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Pharmacological activities of (*Gongronema latifolium*, *Vernonia amygdalina* and *Vitex doniana*): A review

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Abstract

Background: The article is a review of three bitter vegetables consumed in South-eastern Nigeria (*Gongronema latifolium*, *Vernonia amygdalina* and *Vitex doniana*). These vegetables are not very palatable to taste but are highly famed because of the myriad of illnesses that they are reputed to cure and manage. The different aspects of these vegetables reviewed are their ethnobotany, zoo pharmacology, bioactivity, phytochemistry and toxicity.

Materials and Method: The literatures consulted were searched using electronic search engines (Google, Google scholar and Pubmed). Substantial amount of literature was consulted but only those directly related to the main review were selected.

Result: The review revealed that the three bitter vegetables possessed phytochemicals like saponins, flavonoids, alkaloids among others that justify the claims of curing and managing many of the illnesses that traditional folks attribute to them. From literature, antimicrobial, antiinflammatory, antidiabetic, antioxidant and anti cancer activities were attributed to these three bitter herbs. Antinutritional substances like phytate and oxalate reported in these herbs were not regarded as harmful for human consumption because of the traditional method of processing the vegetables by squeeze washing in several changes of water.

Conclusion: The three bitter herbs are regarded as beneficial for human consumption and the information should be disseminated to a large audience.

Keywords: *V. amygdalina*, *V. doniana*, *G. latifolium* and bitter herbs

Introduction

The usefulness of vegetables globally has caused an increase in the demand of knowledge of their nutrients and chemical composition. Green leafy vegetables provide vitamins, mineral elements and chemicals that are necessary for growth and maintenance of good health. Bitter vegetables although not palatable to taste are nevertheless consumed because of their ability to prevent and cure ailments. They are consumed alone or in combination with other vegetables. They contain numerous chemical substances that possess a lot of health benefits. The ones found in south eastern Nigeria include *Gongronema latifolium*, *Vernonia amygdalina* and *Vitex doniana*. Some of the chemicals present in vegetables, which are responsible for their bitter taste are alkaloids, saponins and tannins. The leaves of *G. latifolium* are used by asthmatic patients to relieve wheezing (Mosango, 2011) [34]. Maceration of leaves of *G. latifolium* is reported by Akuodor *et al.* (2010) as a treatment for and management of diabetes. The aqueous extracts of the leaves of *V. amygdalina* is reported to be used as a digestive tonic, appetizer and for wound treatment. Ijeh and Ejike (2011) [26] reported that the leaves of *V. amygdalina* are used during child delivery to increase uterine contraction and hasten childbirth. They also stated that the leaf decoction is drunk to increase breast milk production in nursing mothers, cure cough or whooping cough and treat diabetes. Egharevba *et al.* (2010) [16] reported that the leaves of *V. doniana* are used in the management of diabetes, high blood pressure, in treating ulcers, swellings and oedema. This article aims at reviewing the ethnobotany, phytochemistry, bioactivity and toxicity of the three bitter vegetables consumed in south eastern Nigeria and to highlight the scientific reasons why the consumption of these vegetables should be encouraged.

Materials and Methods

Literature was collected by using electronic search engines (Google Scholar and Pubmed) with the words *Gongronema latifolium*, *Vernonia amygdalina* and *Vitex doniana*, ethnobotany, phytochemistry, bioactivity and toxicity of the three species.

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The information presented in this review was selected after being considered to be directly related to the main thrust of this article.

Result and Discussion

Gongronema latifolium Benth.

Botany of *Gongronema latifolium*

Gongronema latifolium belongs to the family Asclepiadaceae and genus *Gongronema* with up to 70 species. *Gongronema latifolium* is commonly called 'utazi' in south eastern Nigeria and 'arokeke' in south western Nigeria (Eleyinmi, 2008) [17]. It is found mainly in the tropics and subtropical regions of Africa, Asia and Oceania (Dutta, 2005) [12]. It is a climbing and twining shrub and the mode of propagation is mainly by stem cuttings and by seeds. Leaf blade is broadly ovate to almost circular. Leaves are simple, opposite, decussate, occasionally whorled, peltate and usually have no stipules. Leaf margin is entire, venation is palmate and the leaf base is deeply cordate. Leaf is glabrous with acute to acuminate apex. Length is between 7.0-8.5cm and width is between 4.0-6.5cm (Osugwu, *et al.*, 2013) [42]. The adventitious roots arise from the nodes when the stem makes contact with the soil. Inflorescence is a cymose panicle up to 13 cm long. Flowers are bisexual, actinomorphic, pale yellow and fragrant, pedicel is 2-4 mm long. Calyx has five basal glands with elliptical to rounded lobes. Corolla is tubular, about 5 mm long with five triangular to ovate lobes and five scale-like corona inserted at the base of gynostegium. There are five stamens and the filaments form a tube. Anthers are erect with membranous apical appendages. Ovary is superior, the styles are short and the stigma heads are conical in shape. Fruit is a follicle that is oblonganceolate and splits open lengthwise along the seam to release seeds. The fruit is green initially, turning to brown and finally black at maturity. Fruit development takes several months from April to November and dehisces between (December-February). New flowers start to appear between January and March and often meet old fruits. Seeds are flat and attached to a white silky tuft to aid dispersal. The seeds are coma shaped and measure about 0.5 cm in length (Mosango 2011; Osugwu *et al.*, 2013) [34, 42]. Mature seeds planted within two weeks after harvest take seven to fourteen days at temperature of about 27 °C and have germination rate of 67%.

Ethnobotanical uses

Gongronema latifolium is used by folk people in the treatment of various diseases. The twigs and branches are used for cleaning the teeth (chewing stick), in the treatment of cough, diabetes, hypertension and malaria (Etetim *et al.*, 2008) [20]. They reported that the extract or cold infusion of the pounded leafy branches together with lime juice, expels intestinal worms, dispels stomach upset and serves as blood tonic. The leaf juice mixed with pineapple and lime juice is used in the treatment of typhoid fever (Etetim *et al.*, 2008) [20]. In Imo state of Nigeria, *G. latifolium* leaves are used as vegetables for preparation of pepper soup, yam stew and used with other spices to prepare soup usually given to a woman after child delivery and to treat stomach ache (Uzodimma 2013) [48]. An infusion of the aerial parts is taken to treat cough, intestinal worms, dysentery, dyspepsia and malaria (Akuodor *et al.*, 2010; Mosango 2011) [34]. It is also taken to restore loss of appetite. In Sierra Leone, an infusion or decoction of the stem with lime juice is taken as a purgative to treat colic and stomach-ache (Mosango, 2011) [34]. The latex is applied to teeth affected by caries. Asthmatic patients use fresh leaves to

relieve wheezing (Mosango 2011) [34]. *G. latifolium* is reputed as a remedy for inflammation, bacteria infection, ulcer, malaria, diabetes and as analgesic (Etetim *et al.*, 2008; Edet *et al.*, 2009 and Akuodor *et al.*, 2010) [20, 13]. It therefore appears that *G. latifolium* is a reservoir of many antioxidants capable of preventing and treating different diseases.

Bioactivity

Antimicrobial activity

Eleyinmi (2008) [17] confirmed that the methanolic extract of the leaves of *G. latifolium* exhibited inhibitory activity against *Anteridia cholerasius* and *Listeria monocytogenes*. The aqueous extract showed inhibitory activity against *E. coli* and *P. aeruginosa* only. Nwinyi *et al.* (2008) demonstrated that the ethanolic leaf extract showed more inhibitory effect against *E. coli* and *Staphylococcus aureus* than the aqueous extract. The diameter of the zone of inhibition was between 6.0 and 10.0 cm. Evaluation of inhibitory activity of the aqueous and ethanolic extracts together with the essential oil from leaves of *G. latifolium* against bacteria isolated from HIV patients in Lagos, Nigeria, showed moderate inhibitory activity against *Staphylococcus species*, *E. coli*, *Shigella species*, *Salmonella species*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Onchrobacterium anthropi* (Adeleye *et al.*, 2011) [2]. The inhibitory effects they observed in the study were comparable to those of Ampicillin but less than those of Ciprofloxacin and Chloramphenicol.

Antidiabetic activity

The antidiabetic activities of aqueous and methanolic extracts of *G. latifolium* were demonstrated by administering the extracts to alloxan-induced diabetic rats through intraperitoneal injection (Akah *et al.*, 2011) [5]. Udo *et al.* (2013) [46] recorded a dose- and time-dependent decrease in the blood glucose level of rats treated with ethanolic and aqueous leaf extracts of *G. latifolium* compared with the control. Sylvester *et al.* (2015) [45] treated experimental rats that were subjected to streptozotocin-induced diabetes mellitus and reported a significant ($p < 0.05$) lowering of blood glucose by 66.34%. In their study, the diabetic induction caused increase in total cholesterol (TC) and LDL cholesterol (54.42% and 55.4%) respectively. Treatments with the plant extract decreased (TC) by 58.70% and LDL by 71.70%.

Antioxidant activity

Nwanjo *et al.* (2006) [38] reported that the aqueous extract of leaves of *G. latifolium* exhibited anti-lipid peroxidase property. In their study, the extract significantly ($p < 0.05$) increased the activity of superoxide dismutase and lowered the level of plasma lipid peroxidation product, malondialdehyde. Investigation of the antioxidant activity of tannin extracts from the leaves of *G. latifolium* on partially purified lipoxygenase from seeds of *Cucumeropsis monii* was reported by Eze and Nwanguma (2013) [21]. The inhibition of the lipoxygenase by the tannin fraction was comparable to the activity of two known antioxidants, ascorbic acid and propyl gallate. Usuh and Akpan (2015) [47] also reported that when the leaf of *G. latifolium* is used together with the leaf of *Ocimum gratissimum*, the antioxidant effect is higher.

Anticancer activity

Iweala *et al.* (2015) [27] demonstrated that the leaf extract of *G. latifolium* produced strong inhibitory activity against human lung carcinoma and human breast adenocarcinoma *in-vitro*. They also demonstrated the free radical scavenging activity of

the extract against 1, 1-Diphenyl-2-picrylhydrazyl (DPPH) *in-vitro*. Atangwho *et al.* (2009) [9] suggested that the free radical scavenging activity of phytochemicals could prevent cancer by their antioxidant properties.

Phytochemistry

Eze and Nwanguma (2013) [21] reported the occurrence of tannins in the leaves of the plant. β - sitosterol, lupenyl esters, pregnane esters and essential oils were detected in the body parts.

Table 1: Phytochemical Constituents of Various Parts of *Gongronema latifolium*

Parts	Constituents	Author(s)
Leaves	Saponins, proteins, carbohydrates, resins, flavonoids, alkaloids, glycosides, terpenoids, steroids, fats and oil, phytate, anthranoids, anthraquinones, cyanogenic glycoside, glycosides, phlobatannins, hydroxymethyl anthraquinones, polyphenols, reducing compounds, tannins, oxalate, cardiac glycosides, β -sistosterol, essential oils, lupenyl esters, pregnane esters, hydrogen cyanide, biurate, phytosterols, terpenes, anthocyanidins,	Edet <i>et al.</i> , 2009 [13]; Aka <i>et al.</i> , 2011 [5]; Enemor [18] <i>et al.</i> , 2014; Ezekwe <i>et al.</i> , 2014 [22].
Root	Hydrogen cyanide, saponins, flavonoids, alkaloids, tannins, glycosides, reducing sugars polyphenols	Egbung <i>et al.</i> , 2011 [14]
Fruit	Alkaloids, tannins, saponins, flavonoids, phenols, phytic acid, hydrocyanic acid	Osuagwu <i>et al.</i> , 2013 [42]
Stem	Hydrogen cyanide, saponins, flavonoids, alkaloids, tannins	Egbung <i>et al.</i> , 2011 [14]

Source: Balogun, *et al.* (2016)

Toxicity

On intraperitoneal administration of the leaf extract of *G. latifolium* to mice at 1000 mg/kg body weight, Sylvester *et al.* (2015) [45] observed 0% lethality, but 100% mortality when administered at 2000 mg/kg. They suggested that the plant is not toxic at the doses consumed by humans. Abu *et al.*, (2014) [1] reported the presence of low amounts of phytate and oxalate which they claimed is not harmful considering that the quantity detected is small. They noted that antinutrients like phytate, when consumed at low levels offer some benefits to an organism. Sylvester *et al.* (2015) [45] suggested the need for further research on the toxicity of leaf of *G. latifolium*.

Vernonia amygdalina Del.

Botany of *Vernonia amygdalina*

Vernonia amygdalina Del. belongs to the family Asteraceae or Compositae. It is a common shrub or small tree that grows in tropical Africa and in Asia. It is known as etidot (Efik), onugbu (Ibo), chusar duki (Hausa), ndole (Cameroon), tuntwano (Tanzania) and mululuza (Uganda) (Egedigwe, 2010) [15]. It is found along drainage lines, natural forests, and plantation or around homestead. Its common name in Africa is bitter leaf. They are shrubs or trees and grow up to 7 m in height. Bark: Light grey or brown, rough and flakes longitudinally. The branches are brittle (Orwa *et al.*, 2009) [41]. Leaves are leathery, lanceolate to oblong and usually measure 10-15x4-5 cm but can get up to 28x10 cm. They are medium to dark green in colour, the adaxial (upper) surface may or may not have sparse hairs but on the abaxial surface, there are fine soft and pale hairs. Apex is acute, base is tapering and margin is entire or finely toothed. Petiole is usually very short or 1-2 cm long. Flower: Axillary and terminal with small, creamy- white heads about 10 cm long, flowers are in clusters of about 15 cm in diameter and exude sweet odour in the evening (Orwa *et al.*, 2009) [41]. *Vernonia* was named after a 17th Century English botanist and plant collector in North American, William Vernon. The specific name means "like an almond". It is not clear why it was so named (Orwa *et al.*, 2009) [41].

Ethnobotanical Uses

V. amygdalina is used in the treatment of ailments in Africa. It is used for facilitating childbirth due to its ability to increase uterine contraction (Ijeh and Ejike, 2011) [26]. The leaf juice treats ringworm and other skin infections and when drunk, can treat diabetes (Ijeh and Ejike, 2011) [26]. They stated that the leaf decoction is taken to treat pneumonia, increase breast milk production in nursing mothers, cure

cough and whooping cough. They also reported that chewing of the root leads to regaining of lost appetite and treats recalcitrant cough, while the root decoction is drunk to neutralize poison.

Ethnoveterinary and Zoopharmacognostic uses of *V. amygdalina*

Many indigenous tribes attribute the rudiments of their ethnobotany to observing the plants that sick animals consume (Jain *et al.*, 2008) [28]. They listed *V. amygdalina* as one of the plants used by animals to treat amoebic dysentery, other intestinal parasites and stomach disorders. Mohammed and Zakariya'u (2012) [33] cited the case of sick chimpanzees sucking the pith and juice of the unsavoury *V. amygdalina* stalk with empty stomach. They commented that this practice was not their common diet but was for self deparatization, enhanced body fitness, increased strength or appetite and reduced constipation or diarrhea, particularly in rainy season. Mohammed and Zakariya'u (2012) [33] recorded reduced mortality in broiler birds that were fed with 600 g of *V. amygdalina*, whereas birds that were not fed with *V. amygdalina* had higher mortality. The low mortality in birds fed with *V. amygdalina* was attributed to the ability to acquire resistance to some pathogens conferred on the birds by *V. amygdalina* extract. The leaf extract of *V. amygdalina* has been reported to be of use in treating bacilliary white diarrhoea and bronchitis (Gbolade 2009) [24]. He reported that birds fed with *V. amygdalina* leaf encountered lower activity of pathogens.

Bioactivities of *V. amygdalina*

Anticancer and cytotoxic activity of *V. amygdalina*

Anticancer activity of *V. amygdalina* has been reported in literature. Opata and Izevbigie (2006) [40] demonstrated that the cold water extract of the plant possessed moderate cytotoxic effect with IC50 of 218 μ g/ml against MCF-7 cells. Apoptasis against acute lymphoblastic leukemia (ALL) and acute myeloid leukemia (AML) was induced by cold water, hot water and ethanol extracts in patients with IC50 of 5-10 μ g/ml (Khalafalla *et al.*, 2009) [29]. They found the ethanol extract to be the most effective against both (ALL) and (AML). Khalafalla *et al.*, (2009) [29] reported that the petroleum ether/ethyl acetate leaf extract had cytotoxic effect on human hepatoblastoma (Hep G2) and urinary bladder carcinoma (ECV-304) cell lines. Cold water extracts of *V. amygdalina* demonstrated cytostatic action on cell growth of human breast tumours (MCF-7) and DNA synthesis. This was achieved through reduction in the extracellular

signal-regulated protein kinase signaling induction of cytochrome P450 3A4 (3A4) and microsomal epoxide hydrolase expression and altering of cell membrane permeability efflux (Opata and Izevbigie, 2006) [40].

Anti bacterial activity

Some workers have reported on the antibacterial activity of leaves of *V. amygdalina*. Kola (2007) [30] demonstrated that the ethanolic extract of leaves of *V. amygdalina* was effective against gram negative (*E. coli* and *Salmonella typhi*) and gram positive (*Clostridium sporogenes*, *Streptococcus pyogenes* and *S. aureus*) bacteria. He thus endorsed the use of *V. amygdalina* as chewing stick to maintain oral health by dislodging microorganisms, in line with the traditional use of this plant for teeth cleaning.

Antidiabetic activity

Gbolade (2009) [24] stated that the leaves of *V. amygdalina* are popularly used as antidiabetic in traditional medicine in Nigeria. Okafor *et al.*, (2009) [39] observed that the methanol extract (200 and 400 mg/kg b.w.) of fermented black tea of leaves of *V. amygdalina* demonstrated better anti-hyperglycemic effect than the unfermented green tea on rats. This effect was enhanced when leaves of *Ocimum gratissimum* were added to it. Thus, showing that the extracts of leaves of *V. amygdalina* act in synergy with other plants.

Antimalarial/Antiplasmodial activity

Njan *et al.*, (2008) [36] demonstrated that the aqueous extract from leaves of *V. amygdalina* inhibited 73% of *P. berghei* in mice when given 200 mg/kg daily for 4 days.

Liver protection activity

Arhoghro *et al.* (2009) [7] reported that oral administration of aqueous extract of leaves of *V. amygdalina* accelerated the reversion of liver damage. They suggested that reduction of liver marker enzymes like aspartate aminotransferase (AST), alanine transaminase (ALT), alkaline phosphatase (ALA) and others like bilirubin indices in liver biochemical tests might be responsible.

Antioxidant activity

The aqueous and ethanolic extracts of *V. amygdalina* have been reported to possess potent antioxidant properties as demonstrated by the ability to inhibit the bleaching of β -carotene, oxidation of linoleic acid and lipid peroxidation induced by Fe^{2+} ascorbate in a rat liver microsomal preparation. The study demonstrated that the antioxidant activity of the ethanolic extract was higher than that of aqueous extracts but compared favourably with synthetic antioxidants like butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) (Owolabi *et al.*, 2008) [43].

Phytochemistry

The leaves of *V. amygdalina* contain several active secondary metabolites that play major role in the array of bioactivity attributed to it. These secondary metabolites include alkaloids, anthraquinone, cardiac glycosides, coumarins, polyphenolics, reducing sugars, saponins, sesquiterpene lactones, steroids, steroid glucoside compounds and terpenoids (Njan *et al.*, 2008) [36]. Ijeh and Ejike (2011) [26] and Wazis *et al.*, (2013) [5] attributed the bitter taste of the plant to the presence of alkaloids, glucosides, saponins and tannins. In addition to the secondary metabolites mentioned above,

Eleyinmi *et al.*, (2008) [17] recorded the occurrence of oxalate and phytate in this plant.

Toxicity

Agomuo *et al.* (2016) [4] reported the presence of oxalate in *V. amygdalina* that is slightly above the toxic level of 2.5 mg. Oxalates form insoluble compounds with Ca, Mg and Fe, thereby affecting the utilization of these mineral elements. However, Agomuo *et al.*, (2016) [4] opined that since the leaves are consumed by humans after it has been squeezed washed in several changes of water, there seems to be no danger of toxicity from oxalate.

Vitex doniana Sweet

The genus *Vitex* consists of over 270 species, predominantly made up of trees and shrubs. They grow mainly in tropical and subtropical areas, though a few are found in temperate zones. *Vitex doniana* is found in West Africa (Nigeria, Ghana, Cameroon and Burkina Faso), in East Africa and in South Africa (Egharevba *et al.*, 2010) [16].

Botany of *Vitex doniana*

It is a deciduous small to medium sized tree that grows 10-12 m tall in Benin Republic (Egharevba *et al.*, 2010) [16]. It is known as 'utakiri or uchakiri' (in eastern Nigeria) 'oori-nla' or 'cori-nla' (Yoruba), 'danya' in Hausa, 'Galbihi' (Fulani) (Egharevba, 2010) [16]. The bark was described as grayish white to pale grayish brown, fissured and scaly. The leaves are coriaceous, opposite, digitately compound with up to 7 leaflets, obovate to elliptical, notched or rounded or shortly acuminate at apex, entire, leathery, nearly glabrous. Inflorescence is in cymes, the flowers are small and petals are white with the largest lobe being purple (Egharevba *et al.*, 2010) [16]. Fruit is green when young, turning to purplish-black fleshy drupe when ripe with a woody conical seed. Seed is 1.5-2.0 cm long, 1.0-1.2 cm wide.

Ethnobotanical uses

Pare *et al.* (2016) [44] reported that the raw fruits of *V. doniana* are used as appetite suppressant by hunters and farmers who spend many days in the wood without regular food. According to Pare *et al.* (2016) [44], other uses of *V. doniana* include as mulch, to improve land and for nitrogen fixation, as food, as medicine, timber, in boat making, as a tree for housing bees in honey making, also to produce charcoal and dyes. Egharevba *et al.* (2010) [16] claimed that the twig of *V. doniana* is used for teeth cleaning while the boiled leaves, stem bark, root and fruits are used as ink and dye for cloths. The leaves of *V. doniana* are used in the treatment of swelling, oedema, diabetes, ulcer and as diuretic in the management of high blood pressure. The decoction of the leaves is given during labour, just before childbirth to induce strong uterine contraction and shorten delivery time.

Ethnoveterinary uses

The use of the healing properties of plants by humans as well as animals is well known. In Kenya, the bark, root, leaves and fruit of *V. doniana* are used to make smoke and hanging bouquet for the control of ticks in livestock among the Bukusa community of livestock farmers (Wanzala *et al.*, 2012) [49]. Extracts from *V. doniana* in synergy with other plant extracts are used to control coccidiosis and worm infestation in poultry. Arokiyaraj *et al.*, (2009) [8] listed the leaves of *V. doniana* as one of the leaves that serve as fodder for cattle in Northern Nigeria.

Bioactivity

The extracts from the leaves, root and stem bark of *V. doniana* showed antioxidant properties comparable to commonly used antioxidant drugs. Agbafor and Nwachukwu (2011) [3] demonstrated the antibacterial and antifungal activities of the methanol extract of leaves of *V. doniana*, while Lagnika *et al.* (2012) [32] obtained similar results with both the methanol and hydroethanol extracts. They postulated that the antimicrobial activity may be due to the presence of tannins and flavonoids in *V. doniana*.

Phytochemistry

The following phytochemicals are present in *V. doniana* namely: alkaloids, flavonoids, tannins, saponins, anthraquinones, balsam, carbohydrates and resins (Nwachukwu and Uzueto, 2010) [37]. Lagnika *et al.*, (2012) [32] detected the presence of flavonoids, essential oils, tannins, terpene, glycosides, triterpenes and anthracene derivatives in the leaves of *V. doniana* using thin layer chromatography. Agbafor and Nwachukwu (2011) [3] in their own investigation also detected saponins, tannins, anthraquinones, terpenoids and flavonoids. Nwachukwu and Uzueto (2010) [37] detected alkaloids in the leaves of *V. doniana* while Lagnika *et al.* (2012) [32] and Agbafor and Nwachukwu (2011) [3] did not find alkaloids in the leaves of *V. doniana* that they worked on.

Table 2: Phytochemical analysis of *Vitex doniana* extracts

Phytochemicals	Crude Extracts								
	Laq	Baq	Raq	Leth	Beth	Reth	Lace	Bace	Race
Tannins	-	-	+	+	+	+	+	+	+
Saponoids	+	-	-	+	-	+	+	+	+
Flavonoids	-	+	-	+	+	+	-	+	-
Glycosides	-	-	-	+	+	+	+	+	+
Steroids	-	-	-	-	+	+	-	+	+
Proteins	-	-	-	+	+	+	+	+	+
Alkaloids	-	-	-	-	-	-	-	-	-
Phenols	-	-	-	-	-	-	-	-	-

Key: Present = (+), Laq = Aqueous leaf, Leth = Ethanol leaf, Lace = Acetone leaf Absent = (-), Baq = Aqueous bark, Beth = Ethanol bark, Bace = Acetone bark, Raq = Aqueous root, Reth = Ethanol root, Race = Acetone root
Source: Kuta, *et al.*, (2015) [31].

Discussion

The leaves of the three bitter vegetables contain an array of secondary metabolites. Examples include saponins, flavonoids, alkaloids, glycosides, phytate, tannins, oxalate and anthocyanides (Njan *et al.*, 2008; Nwachukwu and Uzueto, 2010) [36, 37]. Some of the secondary metabolites responsible for bitter taste are alkaloids, saponins and tannins (Ijeh and Ejike, 2011) [26]. Antioxidant activity observed in *V. amygdalina* and *G. latifolium* can be attributed to the large quantity of secondary metabolites they contain. Flavonoids and sesquiterpene lactones are implicated in *V. amygdalina* for the antioxidant activity (Farombi and Owoeye, 2011) [23]. Muanda *et al.*, (2009) opined that phenolic compounds present in the leaves of *V. doniana* may be responsible for its antioxidant activity. It can thus be deduced that the presence of phytochemicals in the leaves are the active ingredients behind the antioxidant activities of these bitter herbs. Nwachukwu and Uzueto, (2010) [37] suggested that the antimicrobial properties of *V. doniana* could be as a result of the phytochemicals present in the leaves. Erasto *et al.*, (2006) [19] reported that vernolide and vernodalol, sesquiterpene lactones identified from the leaves of *V. amygdalina* are responsible for their antimicrobial activity. *Vernodalol* and

vernomygdin isolated from the leaves of *V. amygdalina* is reported by Nwanjo *et al.*, (2006) [38] to be responsible for the anticancer activity. Iweala *et al.*, (2015) [27]; Kwalafalla *et al.*, (2009) demonstrated activity of extract of *V. amygdalina* against the growth of cell lines of hepatocellular carcinoma and colon cancer while Kwalafalla *et al.*, (2009), proved that the extract of *V. amygdalina* exhibited activity against human breast tumour, human hepatoblastoma and urinary bladder carcinoma cell lines. They suggested that coumarines, flavonoids, lactones and edotides are responsible for the anticancer activities. Iweala *et al.*, (2015) [27], opined that tannins, glycosides, saponins, flavonoids and alkaloids present in *G. latifolium* are responsible for the inhibitory activity against human breast adenocarcinoma *in-vitro*. There is therefore, need to determine which of the phytochemicals are actually active against cancer cell lines. Saponins have antifungal, antiviral, antimicrobial, antibacterial, anti-inflammatory, antihelminthic, antidermatophytic, anticancer and anticytotoxic activities (Chen *et al.*, 2010) [11]. They impact the immune system and possess cholesterol lowering potential that has been demonstrated in animal and human trials (Güçlü and Mazza, 2007) [25]. According to Güçlü and Mazza (2007) [25], plant extracts containing saponins have been patented for the prevention and treatment of pre- and post-menopausal symptoms, heart disease, hypertension, dementia, gastric and duodenal ulcers. Tannins have astringent and bitter taste and this is presumed to be used by plants as a feeding deterrent. They also have biological antioxidant activity and act as defense against oxidative damage. The presence of tannins in the three vegetables consumed in south eastern Nigeria confers on these vegetables the potency of managing the numerous illnesses attributed to them. Alkaloids are another group of phytochemicals found in these vegetables and are known for having bitter taste. According to Ali (2012), alkaloids are reported to have antitumor, antiviral, antihypertensive, antidepressant, antimicrobial and anti-inflammatory activities. Their presence in these leaves can attest to their use in the management of diseases like high blood pressure (*V. amygdalina*), frequent stooling, diarrhea and dysentery (*V. doniana*). Some of the phytochemicals have antinutrient properties. Phytate or phytic acid binds with Ca, Zn and other minerals and in so doing limit their bioavailability. They however have some health benefits like anticancer, antioxidant, hypocholesterol and hypolipidemic effects. Ali, (2012) reported that the level of phytate can be lowered by processing which is traditionally carried out for *V. amygdalina* and *V. doniana* by washing in several changes of water. Oxalate is another phytochemical found in the leaves of *V. amygdalina* and *G. latifolium*. It can bind to calcium to form calcium oxalate which could precipitate conditions like rickets and osteomalacia. The quantity of oxalate in these two vegetables are either not high or the processing which involves washing in several changes of water causes reduction in the amount available since the incidence of rickets is not significant in south eastern Nigeria. These three vegetables under discussion belong to three different families that have no close phylogenetic relationship: *Gongronema latifolium* (Asclepiadaceae), *V. amygdalina* (Asteraceae) and *V. doniana* (Verbenaceae). The possession of bitter taste and similar phytochemical contents in them can be attributed to congruent evolution.

Conclusion

Isolation of the phytochemical fraction responsible for different bioactivities attributed to each vegetable is recommended. Such fractions could be used as templates in the formulation of drugs in pharmaceutical industry. Further research should be done to verify if the variety of *V. amygdalina* that is consumed without squeeze washing has all the bioactive compounds contained in the bitter variety. It is proposed that further research to investigate relationship between consumption of these vegetables (in combination or singly) and lowering of risk of cancer be carried out. It is proposed that a dissemination of the information contained in this review to ordinary citizens to promote the consumption of these vegetables and acquire defense against oxidative damage to the body. In conclusion, the three plants consumed as vegetables in south eastern Nigeria and as medicines have proven bioactivities and secondary metabolites to support the claims attributed to them by traditionally folks.

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