Botany, Ethnobotanical Uses, Biological and Chemical Properties of *Gethyllis afra* L. (Amaryllidaceae)

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Abstract: *Gethyllis afra* is an important medicinal plant species in South Africa. The current study critically reviewed the botany, ethnobotanical uses, biological and chemical properties of *G. afra.* Information on the botany, ethnobotanical uses, biological and chemical properties of *G. afra* was collected from multiple internet sources which included Scopus, Google Scholar, Elsevier, Science Direct, Web of Science, Pubmed, SciFinder and BMC. Additional information was gathered from pre-electronic sources such as journal articles, scientific reports, books and book chapters obtained from the University library. This study showed that *G. afra* is mainly used as food, aphrodisiac, and herbal medicine for colic, indigestion, stomach-ache, boils, bruises, insect bites, toothache, convulsions, heart problems and sleeplessness. Major compounds isolated from the fruits of *G. afra* include α-pinene, n-butyl n-butyrate, isoamyl acetate, β-pinene and 2-methylbutyl butyrate. There is need to validate the documented ethnomedicinal uses of *G. afra* through phytochemical and pharmacological studies. Therefore, future studies should focus on these knowledge gaps particularly evaluating the chemical and biological activities of *G. afra* crude extracts and compounds isolated from the species.

Keywords: Amaryllidaceae, ethnopharmacology, *Gethyllis afra*, herbal medicine, South Africa.

INTRODUCTION

Gethyllis afra L. is a member of the Amaryllidaceae or amaryllis family. Members of the Amaryllidaceae family are known for their horticultural and ornamental appeal as well as for their medicinal properties [1]. The African Amaryllidaceae genera widely used as sources of herbal medicines include *Agapanthus* L'Hér., *Ammocharis* Herb., *Boophone* Herb., *Clivia* Lindl., *Crinum* L., *Gethyllis* L. and *Scadoxus* Raf. [2-13]. The Amaryllidaceae alkaloids are currently the primary sources of galanthamine which is widely used in the symptomatic treatment of Alzheimer's disease [14]. Research by Nair *et al*. [1] and Takos and Rook [14] showed that species of some of these genera remain a relatively untapped phytochemical source characterized by acetylcholinesterase (AchE) inhibitor properties. *Gethyllis* is a genus of bulbous plants that are endemic to the semi-arid areas of Botswana, Namibia and South Africa [15-19]. The genus name is derived from the Greek word "*gethyon*" which means bulb, onion (*Allium cepa* L.) or leek (*Allium ampeloprasum* L.) in reference to their resemblance to these taxa that are characterized by long-necked bulb structures with white sheathing tunics that surround the base of the leaves [20,21]. In South Africa, *Gethyllis* species are commonly referred to as 'kukumakranka', 'bramakranka' or 'koekoemakranka' in Afrikaans or Khoi [22]. These common names translate to "cure for upset stomach" based on 'koekemakranka brandy' regarded as one of the early Cape remedies for colic and indigestion [11,23-25]. According to Liltveld [20], the genus *Gethyllis* is one of most extraordinary and poorly researched southern African amaryllids.

The genus *Gethyllis* is comprised of 32 species [16,17,19,26] and has been divided into four groups based on leaf shape, hairiness and the presence or absence of a cataphyll [27]. Similarly, Snijman [19] divided the *Gethyllis* into three groups based on whether flowers are fleshy or delicate, numbers of anthers, structure of the stigma and style and whether the leaves are smooth or covered with hairs. In South African traditional medicine, species of the genus *Gethyllis* that are highly valued as sources of herbal medicines and included in a monographic guide of South African medicinal plants written by Van Wyk *et al*. [11] include *G. afra* L., *G. ciliaris* (Thunb.) Thunb. and *G. spiralis* (Thunb.) Thunb. According to Van Wyk *et al*. [11], *G. afra* is included in *materia medica* of South Africa on the basis that the species is presently one of the best known and most fully understood herbal medicines in the country. The fruits of this species are reported to have commercial potential as digestives and tonics in South Africa [28,29]. Van Wyk [29] argued that the fruits of *G. afra, G. ciliaris* and *G. spiralis* have commercial potential in South Africa in the production of a wide diversity of food products that can be derived from the fruits such as jam, processed into fruit juices, sweets, jellies, liqueurs and novel flavours. Similarly,

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research by Reinsten *et al*. [30] showed that *Gethyllis* species, including *G. afra* have commercial potential for the cut flower trade as potted flowers and foliages. Previous research by Van Wyk and Gericke [31], Van Wyk [28,29] and Van Wyk *et al*. [11] emphasized the importance of species such as *G. afra* as priority plant resources for the future benefit of local communities in southern Africa. It is within this context that the current study was undertaken aimed at reviewing the botany, ethnobotanical uses, biological and chemical properties of *G. afra.*

Description of *Gethyllis afra*

Gethyllis afra is endemic to the semi-arid habitats on sandy flats and stony alluvial plains amongst lowland Fynbos vegetation in the Western Cape province of South Africa [16,18,19,24]. The species has been recorded in sandveld Namaqualand to Cape Peninsula to near Heidelberg (Figure **1**) at an altitude ranging from 75 m to 200 m above sea level [16,18,19,21,32,33]. *Gethyllis afra* has an underground water storage bulb that enable the species to survive in the arid west regions of South Africa [34]. The species is characterized by long and fleshy roots. The bulbs of *G. afra* store sufficient reserves to survive the long, dry season in a dormant state but when conditions become favourable they produce leaves [11]. Literature records show that *G. afra* is associated with a single synonym, *Gethyllis pusilla* Baker [16]. *Gethyllis afra* is a bulbous geophyte that grows up to 10 cm to 14 cm in height with an underground bulb of which the scales form a distinctive neck at ground level [16,18,19]. The roots are fleshy, contractile and may be extremely long while some attached to enlarged somewhat rhizomatous basal plates [20]. The leaves are linear and usually 12 to 30 in number, which dry up at flowering. The leaves are usually erect to spreading, spiralled, usually channeled, glabrous or shortly hairy and basal sheath is not prominent. *Gethyllis afra* is identified by its unusual curled, spiralled grey-green, whorled and helical shapes which develop during the winter months and their often stone-like speckled cataphylls which camouflage themselves in their surrounds [21,35]. The cup-shaped flowers are attractive white or pink in colour, keeled with red on reverse which are followed by fragrant club-shaped berries that emerge in mid-winter, long after the flowers and leaves have wilted. The berries are fleshy, yellow to red in colour, characterized by powerful sweet and fruity odour, pushed above the ground at the onset of the new growing phase [18,19]. It is within the fragrant pulp in which the numerous seeds of *G. afra* are embedded in [11].

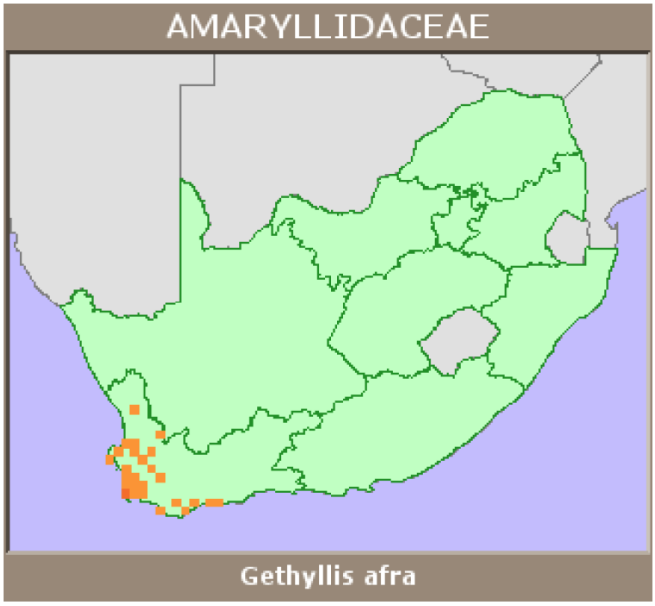

Figure 1: The distribution of *Gethyllis afra* in South Africa (www.ispotnature.org).

Traditional Uses of *Gethyllis afra*

Gethyllis afra is used to cure various ailments and it is a valued medicinal plant species in South Africa [20,23,31,36-40]. The aromatic fruits of *G. afra* are steeped in brandy and the infusion traditionally known as “koekemmakranka brandy” is an old Cape remedy for colic and indigestion [31]. *Gethyllis afra* is traditionally used as remedy for flatulence [23,39], upset stomach and stomach-ache [36,38]. Research by Watt and Breyer-Brandwijk [23] showed that the skin of *G. afra* fruits is used as remedy for boils, bruises and insect bites. The flowers are steeped in boiling water and the infusion is given to babies as remedy for teething troubles [36]. The fruit is boiled in water and used as a traditional aphrodisiac by local communities in Namaqualand in South Africa [41]. The flowers are boiled in water and decoction used as a remedy for toothache [41,42]. Research by Thring and Weitz [43] showed that fruits of *G. afra* are used as remedies for convulsions, heart problems, stomach problems and sleeplessness in Bredasdorp and Elim region of the Western Cape province in South Africa.

The ripe fruits of *G. afra* are sweet, juicy, pleasantly aromatic and good to eat [31,44-46]. The fruits are highly valued to perfume rooms, cupboards, handkerchiefs and linen in South Africa [11,23,24,31,40]. The fruity, sweet flavour and odour associated with the ripe fruits are sometimes used to impart this special aroma to bottles of brandy [31]. The fruits of *G. afra* subsidize to the food and nutritional requirements of local communities in the Western Cape

province in South Africa through essential nutrients such as vitamins and minerals. Research by Van Wyke and Gericke [31] and Thring and Weitz [43] showed that *G. afra* is propagated on a small scale in Namaqualand in South Africa for the fragrant fruits as well as herbal medicine.

Photochemistry and Pharmacological Properties of *Gethyllis afra*

Kamatou *et al*. [40] identified 43 volatile compounds from fruits of *G. afra* with α-pinene (11.2%), n-butyl n-butyrate (8.5%), isoamyl acetate (8.1%), β-pinene (6.4%) and 2-methylbutyl butyrate (5.8%) as the main constituents (Table **1**). These major constituents may be responsible for the banana, piney or fruity odours associated with the *G. afra* [40]. No alkaloids were detected by gas chromatography-mass spectrometry (GC–MS) in extracts of *G. afra* [47]. Lack of acetylcholinesterase (AChE) inhibition and affinity to the serotonin reuptake transport protein (SERT) exhibited by *G. afra* extracts could be explained by lack of alkaloids which are considered to be the biological hallmark of the Amaryllidaceae family [47]. The bulbs, flowers, fruits, leaves and roots of two *Gethyllis* species, *G. multifolia* L. Bolus and *G. villosa* (Thunb.) Thunb. showed antioxidant activities [47]. The whole plant extracts of *G. multifolia* and *G. villosa* exhibited anti-inflammatory and mutagenic effects [39]. Similarly, methanolic extracts of *G. multifolia* and *G. villosa* exhibited antimicrobial activities [49].

Table 1: Phytochemical Compounds Isolated from *Gethyllis afra* Fruits by Kamatou *et al*. [40]

Composition	Values
Benzyl acetate (%)	0.6
Benzyl isovalerate (%)	0.3
Butyl benzoate (%)	0.2
n-Butyl n-butyrate	8.5
Butyl caprylate (%)	0.2
Butyl hexanoate (%)	0.2
1,8-Cineole (%)	5.0
Decyl acetate (%)	0.2
Ethyl acetate (%)	0.7
Ethyl benzoate (%)	2.9
Ethyl butyrate (%)	2.3
Ethyl hexanoate	3.6
Ethyl isovalerate (%)	2.3
Ethyl octanoate (%)	2.0
Hexadecane (%)	0.1
Hexanol (%)	0.2
Hexyl acetate (%)	2.5
Hexyl hexanoate (%)	0.1
Hexyl-3-methyl butyrate (=Hexyl isovalerate) (%)	0.1
Isoamyl acetate (%)	8.1
Isoamyl benzoate (%)	0.7
Isobutyl benzoate (%)	0.4
Isobutyl butyrate (%)	3.1
Isobutyl caproate (%)	0.7
Isobutyl 3-methyl butyrate (=Isobutyl isovalerate) (%)	1.2
Limonene (%)	0.5
2-Methylbutyl butyrate (%)	5.8
2-Methylbutyl isovalerate (%)	4.7
3-Methyl butyl hexanoate (=Isoamyl hexanoate) (%)	1.5
Myrcene (%)	0.5
Myrtenyl acetate (%)	0.1
Neryl isobutyrate (%)	0.6
Octanol (%)	0.6
Octyl acetate (%)	2.7
Octyl 3-methyl butyrate (=Octyl isovalerate) (%)	0.2
Pentacosane (%)	0.4
α-Pinene (%)	11.2
β-Pinene (%)	6.4
trans-Pinocarvyl acetate (%)	0.2
Terpinen-4-ol (%)	0.1
α-Terpineol (%)	1.6
Verbenone (%)	0.1

(Table 1). Continued.

CONCLUSION

Based on research carried out by Van Wyk [28] and Van Wyk *et al*. [11], *G. afra* is an important herbal medicine that has potential as a source of commercial health and pharmaceutical products. However, results of this review showed that the species has not been exploited to its full potential in terms of primary healthcare of local communities and commercialization of its components as there are several research gaps in terms of its phytochemistry and pharmacological properties. The absence of biological activities of crude extracts or compounds isolated from *G. afra* highlights an existing gap requiring attention from researchers. In addition to cytotoxicity, the plant extracts should be subjected to *in vivo* acute and sub-chronic toxicity as the importance of evaluating medicinal plants for safety cannot be overemphasized. The development of

improved herbal medicines, new health promoting or pharmaceutical drugs can only come from linking the scientific tools such as the phytochemistry and biological activities of crude extracts or compounds isolated from the species with ethnomedicinal data. Therefore, future research should focus on evaluating the chemical and biological activities of *G. afra* crude extracts as well as compounds isolated from the species.

AUTHORS' CONTRIBUTIONS

CM wrote the first draft while AM supervised the research and assisted with writing the manuscript.

CONFLICT OF INTEREST

No conflict of interest is associated with this work.

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