Chapter 15

Lesser Known Aromatic Plants in Nigeria

Ngozichukwuka P. Igoli and John O. Igoli

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/66484

Abstract

Herbs and spices are used in all cultures as natural foodstuffs and for medicinal purposes. *Siphonochilus aethiopicus*, *Monodora myristica* and *Crateva adansonii* are some of the spices which are not commonly used. They improve the taste of food, and through their anti-oxidant, anti-microbial and anti-fungal properties, they could act as food preservatives. There is an accumulation of evidence for the usage of these spices medicinally as anti-inflammatory, anti-plasmodial, anti-sickling, anti-oxidant and chemopreventive agents. There have also been investigations to identify the active constituents of these spices and to verify their pharmacological actions. This article aims at reviewing the available data on these investigations and the basis for usage in several diseases and conditions.

Keywords: *Siphonochilus aethiopicus*, *Monodora myristica*, *Crateva adansonii*, herbs, spices

1. Introduction

Aromatic herbs and spices are widely used in Nigeria for culinary and medicinal purposes. While some are quite common and used worldwide, others like: wild ginger (*Siphonochilus aethiopicus* (Schweinf) B.L Burtt), African nutmeg (*Monodora myristica* (Gaertn) Dunal) and sacred garlic pear (*Crateva adansonii* DC) are not. Herbs and spices make important contributions towards the odour and flavour of foods due to the presence of volatile (essential) oils and fixed oils. They confer new aromas to the foods, and their use for improving the taste of foods is a cultural achievement of all races which also led to cultural exchanges very early in history [1]. Moreover, there is an increasing interest in using the extracts of herbs and spices, for food preservation [2] since as natural foodstuffs, they appeal to many consumers who question the safety of synthetic food additives due to their carcinogenicity or other concerns [3, 4]. Indeed, since prehistoric times, herbs were the basis for nearly all medicinal therapy until synthetic drugs were developed, and even today, herbs are still found in 40% of prescription drugs [5].

Thus, in addition to imparting characteristic pleasant flavours, certain herbs and spices prolong the storage life of foods by preventing rancidity through their anti-oxidant activity or through bacteriostatic or bactericidal activity [6]. Consequently, herbs and spices have medicinal values, anti-oxidant and anti-microbial properties [7], and some do contain potent phytochemicals, which provide significant protection against cancer [8].

Wild ginger is an herb with perennial tuberous roots giving rise to annual leafy stems which grows in sub-Saharan Africa especially in savannah regions or regions with dry season [9]. It belongs to the family Zingiberaceae and has leafy shoots (pseudo-stem) which grow to about 35 cm high after flowering and is common throughout the West African region and elsewhere in tropical Africa [9]. The rhizomes which have a terrific scent of violets and ginger are spindle shaped and are about 5 cm by 1 cm, arranged radially on lateral roots that spread fairly readily underground [9]. The Nigerian variety flowers between April and May after the early rains and the flowers, which appear before the leaves, come up in considerable quantity followed by the leaves and the pseudo-stem [10]. The flowers, just borne above ground level in inflorescences separate from the leafy shoot, are purple with white corolla tube and a yellow flare on the central petal and are 7–10 cm long [9]. The leafy shoot dries up between September and December after which it falls off. The herb is found in the wild and could also be cultivated.

The South African variety is a deciduous aromatic plant, bisexual or female, up to 1 m high and sprout annually from the underground stem in spring [11]. The leaves are glabrous and 30–400 × 50–90 mm in size, light green, lance shaped and borne on the end of stem-like leaf bases [11, 12]. Between October and February, it gives faintly scented flowers that are white to bright pink with yellow markings on lip, white corolla tubes 30–40 mm long and tepal lobes 60–80 mm wide [12]. The tremendously attractive flowers often appear before the leaves in spring, perhaps to allow them to be more visible to pollinators [13]. They may also vary in colour from bright pink, purple-pink, yellow to white with a yellow centre and are delicately scented. About 15 flowers are produced per plant over the flowering season, each lasting a single day [14].

The roots, tubers and rhizomes of wild ginger are used for their aroma and medicinal properties in the West and South of Africa. While they are used as spice by the Igede people of Benue State of Nigeria [15], others mainly use them in traditional medicine for colds, coughs, influenza, hysteria, pain and malaria amongst other ailments [16, 17]. It is also used by Zulu people as a protection against lightning and snakes [18]. Infusions of the rhizome and roots are anti-inflammatory (prostaglandin synthetase inhibition), bronchodilatory, smooth muscle relaxant, mild sedative, anti-candidal and used to treat headache, influenza, mild asthma, sinusitis, sore throat, thrush, epilepsy, hysteria and relieve dysmenorrhoea [11] or administered to horses as prophylactics against horse sickness [19]. It is in such popular demand and coupled with the method of harvesting which involves removal of the entire rhizome that it has become extinct in certain areas [20]. The plant does not set much seed and splitting rhizomes is the best available option for plant propagation [14].

The seeds of *Monodora myristica* (Gaertn.) Dunal either fresh or roasted are used both as a spice in cuisine and medicinally in different parts of Africa and in the Caribbean [21, 22]. It is largely underutilized and has recently been used as popcorn flavouring in an attempt to increase its utilization [23]. It is also responsible for the distinct flavour of the Nigerian delicacy “isi ewu”,

http://dx.doi.org/10.5772/66484

and it is used in soups and peanut paste [23, 24]. Its aroma which is enhanced by mild roasting is similar to nutmeg; thus, the plant is commonly known as African nutmeg, calabash nutmeg or Jamaican nutmeg; and it is a large tropical tree which can reach 35 m height and 2 m in diameter [25]. It is native to tropical West Africa and further east to Uganda, Kenya and Tanzania where it grows naturally in evergreen forests but has been introduced to Jamaica, other parts of the Caribbean and elsewhere [26]. Its large leaves (35 cm long and 18 cm wide) are purple at first but turn a smooth deep green on the upper side with paler green underneath. They are prominently veined, and the petiole is purplish. The exotic, conspicuous and scented flowers hang down on long stalks and have three calyx lobes and three petals arranged in two whorls [27]. The flowers are followed by large woody fruits filled with brown seeds embedded in an aromatic pulp [25]. The medicinal uses of the seeds are to treat headaches, pains, toothaches, haemorrhoids, stomach ache, relieve constipation and control passive uterine haemorrhage in women immediately after child birth [24, 25, 28] and hypertension [25].

The leaves of sacred garlic pear (*Crateva adansonii*) which are eaten with soups or mixed with cereal are also used medicinally in different parts of Africa and Asia [29, 30]. It belongs to the family Capparaceae and is widely distributed as a small handsome tree of the galleried forest and savannah woodland often found on river banks across Africa [29]. The species is confined to Africa but bears very close affinity to the Asian *Crateva religiosa* G. Forst with which it has been equated by some authorities [29]. It attains a height of 7 m or more with an irregular trunk which is seldom straight and could be cultivated for ornamental purposes due to its dense masses of white flowers borne at the ends of all the shoots [29]. Where it survives bush burning and repeated stripping of its leaves, the tree is often stunted. The wood is strong-smelling when cut and is soft and yellow [29]. In Eastern Nigeria, *C. adansonii* is used medicinally, its leaves being in high demand for the treatment of ear and parasitic infections [31]. The leaves are applied externally to relieve joint pains; the fresh juice from the leaves is used for the relief of ear ache, eye infection and anodyne in toothache [32]. The leaves are also used in fumigations for treating jaundice and yellow fever, applied to the head as a mild counter-irritant for easing headaches, and a steam bath of over the face is used as a remedy for all troubles due to poor vision [29]. The bark is said to be rubefacient and tonic, widely used as a remedy for stomach-troubles and used both internally and externally for treating sterility. It is used in combination with *Flacourtia flavescens* as a treatment for leprosy [29]. Powdered and boiled in oil, it is used as an application for rheumatic condition, and a bark paste is used as a poultice on swellings [29]. The powdered bark is used in rheumatism, itch, epilepsy, stomach troubles and asthma [33]. The powdered leaves and bark are considered to be rubefacient and are used especially on cysts. The root is used as a febrifuge and in several treatments for syphilis. The dried, ground roots are used as an application to swollen parts of the body, while the seeds have unspecified medicinal uses [29].

This review identifies lesser known aromatic plants in Nigeria and current reports on their utilization, constituents and properties. The aim is to provide an insight into the health-promoting potentials of biologically active constituents of: wild ginger (*Siphonochilus aethiopicus* (Schweinf) B.L Burtt), African nutmeg (*Monodora myristica* (Gaertn) Dunal) and sacred garlic pear (*Crateva adansonii* DC). This is because diets rich in plant foods can provide biologically active phytochemicals that promote health [34].

2. Constituent phytochemicals

The sensory perception of wild ginger depends on a variety of odorants including esters, monoterpenes, sesquiterpenes, aldehydes, pyrazines and thiophenes which are important for the mild and pleasant aroma both in the fresh and in roasted spice as against the hot/pungent flavours of ginger and other Zingiberaceae [35]. Aroma extracts dilution analysis (AEDA) employing the gas chromatography/olfactometry (GC/O) technique was reported for the organoleptic evaluation of these odorants and their odour quality together with quantification from GC-FID/GC-MS profiles [35]. Thus, the sweet/fruity ester flavours, methyl-2-/-3-methyl butanoates and derivatives of the apple flavour were reported to be the most important odorants perceived at the highest dilution of the aroma extract of the fresh spice [35]. These were followed by the monoterpene β-phellandrene which has a terpenish/woody odour and is also important for the aroma of ginger and dill [35–37]. Another sweet/fruity flavour propyl-2-methylbutanoate also an apple flavour follows before the roasty/earthy smelling 2-isopropyl-3-methoxypyrazine and 2-isobutyl-3-methoxypyrazine which are known to have a hot/paprika taste and are also present in paprika pepper and chillies [35–38]. The sesquiterpene curzerenone (sweet/coconut-like) is perceived at the next significant dilution together with the roasty/potato-like methional [35]. In the roasted sample, terpenish/woody β-phellandrene is the most important odorant followed by the roasty/earthy smelling pyrazines before the sweet/fruity flavoured butanoates. The pungent smelling principle 2-acetyl thiophene, which is absent in the fresh sample, is next followed by the sesquiterpene curzerenone (sweet/coconut-like) together with the roasty/potato-like methional [35].

Principal component analysis using GC shows that the constituents of wild ginger are mostly sesquiterpenes as against monoterpenoids or diterpenoids [16, 35, 39]. Five eudesmane sesquiterpenoids as shown in **Figure 1**: 4aαH-3,5α,8aβ-trimethyl-4,4a,8a,9-tetrahydronaphtho[2, 3b]-furan-8-one; 2-hydroxy-4aαH-3,5α,8aβ-trimethyl-4,4a,8a,9-tetrahydro-naphtho[2, 3b]-furan-8(5H)-one; 4aαH-3,5α,8aβ-trimethyl-4,4a,8a,9-tetrahydronaphtho-([2, 3b]-dihydrofuran-2-one)-8-one; 9aβ-hydroxy-4aαH-3,5α,8aβ-trimethyl-4,4a,8a,9-tetrahydronaphtho-([2, 3b]-dihydrofuran-2-one)-8-one and 4aαH-3,5α,8aβ-trimethyl-4,4a,8a-trihydronaphtho-([2, 3b]-dihydrofuran-2-one)-8-one were isolated as the constituents of the South African variety [16, 17]. However, the elemane sesquiterpenoids: curzerenone and *epi*-curzerenone, the germacrane sesquiterpenoids: furanodiene (8,12-epoxy-1(10)E,4Z,7,11-germacratetraene); isofuranodiene (8,12-epoxy-1(10)E,4Z,7,11-germacratetraene) and furanodienone (8,12-epoxy-1(10)E,4Z,7,11-germacratetraen-6-one) together with the labdane diterpenoids: 8(17),12E-labdadiene-15,16-dial, 15-hydroxy-8(17),12E-labdadiene-16-al, and 16-oxo-8(17), 12E-labdadiene-15-oic acid (zerumin A) as also shown in **Figure 1** were isolated from the Nigerian variety [35, 39].

A yield of 45-6g kg^{-1} essential oils containing 75% monoterpene hydrocarbons; the major compounds being: α-phellandrene (50–4%), α-pinene (5–5%) and myrcene (4–35%) has been reported for the African nutmeg [40]. Few sesquiterpene hydrocarbons (3%) and oxygenated compounds such as germacrene-D-4-ol (9–5%) were also reported as against another report of 25.48% germacrene-D-4-ol [41]. Meanwhile, an essential oil yield of 6.2% (dry weight basis) has also been reported [42]. Prenylated indole alkaloids are considered a chemotaxonomic

http://dx.doi.org/10.5772/66484

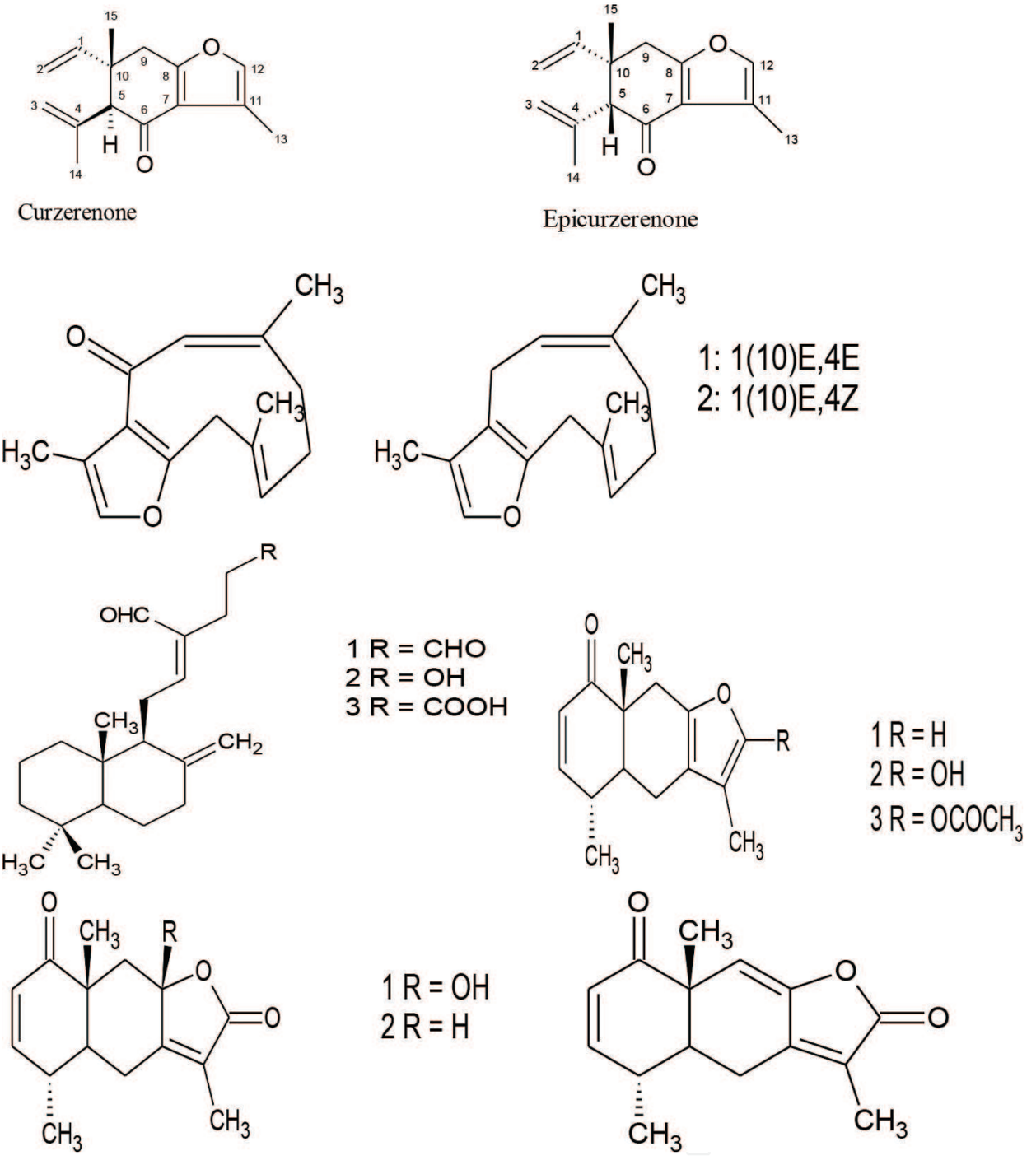


Figure 1. Isolated constituents of *Siphonochilus aethiopicus*.

marker of the genus, and 5-formyl indole and 5-(3-oxo-but-1-enyl) indole as shown in **Figure 2** have been reported from *Monodora myristica* and other species of *Monodora* [21, 43, 44].

The volatile oils of the sacred garlic pear whole plant reportedly show 43.5 and 41.1% oxygenated monoterpenes and aliphatic compounds, respectively. The major constituents are linalool (30.2%) and nonanal (17.2%), and it contains no sesquiterpene hydrocarbons [45]. The

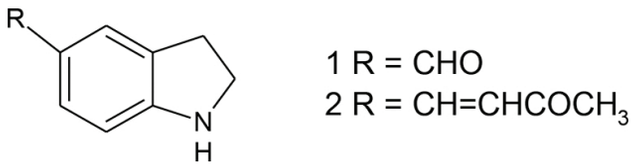


Figure 2. Isolated constituents of *Monodora myristica*.

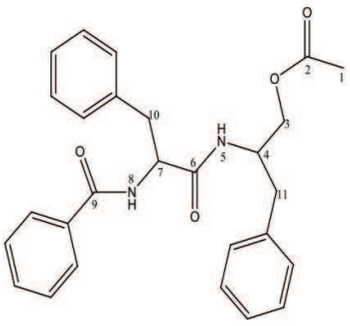
leaves are also known to have a disagreeable smell when crushed [29]. The triterpenes: oleanolic acid and 4-epi-hederagenin were isolated from the 1:1 C_2H_2:MeOH extract of its seed as shown in **Figure 3** [46]. Then, the hexane extract of the leaf yielded the antibiotic aurantiamide acetate while the ethyl acetate extract afforded ethyl pyropheophorbide A, purpurin-18 ethyl ester and pyropheophorbide A as also shown in **Figure 3** [31]. Additionally, the triterpene lupeol was also isolated from a 1:1 dichloromethane/methanol fraction of the leaf as illustrated in **Figure 3** [47].

It has been reported that the leaf and rhizome extracts of *S. aethiopicus* possess anti-microbial and anti-fungal properties [48]. However, the activities of the leaf extracts are much lower than those of the rhizome extracts which inhibited *Bacillus subtilis*, *Micrococcus kristinae*, *Bacillus cereus*, *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Klebsiella pneumoniae* and showed anti-fungal properties against *Aspergillus flavus*, *Aspergillus glaucus*, *Candida albicans*, *Candida tropicalis*, *Trichophyton mentagrophytes* and *Trichophyton rubrum* [48, 49]. This is despite the similar chemical composition of the essential oils of the leaf and rhizome [20]. Again, the anti-fungal activities of some of the isolated constituents of the rhizomes and tubers: *epi*-curzerenone and furanodienone against *Candida albicans*, and 8(17),12E-labdadiene-15,16-dial against *Candida tropicalis* and *Candida guilliermondii* have been reported [50, 51]. Moderate activity of the crude rhizome extract and isolated diterpenes: 8(17),12E-labdadiene-15,16-dial and 15-hydroxy-8(17),12E-labdadiene-16-al against *Mycobacterium tuberculosis* has also been reported [39].

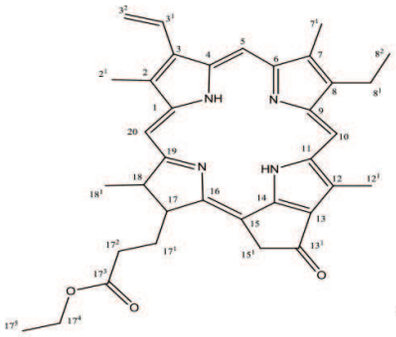
The in vitro anti-proliferative properties of the essential oils of wild ginger against MCF-7 cancer cells were reported [52]; indeed, it has been suggested that the presence of antiseptic monoterpenoids contributes to its bioactivity [11]. In vitro cytotoxicity determinations of the crude rhizome extract and isolated constituents using five cell lines: SH-SY5Y, Jurkat, L929, Hep G2 and Hs 27 were also carried out [39]. *Epi*-curzerenone and furanodienone were inactive against the five different cell lines tested, while two of the diterpenes reportedly showed specific cytotoxic effects. 8(17),12E-Labdadiene-15,16-dial had moderate effect on the normal cell line Hs 27 and was cytotoxic to SH-SY5Y, the cancerous Jurkat and L929. However, only Jurkat and SH-SY5Y were affected by 15-hydroxy-8(17),12E-labdadiene-16-al [39].

The in vitro and in vivo anti-inflammatory properties of *S. aethiopicus* have also been reported [53]. The rhizome extract and the isolated furanoterpenoid, 4aαH-3,5α,8aβ-trimethyl-4,4a,8a,9-tetrahydronaphtho[2, 3b]-furan-8-one, showed in vitro inhibition of glucocorticoid and histamine H1 receptor binding and phosphodiesterase IV activity [53]. OVA-sensitized and challenged mice showed significantly reduced lung inflammation and the percentage of eosinophils in bronchoalveolar lavage fluid after administration of *S. aethiopicus* extracts but airway hyper reactivity was not influenced supporting anecdotal accounts of effectiveness against asthma, sinusitis, colds and flu [53]. Another report on the anti-inflammatory properties of the extracts of various parts of *S. aethiopicus* showed that the in vitro cyclooxegenase-1 (COX-1) inhibition of the stem and leaf extracts was reportedly higher than that of the rhizome [54]. High

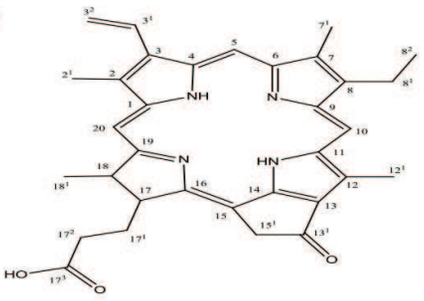
http://dx.doi.org/10.5772/66484



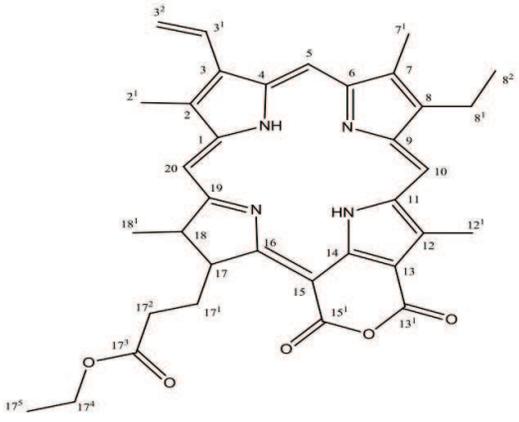
Aurantiamide acetate



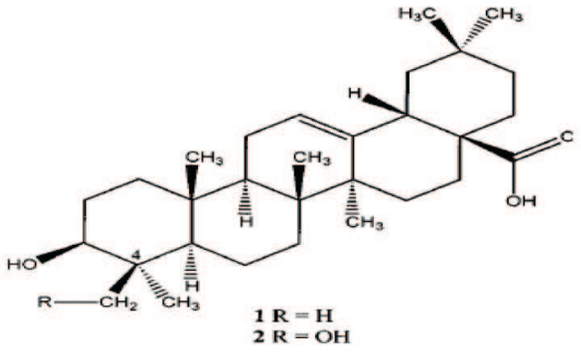
Ethyl Pyropheophorbide



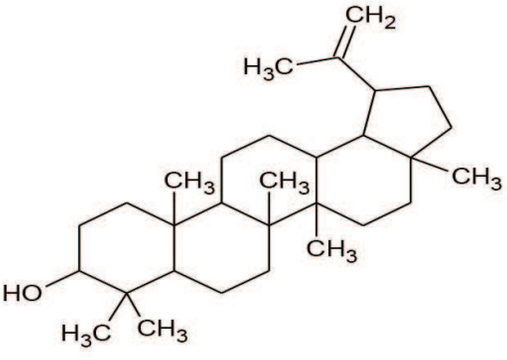
Pyropheophorbide A



Purpurin-18 ethyl ester



Oleanolic acid (1) and 4-epi-hederagenin (2)



Lupeol

Figure 3. Isolated constituents from *Crateva adansonii* bioactivity.

inhibition of cyclooxygenase and hence the prostaglandin pathway which should prevent uterine contraction and relieve dysmenorrhoea was again reported for the leaves and tubers of wild ginger [55]. However, in vitro reduction of pre-contracted uterine muscle was not observed [55].

Additionally, the in vitro anti-plasmodial activity for the ethanolic extracts and isolated eudesmane sesquiterpenoids of *S. aethiopicus* rhizomes against the chloroquine-sensitive and chloroquine resistant strains of *Plasmodium falciparum* has also been reported [17]. The substitution of the OH group in the sesquiterpene structure with hydrogen resulted in a threefold increase in activity against the chloroquine-resistant strain and an introduction of a double bond further improved the activity [17]. It is suggested that the anti-plasmodial activity is due to the furan moiety [17, 56]. Further in vitro anti-protozoal property of *S. aethiopicus* was reported against T*rypanosoma brucei brucei* (S427) blood stream forms by the crude rhizome extract, and it increased with the pure components: 8(17),12E-labdadiene-15,16-dial, *epi*-curzerenone and furanodienone [39].

The crude seed extract of *Monodora myristica* and isolated 5-formyl indole and 5-(3-oxo-but-1-enyl)indole reportedly showed no in vitro cytotoxicity against normal PNT2A cells and no anti-trypanosomal activity against *Trypanosoma brucei brucei* (S427) blood stream forms [43]. There was also no in vitro cytotoxicity when the crude seed extract was tested against five different cancerous cell lines [57]. Similarly, no lethality against brine shrimp (*Artemia salina*) and low anti-microbial activity against the *Mycobacterium* species: *M. madagascariense* and *M. indicus pranii* were reported for the stem bark extract of *Monodora carolinae* and constituent 5-formyl indole [58]. However, some of these prenylated indole alkaloids reportedly show interesting in vitro anti-plasmodial properties against the multi-drug-resistant strain K1 of *Plasmodium falciparum* [59].

Again, there are reports on the in vitro anti-oxidant properties and protective potential against free radicals of *M. myristica* seeds which suggest usage in the management of diseases associated with oxidative stress [28, 59, 60]. In vivo studies on the aqueous extracts of the seed and fruit also suggest that anti-oxidant bio-constituents play an important role in the prevention of liver toxicity possibly by inhibiting bioaccumulation of free radicals in animal models and could also reverse liver toxicity induced by high cholesterol diets and exert hypocholesterolemic effects [25, 61].

Also, the crude seed extracts of *M. myristica* reportedly exhibit profound in vitro anti-sickling properties suggesting that the spice/extracts could be used in combination with other foods in the management and prophylactic control of sickle cell crisis [62].

In vitro anti-microbial properties have been reported for *C. adansonii* leaf extracts against *Pseudomonas aeruginosa*, *Escherichia coli*, *Salmonella typhii*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Bacillus subtilis*, *Shigella sonei*, *Pasteurella pestis*, *Yersinia enterocolitica* and anti-fungal properties against two fungi: *Aspergillus niger* and *Candida albicans* [63–65]. It has also been suggested that the traditional use of the leaves against several inflammatory diseases such as rheumatism, arthritis and gout is due to xanthine oxidase inhibition [32].

In vitro anti-oxidant properties and in vivo analgesic properties have also been reported for the methanolic extracts of the stem bark [66]. The methanolic extracts of the leaves and constituent lupeol were also reported to show in vitro anti-oxidant properties [47].

Additionally, there is a report on the in vitro anti-trypanosomal activity of the leaf extracts and isolated aurantiamide acetate, ethyl pyropheophorbide A, purpurin-18 ethyl ester and pyropheophorbide A against the African trypanosome *Trypanosoma brucei brucei* (S427) blood

stream forms [31]. *In silico* testing of these ligands with the potential biomolecular targets of *T. brucei*: riboflavin kinase, trypanothione reductase, sterol-14α-demethylase, rohedsain and glutathione synthetase revealed multi-functional scaffolds validating the possibility of anti-trypanosomal activity [31].

3. Conclusion

Overall, organoleptic studies encourage the increased utilization of wild ginger, African nutmeg and sacred garlic pear to flavour foods. Moreover, a significant number of in vitro and laboratory animal studies support and explain the folk medicinal usage of these herbs and spices. These spices have anti-microbial, anti-oxidant, anti-inflammatory and in some instances anti-plasmodial and anti-cancer actions. As several metabolic diseases and age-related degenerative disorders are closely associated with oxidative processes in the body, further clinical studies on the use of these spices or their constituents as sources of anti-oxidants and anti-inflammatory agents are needed.

Author details

Ngozichukwuka P. Igoli[1]* and John O. Igoli[2]

*Address all correspondence to: ngozi_igoli@yahoo.com

1 Centre for Food Technology and Research, Benue State University, Makurdi, Nigeria

2 University of Agriculture, Makurdi, Nigeria

References

[1] Alais C, Linden G. Food Biochemistry. 2nd ed. Maryland: Aspen; 1999. 213p.

[2] Smid EJ, Gorris LGM. Natural antimicrobials for food preservation. In: Rahman MS, editor. Handbook of Food Preservation. New York: Marcel Dekker; 1999. pp. 285–308.

[3] Ito N, Fukushima S, Hasegawa A, Shibata M, Ogiso T. Carcinogenicity of butylated hydroxy anisole in F344 rats. J. Natl. Cancer Inst. 1983; **70**: 343–347. doi:10.1093/jnci/70.2.343

[4] Shan B, Cai Y-Z, Brooks JD, Harold Corke H. The in vitro antibacterial activity of dietary spice and medicinal herb extracts. Int. J. Food Microbiol. 2007; **117**: 112–119. doi:10.1016/j.ijfoodmicro.2007.03.003

[5] Smith RJ, Winder ML. Medicinal Garden. In: Ober R, editor. The National Herb Garden Guidebook. Springfield: The Herb Society of America; 1996. pp. 61–71.

[6] Beuchat LR, Golden DA. Antimicrobials occurring naturally in foods. Food Technol. 1989; **43**: 134–142.

[7] Rehm S, Espig G. The Cultivated Plants of the Tropics and Subtropics. Berlin: Priese GmbH; 1991. pp. 277–321.

[8] Lai PK, Roy J. Antimicrobial and chemopreventive properties of herbs and spices. Curr. Med. Chem. 2004; **11**: 1451–1460. doi:10.2174/0929867043365107

[9] Burkill HM. The Useful Plants of West Tropical Africa. 2nd ed. vol. 5. Families S – Z. London: Crown Agents for Overseas Governments; 2000. 320–321p.

[10] Igoli NP. Identification of the flavour components of wild ginger (*Siphonochilus aethiopicus* (Schweinf) B.L. Burtt). [thesis]. Nsukka. University of Nigeria; 2009.

[11] Manzini TZ. Production of wild ginger (*Siphonochilus aethiopicus*) under protection and indigenous knowledge of the plant from traditional healers. [thesis]. Pretoria. University of Pretoria; 2005. [Internet] Available from: http://hdl.handle.net/2263/27497 [Accessed: 2016-09-06].

[12] Kiew KY. Taxonomic Studies in the genus *Kaempferia* (Zingiberaceae). Notes from the Royal Botanic Garden Edinburgh. 1980; **38**: 1–12.

[13] van Wyk B-E, Gericke N. People's Plants: A Guide to Useful Plants of Southern Africa. Pretoria: Briza Publications; 2007. 352pp.

[14] Nichols G. Some notes on the cultivation of Natal ginger (*Siphonochilus aethiopicus*). Veld Flora. 1989; **75**: 92–93.

[15] Igoli JO, Ogaji OG, Tor-Anyiin TA, Igoli NP. Traditional medicine practices amongst the igede people of nigeria. Part 11. Afr. J. Trad. CAM 2005; **2**: 134–152. doi:10.1.1.540.8653 &rep=rep1&type=pdf

[16] Holzapfel CW, Marais W, Wessels PL, Van Wyk BE. Furanoterpenoids from *Siphonochilus aethiopicus*. Phytochemistry. 2002; **59**: 405–407. doi:10.1016/S0031-9422(01)00402-2

[17] Lategan CA, Campbell WE, Seaman T, Smith PJ. The bioactivity of novel furanoterpenoids isolated from *Siphonochilus aethiopicus*. J. Ethnopharmacol. 2009; **121**: 92–97. doi:10.1016/j.jep.2008.10.007

[18] Hutchings A. A survey and analysis of traditional medicinal plants as used by the Zulu, Xhosa, and Sotho. Bothalia. 1989; **19**: 111–123. doi:10.4102/abc.v19i1.947

[19] Watt JM, Breyer-Brandwijk MG. The medicinal and poisonous plants of Southern and Eastern Africa. 2nd ed. London: Livingstone; 1962. 1467 p.

[20] Viljoen AM, Demirci B, Baser KH, van Wyk B-E. The essential oil composition of the roots and rhizomes of *Siphonochilus aethiopicus*. S. Afr. J. Bot. 2002; **68**: 115–116. doi:10.1016/S0254-6299(16)30467-7

[21] Nwaji MN, Onyiriuka SO, Taylor DA. 6-(3=Methylbuta-1 ,3=dienyl)indole from *Monodora tenuifolia*. J. Chem. Soc. Chem. Commun. 1972; 327–327. doi:10.1039/C39720000327

[22] Burkill HM, Dalziel JM. The Useful Plants of West Tropical Africa. vol. 1. Kew: Royal Botanic Gardens; 1985. 976 p.

[23] Enweruzoh RO, Okafor DC, Uzoukwu AE, Ukanwoke MO, Nwakaudu AA, Uyanwa CN. Flavour Extraction from *Monodora myristica* and Tetrapleura tetraptera and Production of Flavoured Popcorn from the Extract [Internet]. 2015. Available from: http://www.eajournals.org/wp-content/uploads/Flavour-Extraction-from-Monodora-myristica-And-Tetrapleura-tetraptera-and-Production-of-Flavored-Popcorn-from-the-Extract.pdf [Accessed: 2016-09-07].

[24] Eze-Steven PE, Ishiwu CN, Udedi SC, Ogeneh BO. Evaluation of antioxidant potential of *Monodora myristica* (African Nutmeg) [Internet]. 2013. Available from: http://www.ijcmas.com/vol-2-11/P.E.Eze-Steven, %20et %20al.pdf [Accessed: 2016-09-07].

[25] Nwozo SO, Kasumu TF, Oyinloye BE. African Nutmeg (*Monodora Myristica*) Lowers Cholesterol and Modulates Lipid Peroxidation in Experimentally Induced Hypercholesterolemic Male Wistar Rats [Internet]. 2015. Available from: https://www.ncbi.nlmnih.gov/pmc/articles/PMC4502738/ [Accessed: 2016-09-07].

[26] Keay RWJ. Trees of Nigeria. A revised version of Nigerian trees (1960, 1964) by Keay RWJ, Onochie CFA, Stanfield DP. Oxford: Clarendon; 1989. 5 p

[27] Kew Science. *Monodora myristica* (calabash nutmeg) Kew Science [Internet]. 2011? Available from: http://www.kew.org/science-conservation/plants-fungi/monodora-myristica-calabash-nutmeg [Accessed: 2016-09-07].

[28] Feyisayo AK, Oluokun OO. Evaluation of antioxidant potentials of *Monodora myristica*(Gaertn) dunel seeds. Afr. J. Food Sci. 2013; **7**: 317–324. doi:10.5897/AJFS2013.1020

[29] Burkill HM. The Useful Plants of West Tropical Africa. vol. 1. Families A-D. Kew: Royal Botanic Gardens; 1985. 331–333p.

[30] Flowers of India. Garlic Pear Tree [Internet]. 2008? Available from: www.flowersofIndia.net/catalog/slides/Garlic%20Pear%20Tree.html [Accessed: 2016-09-13].

[31] Igoli NP, Clements CJ, Singla RK, Igoli JO, Nzekwe U, Gray AI. Anti-trypanosomal activity & docking studies of *Crateva adansonii* DC leaves: novel multifunctional scaffolds. Curr. Top. Med. Chem. 2014; **14**: 981–990.

[32] Abudullahi A, Hamzah RU, Jigam AA, Yahya A, Kabiru AY, Muhammad H, Sakpe S, Adefolalu FS, Isah MC, Kolo MZ. Inhibitory activity of xanthine oxidase by fractions *Crateva adansonii*. J. Acute Dis. 2012; **1**:126–129. doi:10.1016/S2221-6189(13)60029-3

[33] Sivarajan VV, Balachandran I. Ayurvedic Drugs and their Plant Sources. Delhi: Oxford and IBH Publishing; 1994. pp. 234–456.

[34] Shukla Y, Singh M. Cancer preventive properties of ginger: a brief review. Food Chem. Toxicol. 2007; **45**: 683–690. doi:10.1016/j.fct.2006.11.002

[35] Igoli NP, Obanu ZA. The volatile components of wild ginger (*Siphonochilus aethiopicus* (Schweinf) B.L. Burtt). Afr. J. Food Sci. 2011; **5**: 541–549.

[36] Belitz H-D, Grosch W. Food Chemistry. Berlin: Springer-Verlag; 1999. 319p.

[37] Kirk RS. Pearson's Composition and Analysis of Foods. Kirk RS, Sawyer R, editors. 9th ed. Essex: Longman; 1991. 393 p.

[38] Bruice PY. Organic Chemistry. 5th ed. New Jersey: Pearson; 2007. 732p.

[39] Igoli NP, Obanu ZA, Gray AI, Clements C. Bioactive diterpenes and sesquiterpenes from the rhizomes of wild ginger (*Siphonochilus aethiopicus* (Schweinf) B.L. Burtt). Afr. J. Trad. CAM. 2012; **9**: 88–93.

[40] Onyenekwe PC, Ogbadu GH, Deslauriers H, Gagnon M, Collin GJ. Volatile constituents of the essential oil of *Monodora myristica* (Gaertn) dunal. J. Sci. Food Agric. 1993; **61**: 379–381. doi:10.1002/jsfa.2740610317

[41] Owokotomo IA, Ekundayo O. Comparative study of the essential oils of *Monodora myristica* from Nigeria [Internet]. Available from: http://www.eurchembull.com/index.php/ecb/article/view/48/108 Accessed: 2016-09-14.

[42] Nguefack J, Letha V, Amvam Zollo PH, Mathur SB. Evaluation of five essential oils from aromatic plants of Cameroon for controlling food spoilage and mycotoxin producing fungi. Int. J. Food Microbiol. 2004; **94**: 329–334. doi:10.1016/j.ijfoodmicro.2004.02.017

[43] Igoli JO, Gray AI, Clements CJ, Mouad HA. Antitrypanosomal activity and Cytotoxicity of some Compounds and Extracts from Nigerian Medicinal Plants. In: Phytochemical-Bioactivities and impact on Health. Croatia: Intech; 2011. pp. 375–388.

[44] Nkunya MH, Makangara JJ, Jonker SA. Prenylindoles from Tanzanian *Monodora* and *Isolona* Species. Nat. Prod. Res. 2004; **18**: 253–258. doi:10.1080/14786410310001620529

[45] Ogunwade IA, Ogunbinu AO, Flamini G, Cioni PL, Okeniyi SO. Essential oil profiles of some Nigerian medicinal plants. J. Essent. Oil-Bearing Plant. 2009; **12**: 225–235.

[46] Cantrell CL, Berhow MA, Phillips BS, Duval SM, Weisleder D, Vaughn SF. Bioactive crude plant seed extracts from the NCAUR oilseed repository. Phytomedicine. 2003; **10**: 325–333. doi:10.1078/094471103322004820

[47] Tchimene MK, Nwaehujor CO, Ezenwali M, Okoli CC, Iwu MM. Free radical scavenging activity of lupeol isolated from the methanol leaf extract of *Crateva adansonii* Oliv. (Capparidaceae). Int. J. Pharmacogn. Phytochem. Res. 2016; **8**: 419–426.

[48] Coopoosamy RM, Naidoo KK, Buwa L, Mayekiso B. Screening of Siphonochilus aetiopicus (Schweinf.) B. L. Burtt for antibacterial and antifungal properties. J. Med. Plants Res. 2010; **4**: 1228–1231. doi:10.5897/JMPR10.240

[49] Stafford GI, Jäger AK, van Staden J. Effect of storage on the chemical composition and biological activity of several popular South African medicinal plants. J. Ethnopharmacol. 2005; **97**: 107–115. doi:10.1016/j.jep.2004.10.021

[50] Dolara P, Corte B, Ghelardini C, Pugliese AM, Cerbal E, Menichetti S, Lo Nostro A. Local anaesthetic, antibacterial and antifungal properties of sesquiterpenes from myrrh. Planta Med. 2000; **66**: 356–358. doi:10.1055/s-2000-8532

[51] Morita H, Itokawa H. Cytotoxic and antifungal diterpenes from the seeds of *Alpinia galanga*. Planta Med. 1988; **54**: 117–120. doi:10.1055/s-2006-962365

[52] Noudogbessi JP, Delort L, Chalard P, Billard H, Figueredo G, Ruiz N, Chalchat JC, Sohounhloue D, Chézetquée FC. Anti-proliferative activity of four aromatic plants of Benin. J. Nat. Prod. I. 2013; **6**: 123–131.

[53] Fouche G, Nieuwenhuizen N, Maharaj V, van Rooyen S, Harding N, Nthambeleni R, Jayakumar J, Kirstein F, Emedi B, Meoni P. Investigation of in vitro and in vivo anti-asthmatic properties of *Siphonochilus aethiopicus* [Internet]. 2011. Available from: <http://researchspace.csir.co.za/dspace/bitstream/10204/5647/1/Fouche_2011.pdf> [Accessed: 2016-09-14].

[54] Zschocke S, Rabe T, Taylor JL, Jäger AK, van Staden J. Plant part substitution—a way to conserve endangered medicinal plants? J. Ethnopharmacol. 2000; **71**: 281–292. doi:10.1016/S0378-8741(00)00186-0

[55] Lindsey K, Jäger AK, Raidoo DM, van Staden J. Screening of plants used by Southern African traditional healers in the treatment of dysmenorrhea for prostaglandin-synthesis inhibitors and uterine relaxing activity. J. Ethnopharmacol. 1999; **64**: 9–14. doi:10.1016/S0378-8741(98)00097-X

[56] Pillay P, Vleggar R, Maharaj VJ, Smith P, Lategan CA, Chouteau F, Chibale K. Antipla–smodial hirsutinolides from *Vernonia staehelinoides* and their utilization towards simplified pharmacophore. Phytochemistry. 2007; **68**: 1200–1205. doi:10.1016/j.phytochem.2007.02.019

[57] Iweala EEJ, Liu F-F, Cheng R-R, Li Y, Omonhinmin CA, Zhang Y-J. Anti-cancer and free radical scavenging activity of some Nigerian food plants in vitro. Int. J. Cancer Res. 2015; **11**: 41–51. doi:10.3923/ijcr.2015.41.51

[58] Magori N, Nyandoro SS, Munissi JJE, Heydenreich M. Antimycobacterial and cytotoxicity evaluation of the constituents of *Monodora carolinae* [Internet]. 2013. Available from: http://www.ajol.info/index.php/tjs/article/download/105696/95712

[59] Onguéné PA, Ntie-Kang F, Lifongo LL, Ndom JC, Sippl W, Mbaze LM. The potential of anti-malarial compounds derived from African medicinal plants. Part I: A pharmacological evaluation of alkaloids and terpenoids. Malaria J. 2013; **12**: 449. doi:10.1186/1475-2875-12-449

[60] Erukainure OL, Oke OV, Owolabi FO, Kayode FO, Umanhoulen EE, Aliyu M. Chemical properties of *Monodora myristica* and its protective potentials against free radicals in vitro. Oxid. Antioxid. Med. Sci. 2012; **1**:127–132. doi:10.5455/oams.080712.or.009

[61] Oyinloye BE, Adenowo AF, Osunsanmi FO, Ogunyinka BI, Nwozo SO, Kappo AP. Aqueous extract of *Monodora myristica* ameliorates cadmium-induced hepatotoxicity in male rats. Springerplus. 2016; **5**: 641. doi:10.1186/s40064-016-2228-z

[62] Uwakwe AA, Nwaoguikpe RN. *In-vitro* antisickling effects of *Xylopiaa ethiopica* and *Monodora myristica*. J. Med. Plant Res. 2008; **2**: 119–124.

[63] Igoli NP, Gray AI, Clements C, Igoli JO, Nzekwe U, Singla RK. Scientific Investigation of Anti-trypanosomal Activity of *Crateva adansonii* DC Leaves. Indo Global J. Pharm. Sci. 2012; **2**: 226–229.

[64] Agboke AA, Attama AA, Momoh MA. Evaluation of the antimicrobial activities of crude extract of *Cryptolepis sanguinolenta* and *Crateva adansonii* leaves and their interactions. J. Appl. Pharm. Sci. 2011; **1**: 85–89.

[65] Lagnika L, Anago E, Atindehou M, Adjahoutonon B, Dramane K, Sanni A. Antimicrobial activity of *Crataeva religiosa* Forst against bacteria isolated from *Thryonomys swinderianus* Temminck. Afr. J. Biotechnol. 2011; **10**: 10034–10039. doi:10.5897/AJB10.2435

[66] Udeh NE, Onoja SO. Analgesic and free radical scavenging activities of hydromethanolic extract of *Crateva adansonii* stem bark. J. Intercult. Ethnopharmacol. 2015; **4**: 224–227. doi:10.5455/jice.20150430010855