ETHNOBOTANY, PHYTOCHEMISTRY AND PHARMACOLOGICAL PROFILE OF VERNONIA GALAMENSIS (CASS.)LESS: A REVIEW

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A B S T R A C T

Vernonia galamensis is an oilseed plant known for the treatment of diabetes mellitus, chest pain, gastrointestinal diseases, malaria, eye infections, skin infections and as an insecticide. Extracts of V. galamensis are known to have sedative, analgesic, larvicidal activity, anti-diabetic, insecticidal, anti-uler and aqueous extracts of the leaves showed no toxicity. The phytochemical constituents of the leaves, roots, flowers and seeds of V. galamensis include flavonoids, coumarins, triterpenes, sterols, sesquiterpene lactones, epoxidized fatty acids and adenosine. This review summarizes the ethnomedicinal, pharmacological, phytochemical and toxicity studies of V. galamensis (Cass) Less

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INTRODUCTION

In the socio-economic context of developing countries, the valorization of medicinal plants can lead to the obtaining of adequate and inexpensive therapeutic responses. Mali has undertaken efforts in this direction by establishing the Department of Traditional Medicine (DMT), which is conducting studies on for the development of improved traditional medicines. The genus Vernonia is one of the largest groups in the family Asteraceae and includes more than 1000 species distributed widely in tropical and sub-tropical regions of Africa, Asia and America (Jeffrey and Kew, 1988). A total of 109 Vernonia species were reported in the literature to have medicinal properties. One hundred and five (105) plants were linked to the treatment or management of 44 human diseases. Plants of the genus also used in ethnoveterinary and zoopharmacognostic practices. A total of 12 Vernonia species are reported to be used in ethnoveterinary medicine while 2 species are used in self-medications practices by chimpanzees and gorillas (Toyang et Verpoorte, 2013). The present study, examined the literature on the medicinal properties of V. galamensis. It showed that important ethnomedical, phytochemistry and pharmacology data exist. Traditional healers are using of subspecies and varieties of V. galamensis of the treatment of various diseases including diabetes mellitus (Autamashih et al., 2011), chest pain, gastrointestinal diseases and external wounds (Teklehaymanot and Giday, 2010), malaria (Asres et al., 2001, Tarwish, 2015), skin infections (Asres et al., 2001; McClory and Atkinson, 2010). Other studies have shown the interest of V. galamensis in sedative (Johri et al., 1995), analgesic (Johri et al., 1995), anti-ulcer (Awaad and Grace, 1999; Johri et al., 1995), larvicidal activity (Tarwish, 2015), anti-diabetic (Autamashih et al., 2011), insecticide (Favi and Kraemer, 2006) and in the treatment of skin diseases (McClory and Atkinson, 2010). Chemists studied the composition of leaves, flowers, roots and seeds of its sub-species and varieties and isolated an impressive series of molecules including phenolic acids and derivatives (Awaad et al., 2000), flavonoids (Awaad and Grace, 1999; Doucouré et al., 2010; Miserez et al., 1996; Keita et al., 2016b), coumarins (Awaad et al., 2000), triterpenes (Perdue et al., 1993), sterols (Artaud and Iatrides, 1990), glucolide-type sesquiterpene lactones (Favi et al., 2008; Perdue et al., 1993; Zdero et al., 1990) and fatty acids epoxidized (Fiseha et al., 2010; Thompson et al., 1994). The aim of this review is to gather information on traditional therapeutic uses, phytochemistry data and the pharmacological profile of V. galamensis (Cass.) Less.

METHODOLOGY

V. galamensis is more known as a plant of commerce for the value of its seed oil than for its medicinal potential (Toyang and Verpoorte, 2013). This work aims to highlight the
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Phytochemical, chemical and medicinal potential of V. galamensis. The current review was achieved using an organized search of the scientific data published on ethnobotany, pharmacology, phytochemistry and acute toxicity of V. galamensis. The search was conducted between October 15, 2016 and March 28, 2017, using the keyword search term V. galamensis. The searches were carried out using various databases, including PubMed, Google Scholar (https://scholar.google.com/); Science Direct http://www.sciencedirect.com/, Access to Global Online Research in Agriculture (AGORA) (http://www.fao.org/agora/en/).

Plant Description

Taxonomy According to Gilbert's concept of V. galamensis, this widely distributed species includes six subspecies: afromontana, gibbosa, lushotoensis, mutumoensis, nairobiensis, galamensis (Gilbert, 1986). The subspecies V. galamensis ssp. galamensis M. Gilbert is widely distributed, with four botanical varieties: galamensis, petitiana, australis and ethiopica (Burkill, 1985; Gilbert, 1986; Perdue et al., 1986).

Geographical distribution

The greatest diversity is found in East Africa, whereas in West Africa only one variety is present: V. galamensis ssp. galamensis var. galamensis M. Gilbert or V. galamensis (Cass.) Less or Centrhapalus pauciflora (Willd.) H. Rob. or V. pauciflora (Willd) (Perdue et al., 1986).

Fig.1 The general distribution of V. galamensis Ssp. galamensis. a = Var. galamensis (West Africa region (Extending from Guinea through Ivory Coast, Mali, Burkino Faso, Ghana to Nigeria) b = Var. petitiana (Sudan, Kenya and Tanzania region); c = Var. ethiopica (central-southern Ethiopia); d = Var. australis (Malawi, Mozambique and eastern Zimbabwe region) (Perdue et al., 1986).

Fig.2 A photograph showing flowers of V. galamensis (Cass.)Less.

Ethnobotany

Chest-pain and gastrointestinal diseases In Tanzania and Kenya, the leaves of V. galamensis Ssp. galamensis Var. petitiana are eaten, boiled, or infused to treat chest-pain and gastrointestinal diseases (Baye et Oyen 2007; Burkill, 1985).

Diabetes mellitus

The decoctions of leaves of V. galamensis have been used in folk medicine for ages in the treatment of diabetes mellitus in Tanzania and Nigeria (Autamashih et al.2011; Chhabra et al. 1989).

Eye infections

The juice of V. galamensis Ssp. nairobiensis is applied in the eyes to treat eye infections (Bussmann, 2006).

Larvical activity

Larvical trials against larvae of the third larval stage of Anophyles gambiae, the most active extract recorded was that of acetone root extract of V. galamensis with an LC50 of 22.85 (Tarwish, 2015).

External injuries, infections and wounds

In Ethiopia, V. galamensis is used to treat external injuries, infections and wounds (Baye and Oyen, 2007; Teklehaymanot and Giday, 2010).

Insectical properties

In Senegal, it is used, especially against termites, to protect palisades and timber (Burkill, 1985).

Pharmacology

Some pharmacological interests of the species are given in the following sections:

Sedative activity

The non-polar fractions of V. galamensis leaves revealed sedative properties at 200 mg/kg in rats (Johri et al.1995).

Analgesic activity

Analgesic activity was detected at 200 mg/kg in rats in leaf and seed extracts of V. galamensis (Johri et al.1995).

Gastric and duodenal ulcers

Leaf and seed extracts of V. galamensis had antiulcerogenic effects when tested using either hydrochloric acid or ethanol.
as the necrotising agent in rats (Dahanukar et al., 2000; Johri et al. 1995)

**Anti-dermatitis**

Epoxidized oil from the seeds of V. galamensis provides topical medicinal preparations that are effective in the prevention and treatment of various forms of skin diseases, skin lesions and wounds (McClory and Atkinson, 2010).

**Anti-diabetic**

The antidiabetic properties of the aqueous extract of the leaves of V. galamensis were confirmed at a dose of 700mg/kg (Autamashih et al. 2011). The tablet formulation based on the crude aqueous extract of leaves of V. galamensis, carried out according to the wet granulation method, is now commercially available in Nigeria for the treatment of diabetes mellitus (Autamashih et al. 2011).

**Insecticide activity**

The test volatiles from the leaves of V. galamensis is used as an alternative to methyl bromide, a fumigant rescheduled to phase out by 2010 due to its capability to deplete atmospheric ozone. Plant volatiles from leaf extract of V. galamensis were released at room temperature and tested against adult whiteflies and confused flour beetles. One and two hundred microlitres of our extract significantly killed adult whiteflies within an hour (F = 7.86, df = 7, p = 0.0022) and continued to be active for twenty hours (F=10.60, df = 5, p = 0.0010). There was significant mortality of confused flour beetles fumigated with 3 mL of plant extract within twenty hours (F = infinity, df = 4, p = infinity) whether they were under one gram or ten grams of flour. However, no mortality was observed by the same quantity of plant extract when beetles were under 500 g of flour (Favi and Kraemer, 2006).

**Antibacterial activity**

A study (Carlos, 2015) of the fixed oil of the seeds isolated unsaturated fats, subsequently converted into aminated fats, vernolamide, tested the antimicrobial activity against the bacteria Escherichia coli, Bacillus subtilis and Saccharoyces aureus, and the fungi Staphylococcus cerevisiae, Microsporum gypseum and Trichophyton mentagrophytes. The authors used the disk diffusion method and the results showed activity against strains of Escherichia and Bacillus subtilis, but not against the yeast and dermatophyte fungi tested.

**Membrane stabilizers**

The leaf and root extracts of V. galamensis demonstrated prominent in vitro membrane stabilising property as determined by the percentage inhibition of RBC lysis (Johri et al. 1995).

**Acute toxicity**

At an oral dose of 5000 mg/kg in rats, no toxicity or adverse effects were observed for extracts of the leaves form V. galamensis. LD50’s greater than 5000 mg/kg body weight are of no practical interest, therefore the crude extract is considered relatively safe (Autamashih et al. 2011).

**Phytochemical screening**

**Leaves**

Phytochemical studies show that the aqueous extract of V. galamensis contains saponins, glycosides, carbohydrates, flavonoids and alkaloids (Autamashih et al. 2011).

**Flowers**

As regards, the flowers of V. galamensis Ssp. galamensis Var. galamensis phytochemical screening has shown that they contain flavonoids, tannins, sterols and triterpenes, coumarins, saponosides, reducing compounds, oses and holosides (Doucœur et al. 2010).

**Roots**

A phytochemical screening has highlighted the presence of triterpenes, sterols, flavonoids and alkaloids in the roots of V. galamensis Ssp. nairoensis (Mwaura, 1997).

**Extracts**

Phytochemical screening revealed presence of steroids, saponins, flavonoids, terpenoids and cardiac glycosides in Hexane, chloroformic, ethyl acetate, acetone, methanol and water extracts of leaves and roots of V. galamensis. Tannins were present in methanol, water and in acetone extracts of the leaves of V. galamensis (Tarwish, 2015).

**Phytochemistry**

The different classes of compounds isolated from subspecies and varieties of V. galamensis are categorized as:

**Phenolic acids and derivatives**

Four (04) molecules of the series of phenolic acids and derivatives were isolated from the alcoholic extract of the leaves of V. galamensis Ssp. galamensis Var. Petittiana: caffeic acid (1), 4-hydroxy-3-methoxycinnamic acid (2), 3-O-methyljuglantate (3) et 1-(3, 5- dihydroxyphenyl) propene (4) (Fig.3) (Awaad et al. 2000).

![Fig 3 Molecular structures of phenolic acids and derivatives isolated from the leaves of V. galamensis Ssp. galamensis Var. Petittiana.](image-url)

**Flavonoids and Favanoid glycosides**

Flavonoids and their glycosides have been reported from many subspecies and varieties of V. galamensis. The typical flavonoid aglycones like oriented quercetin and isorhamnetin. The fractionation of the methanolic extract from the leaves of V. galamensis Ssp. nairoensis allowed to isolate four molecules of the series of flavonos of type 3-O-glycosides: quercetin 3-O-β-D-galactopyranoside (5), quercetin 3-O-β-D-apio-D-furanosyl (1→2) galactopyranoside (6), quercetin 3-O-α-L-rhamnopyranosyl (1→6) galactopyranoside (7) et isorhamnetin 3-O-β-D-apio-D-furanosyl (1→2)-β-D-galactopyranoside (8) (Fig.4) (Miserez et al. 1996).
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Six flavonoids, including also five 3-O-glycosides, were detected from the alcoholic extract of the leaves of V. galamensis Ssp. galamensis Var. pettiana: quercetin 3-O-β-D-galactopyranoside (5), isorhamnetin 3-O-β-D-apio-D-furanosyl (1 → 2) β-D-galactopyranoside (8), quercetin (9), quercetin 3-O-β-D-glucoside (10), isorhamnetin 7-O-α-L-rhamnoside (11) and isorhamnetin 3-O-α-L-rhamnosyl (1→6) β-D-glucopyranoside (12) (Fig.5) (Awaad and Grace, 1999).

We report the isolation of 3-O-methylquercetin (13) from the chloroform phase and three monoglycosylated flavonols from the acetate, butanol phases of the hydromethanolic extract of the flowers of V. galamensis Ssp. galamensis Var. galamensis: kaempferol-3-O-α-L-rhamnoside (14), quercetin 3-O-rhamnoside (15) and 3-O-methylquercetin 4′-O-β-D-glucoside (16) (Fig.6) (Doucoure et al.2010; Keita et al.2016a).

![Fig 5](image)

**Fig 5** Molecular structures of flavonoids isolated from the leaves of *V. galamensis* Ssp. *nairobenensis*.

**Coumarins**

Of the variety *V. galamensis* Ssp. *galamensis* Var. *Petitiana*, coumarins scopoletin (17) and ombelliferone (18) widely distributed in higher plants, have been isolated (Fig. 7) (Awaad et al.2000).

![Fig 7](image)

**Fig 7** Molecular structures of coumarins isolated from *V. galamensis* Ssp. *galamensis* Var. *petitiana*.

Sesquiterpene lactones

The chemical investigation of the MeOH/Et₂O/petroleum ether (1:1:1) extract of the aerial parts of two varieties of *V. galamensis*: *V. galamensis* Ssp. *galamensis* Var. *Petitiana*; *V. galamensis* Ssp. *galamensis* Var. *ethiopica* and two subspecies: *V. galamensis* Ssp. *gibbosa*; *V. galamensis* Ssp. *afromontana* identified six compounds consisting of five sesquiterpene lactones of type and benzyl senecioate: prevernocoistifolide-8-O-senecioate (19), 14-O-prevernocoistifolide-8-O-senecioate (20), 2α,3α-epoxyprevernocoistifolide-8-O-senecioate (21), 14-O-prevernocoistifolide-8-O-isobutyrate (22), prevernocoistifolide-8-O-isobutyrate (23) and benzyl senecioate (24) (Perdue et al.1993), from *V. galamensis* Ssp. *galamensis* Var. *ethiopica*; the prevernocoistifolide-8-O-isobutyrate (23) (Fig.8) was isolated (Favi et al.2008).

![Fig 8](image)

**Fig 8** Molecular structures of sesquiterpene lactones and benzyl senecioate (24) isolated from *Var. pettiana* et *Var. pettiana* and (Ssp. *gibbosa* et Ssp. *afromontana*) of *V. galamensis*.

Treatment of the (Et₂O / MeOH: 9: 1) of the extract MeOH / Et₂O / Petroleum ether (1: 1: 1) of the aerial parts of *V. galamensis* Ssp. *nairobenensis* gave two new glaucoles: glaucogalamosolide and isovalerate (25) and glaucogalamosolide isobutyrate (26) (Fig.9) (Zdero et al.1990).

![Fig 9](image)

**Fig 9** Molecular structures of sesquiterpene lactones isolated from *V. galamensis* Ssp. *nairobenensis*.

**Triterpenes and sterols**

Four triterpenes including: taraxasteryl acetate (27), taraxasterol (28), friedelan (29), friedelan-3 β-ol (30) (Fig.9), and two sterols: β-sitosterol (31) and stigmast-5,22-dien-3-ol (32) were isolated and identified hexane extract (Fig.10) (Mwaura, 1997).

![Fig 10](image)

**Fig 10** Molecular structures of triterpenes and sterols isolated from the roots of *V. galamensis* ssp. *nairobenensis*.

The presence of triterpenes and sterols were demonstrated by GC / MS identification in the leaves, roots and aerial parts of...
two varieties of V. galamensis: V. galamensis Ssp. galamensis Var. pettiana (α-amyrin (32), α-amyrin acetate (33), β-amyrin (34), β-amyrin acetate (35), caryophyllene (36), lupeol acetate (37), lupeyl (39), cyperene (40) and V. galamensis Ssp. galamensis Var. ethiopica (α-amyrin (32), α-amyrin acetate (33), β-amyrin acetate (35), caryophyllene (36), taraxasterol acetate (27), lupeyl acetate (39), β-sitosterol (31), stigmasterol (40).

The following compounds were identified as two sub-species: V. galamensis Ssp. gibbosa (α-amyrin (32), β-amyrin (34), α-amyrin acetate (33), β-amyrin acetate (35), taraxasterol acetate (27), lupeol, lupeyl acetate (37), β-sitosterol (31) and stigmasterol (41) and V. galamensis Ssp. afronauta (α-amyrin (33), β-amyrin acetate (35), taraxasterol acetate (27), α-humulene (38), lupeyl acetate (39), β-sitosterol (31), stigmasterol (41) (Fig.11) (Perdue et al., 1993).

Three pentacyclic triterpenes (β-amyrin acetate (35), 3-oxo-urs-12-en-24-oic acid methyl ester (52) and 3β- (acetyloxy) ursan-12-one (53) (Fig.11) were identified by GC / MS in electron impact (EI) and positive chemical ionization (PICI) of the petroleum ether phase of the hydromethanolic extract of the flowers of V. galamensis Ssp. galamensis Var. galamensis) (Keita et al. 2014).

The CG / MS sterol composition of the seed oil of V. galamensis Var. Australis from Zimbabwe is cholesta-5-en-3β-ol (42), 24-methyl cholesta-5-en-3β-ol (43), 24-ethyl cholesta-5,22-diene-3β-ol (44), 24-ethyl cholesta-5-en-β-ol (45), 24-ethylidene cholesta-5-en-3β-ol (46), 24-ethyl cholesta-7-en-3β-ol (47), 24-ethylidene cholesta-7-en-β-ol (48). The most predominant were 24-ethyl cholesta-5-en-3β-ol (36.9%) (49), cholesta-7-en-3β-ol 24-ethyl (25.2%) (50) and 24-ethyl cholesta-5,22-diene-3β-ol (18.5%) (51) (Artaud and Iatrides, 1990).

Nucleoside

The phytochemical study of the butanol phase of the hydromethanolic extract from the flowers of V. galamensis Ssp. galamensis Var. galamensis allowed the isolation and identification of 9-β-D-ribofuranosyl-6-amino purine (54) (Fig.12) (Keita et al. 2016b) The seeds of V. galamensis (Cass.) Less contain 40% epoxy oil (trivernolin) (55) (Fig.13), which, when hydrolyzed, yields different fatty acids with a very high content (80%) of vernolic acid (cis-12,13-epoxy-cis-9-octadecenoic acid) (56) (Fig.14) (Fiseha et al., 2010). Within the four varieties of Ssp. galamensis, in which most of the current domestication effort is centered on, oil contents ranged from 31.8% to 38.4%, and 18:1 epoxy fatty acid ranged from 68.0% to 77.0%. Mean levels of other fatty acids within the species were about 14% for linoleic acid (18:2) (57), 7% for oleic acid (18:1) (58), and from 2 to 3% for both palmitic acid (16:0) (59) and stearic acid (18:0) (60) (Fig.13) (Thompson et al.1994).

On the other hand chemical investigation of the seeds of V. galamensis found two compounds, which are vernolic acid derivatives. Successive fractionation of 30 g of thick oil of the CHCl₃ extract and 25 g of MeOH extract of the seed by flash chromatography resulted in the isolation and characterization of two vernolic acid derivatives, cis-(12S,13R)-(3-methylpentyl) vernolate (61) and cis-(12S,13R)-(2,3-propanediol) vernolate (62) (Fig.14) (Fiseha et al.2010).
DISCUSSIONS

This review certifies the richness as well as the structural diversity in secondary metabolites of the sub-species and varieties of Vernonia galamensis. It highlights the role of the species in the prevention and treatment of various pathologies in traditional medicine. Data from the literature on the chemical composition of the leaves, roots, flowers and seeds of sub-species and varieties of V. galamensis indicate a wide variety of secondary metabolites including sesquiterpene lactones, coumarins, phenolic acids, flavonoids, triterpenes, sterols and fatty acids with natural epoxidation and their derivatives. This work constitutes a valuable source of information for the African medicinal flora. It could be a database for further research in the fields of phytochemistry and pharmacology and for the purpose of seeking new natural substances.

CONCLUSION

This review constitutes a source of information which contributes to knowledge of the African medicinal flora and to a safeguard of the local popular knowledge. The approach used clearly identified all uses of V. galamensis. It may also constitute a database for the valorization of the species V. galamensis in order to discover active principles which can be used in pharmacology.

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