated isolate. Only three extracts: *B. ferruginea*, *Term. glaucescens*, and *A. leiocarpus* showed appreciable activity against the facultative Gram negative rods (*Escherichia*, *Citrobacter*, and *Enteroabacter* spp.) although *V. paradoxa*, *Garcinia cola*, and *Cn. ferruginia* (fruit) extracts demonstrated modest activity against these strains. With the exception of *Cit. sinensis*, all the 11 extracts that were tested against clinical isolates demonstrated some activity against the obligate anaerobes with the extracts from *P. muellerianus*, *A. leiocarpus*, and *Cn. ferruginea* (fruit) being the most active. More than half of the 11 extracts demonstrated a broad antimicrobial spectrum that covered all the classes of bacteria represented.

Discussion

Eleven of the 18 aqueous extracts from chewing sticks used in oral hygiene in South Western Nigeria were found to be active against at least two of the type organisms used in this study and were further tested against 24 different organisms isolated from patients with orofacial infections. The anaerobic clinical organisms used in these tests were found to be particularly susceptible to all the extracts tested in the second stage of the study with the exception of *C. sinesis*, which gave MIC values in excess of 20mg/mL in each case. Similarly, the extracts were found to be effective against the Gram-positive organisms isolated in the course of the study; MIC values being largely below 2.5mg/mL, although the

Table 2. Results of preliminary screening against type cultures.

Botanical name	Part	*S. aureus*	*B. subtilis*	*E. coli*	*Ps. aeruginosa*
V. paradoxa	Root	2	2	1	1
B. ferruginea	Stem and twigs	2	2	1	1
P. muellerianus	Stem	2	2	1	1
M. acuminata	Stem wood	1	1	1	1
Cl. anisata	Stem and Twigs	1	1	1	1
Ps. guajava	Stem	2	2	1	1
G. kola	Stem and twigs	2	2	1	1
Vitex doniana	Stem	1	1	1	1
P. pinnata	Root	2	2	1	1
R. vomitoria	Root	1	1	1	1
Vern. amygdalina	Root	1	1	1	1
An. leiocarpus	Root	2	2	1	1
Term. glaucescens	Root	2	2	2	2
M. lucida	Root	2	2	1	1
Cit. sinesis	Branch, branchlets	2	2	1	1
Z. tessmannii	Root	1	1	1	1
Cn. ferruginea	Fruit	2	2	2	2
Cn. ferruginea	Stem	1	1	1	1
Chlorocresol	Reference compound	2	2	2	2

Key: 2= active; 1=inactive

Table 3. Activity of antimicrobial chewing stick extracts against organisms from oral infections.

Organism	MICs to chewing stick extracts in mg/ml[2]											MIC to chloro-cresol
(No of strains tested)	1	2	3	6	7	9	12	13	14	15	17	in µg/ml
Staphylococcus aureus NCTC 6571	<2.5	<2.5	<2.5	<2.5	<2.5	5	<2.5	<2.5	<2.5	20	5	<10
Clinical isolates												
Staph. aureus (4)	<2.5	<2.5	<2.5 (1), 5 (3)	<2.5	<2.5 (1), 10 (3)	5 (1), >20 (3)	<2.5	<2.5	<2.5 (3), 20 (1)	20 (1), >20 (3)	5	<10 (2), 20 (2)
Coagulase negative Staphylococci (1)	<2.5	<2.5	<2.5	<2.5	<2.5	5	<2.5	<2.5	<2.5	20	5	<10
Streptococcus mutans. (4)	<2.5	<2.5	<2.5 (2), 5 (2)	<2.5	<2.5 (1), 10 (3)	5 (1), >20 (3)	<2.5	<2.5	<2.5 (3), 10 (1)	20	5	<10 (2), 10 (2)
Escherichia coli (1)	10	10	>20	>20	10	>20	5	5	>20	>20	10	20
Citrobacter freundii (1)	10	5	>20	>20	10	>20	<2.5	5	>20	>20	10	20
Enterobacter cloacae (1)	10	5	>20	>20	10	>20	<2.5	5	>20	>20	10	20
P. melaninogenica.(8)	10	10	10	>20	10	>20	10	10	10	>20	5	20
Porphyr. gingivalis. (1)	10	10	5	>20	10	20	10	10	10	>20	5	20
Fusobact. nucleatum (1)	10	10	5	10	10	10	5	10	10	>20	5	20
Peptostrept. prevotii (1)	5	10	5	10	10	10	5	10	10	>20	5	20
Staphylococcus saccharolyticus (1)	10	10	5	10	10	10	5	10	10	>20	5	20

Plant extracts: 1= *V. paradoxa*, 2 = *B. ferruginea*, 3 = *P. muellerianus*, 6 = *P. guajava*, 7 = *G. cola*, 9 = *P. pinnata*, 12 = *An. leiocarpus*, 13 = *T. glaucescens*, 14 = *M. lucida*, 15 = *Cit. sinesis*, 17 = *Cn. ferruginea*(fruit)
[2]Key: Extract numbers as indicated in Table 1

encapsulated *Staph. aureus* strains used were found to be less susceptible to the activity of the extracts. These results suggest the chewing stick extracts tested are potential sources of agents that can be used in the treatment of oral infections, and further studies are required to evaluate their value in this regard.

Gram-negative organisms tend to have a higher intrinsic resistance to most antimicrobial agents. In this study the Gram-negative organisms were less susceptible than Gram-positive organisms to the activity of the extracts. In spite of this, impressive activity against the Gram-negative organisms has been noted with *Bridellia ferruginea* (#2), *Anogeissus leiocarpus* (#12), and *Terminalia glaucescens* (#13). The broad-spectrum activity of the last two plants was similarly recognized by Taiwo et al.[20] Other extracts, while not as effective as these, also demonstrated some activity against Gram-negative organisms.

Three of the extracts screened in this study were previously investigated by Sote and Wilson[7] against a more limited set of isolates. The results concur that *T. glaucescens* extract showed a broad spectrum of activity, while *M. acuminata* was found to be inactive *in vitro* against periodontopathic bacteria in both studies even though it was found to have considerable activity against type cultures. In both studies *G. cola* demonstrated a narrow spectrum.

On the whole the results of this study confirm a number of plants used in Africa as chewing sticks can be regarded as a source of substances, which may be used as antibacterial agents in the treatment of oral infections caused by a broad spectrum of pathogenic organisms. In particular the extracts obtained from *C. ferruginea* fruit (#17), *B. ferruginea* (#2), *T. glaucescens* (#13), and *A. leiocarpus* (#12) were all found to show impressive activity against the broad spectrum of organisms used in this test. It should be noted that although it continues to be employed in local dental hygiene, Rotimi et al[18] found extracts of *A. leiocarpus* acutely toxic in mice. Therefore, their seems to be significant interest in conducting further studies on chewing sticks in order to test their potential for being sources of antibacterial principles, which may be used in the chemotherapy of orofacial infections.

References

1. Adekeye E, Prabhu S. Odontogenic infections of the jawbones and related structures. In: Oral Diseases in the Tropics. S Prabhu, D Wilson, D Daffary and N Johnson editors. New York: Oxford University Press, 1992; 674-685.
2. Ndukwe KC, Fatusi OA, Ugboko VI. Craniocervical necrotizing fascitis in Ile-Ife, Nigeria. British J of Oral and Maxillofac. Surg 2002; 40: 64-67.
3. Okeke IN, Lamikanra A, Edelman R. Socioeconomic and behavioral factors leading to acquired bacterial resistance to antibiotics in developing countries. Emerg Infect Dis 1999b; 5: 18-27.
4. Levy SB. Antibiotic resistance: an ecological imbalance. Ciba Found Symp 1997; 207(1-9; discussion 9-14.
5. Otuyemi O, Abidoye RO, Dada D. Oral helath knowledge, attitudes and behaviour of 12-year-old suburban and rural school children in Nigeria. Afr Dent J 1994; 8: 20-25.
6. Wu CD, Darout IA, Skaug N. Chewing sticks: timeless natural toothbrushes for oral cleansing. J Periodontal Res 2001; 36:275-84.
7. Sote EO, Wilson M. In vitro antimicrobial effects of extracts of Nigerian tooth cleaning sticks on peridotopathic bacteria. African Dent J 1995; 9: 15-19.
8. Danielsen B, Baelum V, Manji F, et al. Chewing sticks, toothpaste, and plaque removal. Acta Odontol Scand 1989; 47: 121-125.
9. Van Palentstein Helderman W, Munck L, Mushendwa S, et al. Cleaning effectiveness of chewing sticks among Tanzanian schoolchildren. J of Clinical Periodontol 1992; 19: 460-463.
10. Aderinokun GA, Lawoyin JO, Onyeaso CO. Effect of two common Nigerian chewing sticks on gingival health and oral hygiene. Odontostomatol Trop 1999; 22:13-8.
11. Almas K, Al-Zeid Z. The immediate antimicrobial effect of a toothbrush and miswak on cariogenic bacteria: a clinical study. J Contemp Dent Pract 2004; 5:105-14.
12. Sathananthan K, Vos T, Bango G. Dental caries, fluoride levels and oral hygiene practices of school children in Matebeleland South Zimbabwe. Community Dent Oral Epidemiol 1996; 24:21-24.
13. Almas K, al-Lafi TR. The natural toothbrush. World Health Forum 1995; 16:206-10.
14. Fudulu SO. Antimicrobial properties of the buffer extracts of chewing sticks used in Nigeria. Planta medica 1975; 27: 123-126.
15. Akpata ES, Akinrimisi EO. Antibacterial activity of extracts from some African chewing sticks. Oral Surg 1977; 44: 717-722.
16. Wolinsky LE, Sote EO. Inhibiting effect of aqueous extracts of eight Nigerian chewing sticks on bacterial properties favouring plaque formation. Caries Res 1983; 17:253-257.
17. Wolinsky LE, Sote EO. Isolation of natural plaque-inhibiting substances from Nigerian chewing sticks. Caries Res 1984; 18:216-225.
18. Rotimi V, BE L, Bartlett J, et al. Actvities of Nigerian chewing stick extracts against Bacteriodes gingivalis and Bacteriodes melaninogenicus. Antimicrob Agents and Chemo 1988; 32:598-600.
19. Li X-C, Cai L, Wu CD. Antimicrobial compounds from Ceanothus americanus against oral pathogens. Phytochemistr 1997; 46:92-102.
20. Taiwo O, Xu H, Lee S. Antibacterial activities of extracts from Nigerian chewing sticks. Phytotherapy Res 1999; 13:675-679.
21. Killoy W. Chemical treatment of periodontitis: local delivery of antimicrobials. International Dent J 1998; 48 (Suppl 1):305-315.
22. Li XC, van der Bijl P, Wu CD. Binaphthalenone glycosides from African chewing sticks, Diospyros lycoides. J Nat Product 1998; 61:817-820.
23. Cai L, Wei GX, van der Bijl P, et al. Namibian chewing stick, Diospyros lycioides, contains antibacterial compounds against oral pathogens. J Agric Food Chem. 2000; 48:909-914.
24. Ndukwe KC, Okeke IN, Akinwande JA, et al. Bacteriology and antimicrobial susceptibility profile of agents of orofacial infections in Nigerians. Afr J of Clinical and Experimental Microbiol 2004; 5: 272-277.
25. Lamikanra A, Ogundaini AO, Ogungbamila FO. Antibacterial constituents of Alchornea cordifolia leaves. Phytotherapy Res 1990; 4:198-200.
26. 26.Okeke IN, Ogundaini A, Ogungbamila F, et al. A. Antimicrobial spectrum of Alchornea cordifolia leaf extract. Phytotherapy Res 1999a; 13: 67-69.

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