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Medicinal bulbous plants of South Africa and their traditional relevance in the control of infectious diseases

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Abstract

Natural products are becoming more important in modern-day society as man is moving away from synthetic products, which can be detrimental to the environment and human health. Scientific research on the healing properties and bioactivity of natural compounds, especially of plant origin, has been extensive particularly in the Western world. However, a rich heritage of floral biodiversity is found in developing countries. South Africa, a country with a strong history of traditional healing, hosts a variety of around 30 000 plant species. Indigenous bulbous plants of importance to South African traditional healers mainly belong to the Amaryllidaceae and Hyacinthaceae families. A number of these plants have particular uses as disinfectants and anti-inflammatory agents, although there is still a lack of scientific research regarding their unique pharmacological compounds.

Keywords: Traditional healing; Ethnobotany; Amaryllidaceae; Hyacinthaceae; Bulbs

1. Introduction

An estimated three million people in South Africa are currently using indigenous, traditional plant medicine for primary health care purposes (Van Wyk and Gericke, 2000). The country's vast variety of indigenous floral species (Van Wyk et al., 1997) indicates a high potential for the discovery of novel bioactive chemicals (Duncan et al., 1999).

Several outstanding books have been published on South African medicinal plants (Watt and Breyer-Brandwijk, 1962; Roberts, 1990; Hutchings et al., 1996; Van Wyk et al., 1997), as well as numerous publications on the healing values and bioactivity of these plants. However, not much attention has been given to the indigenous bulbous plants of South Africa to date. They are particularly noteworthy due to a range of biochemicals that are only produced by members of these families (Fennell and Van Staden, 2001). We hope that this review would encourage further research into the healing effect of bulbous plants and their possible applications as alternative medicine or antimicrobial agents.

2. Plant medicine in developing countries

The therapeutic action of a range of wild plants, although not scientifically proven, has been discovered by indigenous people over centuries (Hutchings et al., 1996). Developing countries are often subject to shortages of funds, medical facilities and newly developed medicine, which make them more dependent on their natural resources (Mammem and Cloete, 1996; Shale et al., 1999). Among these, various African communities still use traditional remedies for primary health care.

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2.1. Traditional healing in South Africa

In South Africa, traditional healers, also called Dingaka or Inyanga, passed on practical knowledge regarding the healing powers of plants to next generations by word of mouth and experience. Most diseases could be treated with the aid of plants from the field, and it was believed that the synergistic action of additives, such as animal or insect parts, yielded even stronger or more potent medicines (Reyneke, 1971). However, the healing action predominantly resulted from medicinal plant compounds, since the base ingredients in the majority of medicines were of plant origin (Theunis et al., 1992). Although additives are still used in traditional medication today, the plant kingdom in particular has proved to be most valuable in the treatment of ailments.

Around 147 plant families are used traditionally for medicinal purposes by the Zulu, Xhosa and Sotho people of South Africa (Hutchings et al., 1996). The most prominent of these, listing over 50 plant species each, are the Fabaceae, Asteraceae, Euphorbiaceae, Rubiaceae and Orchidaceae families. The wide spread global use of the majority of these families highlights the traditional focus on herbal plants and trees for healing purposes. An analysis of the most important South African medicinal plants, discussed by Van Wyk et al. (1997), has revealed that roughly a third of the most frequently used indigenous plants are tree species. Another third can be classified as herbaceous plants or shrubs. The rest of the spectrum is divided between rhizomatous, succulent or leafy, and bulbous plants, of which the latter contributes the smallest percentage (Louw, 2002). Most of these bulbous plants are used for anti-inflammatory purposes, suggesting some degree of antimicrobial activity (Watt and Breyer-Brandwijk, 1962; Hutchings et al., 1996).

2.2. South African medicinal bulbous plants

Bulbous plant species belong to the monocotyledonous plants. Members of roughly 20 plant families of the Monocotyledonae are traditionally used against infection related ailments (Table 1). Families believed to possess antimicrobial activity include the Alliaceae, Araceae, Arecaceae, Asphodelaceae, Colchicaceae, Commelinaceae, Cyperaceae, Eriospermaceae, Hyacinthaceae, Poaceae and Typhaceae. Partly due to their less frequent medicinal usage, as mentioned above, the existing biochemical knowledge of this subdivision is not as extended as that of herbs and trees (Van Wyk et al., 1997).

The medicinal monocotyledonous plants that stood out most prominently for their traditional antimicrobial uses in South Africa belong to the families Amaryllidaceae, Asphodelaceae, Hyacinthaceae and Iridaceae (Table 1). Only a few of the monocotyledonous families, particularly the Amaryllidaceae, Hyacinthaceae, but also some Alliaceae and Iridaceae, produce bulbs as storage organs (Hutchings et al., 1996).

Some bulbous plants that are well known for their antimicrobial action, such as garlic, onion and green onion, are edible and have wider culinary uses. Extracts of these bulbous herbs show higher levels of fungal inhibition than other herbs, such as ginger, basil and hot peppers. Garlic's general antimicrobial action is ascribed to allicin, ajoene and other sulphite compounds (Yin and Cheng, 1998). Other antimicrobial compounds are found in the roots of bulbous plants, such as fistulosin from *Allium fistulosum* L. (Phay et al., 1999).

The limited medicinal usage of monocotyledonous plants does not imply a lack of potency or active components, but rather reflects the potential future gain and practical application of biochemical knowledge on these plants. However, in the search for bioactive chemicals or antimicrobial activity of bulbous plant extracts for potential human consumption, some have to be used with caution, due to their reported human toxicity (Foukaridis et al., 1995; Gaillard and Pepin, 1999). Some bulbs contain toxic substances, e.g. *Urginea sanguinea* Schinz, previously used for blood purification, venereal diseases, abdominal pain and backache (Foukaridis et al., 1995). Plants or plant parts should therefore be selected that would not impose harm to the consumer.

2.3. Preparation and administration of plant medicines

Drugs used by traditional healers are mostly prepared by some form of aqueous extraction, as they do not usually have access to other more lipophilic solvents (Kelmanson et al., 2000). Alcohols, normally ethanol or methanol, which typically possess antimicrobial or anti-inflammatory properties, are also used as extraction solvents. These solvents are relatively inexpensive and freely available (Foukaridis et al., 1995).

For the preparation of medicine from trees, the bark, leaves or roots are generally harvested, whereas leaves of herbs are normally used to prepare medicine (Van Wyk and Gericke, 2000). In the case of bulbous, tuberaceous or rhizomatous plants, storage organs, such as bulbs or tubers are normally regarded as the most valuable material (Likhitwitayawuid et al., 1993; Zschocke et al., 2000). Herbalists claim to use underground plant parts most frequently, believing that they contain the highest concentration of potent healing agents (Shale et al., 1999). These slower growing storage organs can be kept for longer periods and would normally retain their medicinal compounds for later use. Leaves or flowers of bulbous plants are used less frequently in traditional practice (Bangani et al., 1999; Crouch et al., 1999; Zschocke et al., 2000; Kelmanson et al., 2000).

Table 1
Antimicrobial medicinal usage of South African plants from the Angiospermae, Monocotyledonae, by Zulu healers (compiled from Hutchings et al., 1996)

Plant family	Species in family with medicinal uses	Diseases treated with members of plant family						
		Urinary or venereal diseases	Gastro-intestinal problems	Internal purifiers	Respiratory problems	Headache, fever	Swellings, growths, joints	Skin problems, bruises, sprains, fractures
Agavaceae	1[a]		1[b]					
Alliaceae	4		2		1	2	2	1
Amaryllidaceae	13	8	3	2	4	6	6	5
Araceae	3		2		2	1	1	1
Arecaceae	1				1			
Asparagaceae	4	1	2		2			
Asphodelaceae	15	4	6	1	2	2	3	7
Colchicaceae	1							1
Commelinaceae	2		1				1	
Cyperaceae	3		3			1		
Dioscoreaceae	2			1	1			1
Eriospermaceae	1			1				
Hyacinthaceae	14	4	5		4	6	8	2
Hypoxidaceae	4	1			1	1		1
Iridaceae	12	1	5		3	3		4
Orchidaceae	3		2				1	
Poaceae	9	1	2	3	1	3	1	3
Strelitziaceae	1	1						
Typhaceae	1	1		1				
Zingiberaceae	2				2	2		

[a] Total number of species in family used for antimicrobial related purposes.
[b] Depicts total number of indigenous plant species in a family used to treat specific infection related diseases, as indicated in the table.

3. Bioactive chemicals found in bulbous plants

Herbal plants and trees are generally mentioned in the search for antimicrobial compounds. However, the healing potential of bulbous plants should not be overlooked. Members of the Monocotyledonae, including the Liliaceae, to which most bulbous plants belonged previously, were reported to contain low tannin levels (Duncan et al., 1999). Members of the Alliaceae, Amaryllidaceae, Asparagaceae, Asphodelaceae, Colchicaceae, Dracaenaceae, Hyacinthaceae and Smilaceae were all formerly classified as Liliaceae (Hutchings et al., 1996). In several cases, these families produced other biochemicals specific to the family. Some of the biochemicals of plants belonging to the families Amaryllidaceae and Hyacinthaceae, the two families with the most members producing bulbs as storage organs, will be discussed subsequently.

3.1. Amaryllidaceae

The majority of compounds found in the Amaryllidaceae family are alkaloids (Fennell and Van Staden, 2001). Specific alkaloids, which are unique to the family, are associated with its members. Amaryllidaceae alkaloids repeatedly indicated antitumour potential and, amongst other characteristics, showed in vivo activity against various human viruses (Duri et al., 1994; Hutchings et al., 1996). The bulbs also contain flavonols, organic acids, carbohydrates and soluble nitrogen compounds.

Several members of the Amaryllidaceae are toxic and can cause symptoms such as headaches, excessive salivation, nausea, dizziness, heartbeat irregularities, visual disturbances and dermatitis. Some toxic principles include lycorine and haematin, and the inappropriate use of a number of species can be fatal (Hutchings et al., 1996). Nevertheless, other species are administered orally as medicine to children or eaten in porridge by local people (Crouch et al., 1999).

3.2. Hyacinthaceae

The abundant production of saponins is typical among members of this family (Hutchings et al., 1996). The subfamily Hyacinthoideae can be characterised phytochemically by the production of homoisoflavanones (Speta, 1998). The presence of steroids, cardiac glycosides and alkaloids in some species can often indicate toxicity. Symptoms of poisoning include diarrhoea, abdominal pain, emphysema and increased pulse rate, which can be fatal (Van Wyk et al., 1997). Various bioactive chemicals were found in members of the Hyacinthaceae.

4. Current usage and biochemical knowledge of some South African bulbous plants

4.1. Ammocharis

Some members of *Ammocharis* (Amaryllidaceae), a widely distributed genus, generally inhabit seasonal wet places (Machocho et al., 1999). *Ammocharis coranica*, a species which contains biochemicals such as alkaloids and triterpenoids in its bulbs (Koorbanally et al., 2000), has previously been noted as toxic. Therefore, instead of oral administration, fresh, wet scales are cooked and used as enemas for blood cleansing or applied topically to open wounds or boils (Rood, 1994).

4.2. Boophane

These plants are known for their large bulbs and production of characteristic Amaryllidaceae alkaloids (Viladomat et al., 1995). *Boophane disticha* (L.f.) Herb. is known as a toxic plant, containing compounds with alleged hallucinogenic potential (De Smet, 1996; Du Plooy et al., 2001). However, bulb scales or infusions are used on septic wounds and external sores, as well as rheumatism and for the relief of pain (Rood, 1994; Shale et al., 1999). Decoctions are also used for the treatment of headaches, cramps and internal pains (Hutchings et al., 1996).

4.3. Brunsvigia

This genus is a member of the Amaryllidaceae and produces large bulbs containing a number of alkaloids (Viladomat et al., 1996), previously shown to have significant antimalarial, cytotoxic and antineoplastic activity (Charlson, 1980; Campbell et al., 2000). The bulbs are applied as antiseptic dressings on fresh wounds (Hutchings et al., 1996), whereas bulb decoctions are administered as treatment of coughs, colds, abdominal, renal and liver complaints (Watt and Breyer-Brandwijk, 1962).

4.4. Clivia

Although root infusions of *C. miniata* (Lindl.) Regel, belonging to the Amaryllidaceae, are reportedly applied to snakebite and wounds (Bryant, 1966), roots and leaves are generally taken by South African women during pregnancy and child birth. Aqueous leaf extracts have proven to augment or induce labour (Veale et al., 1989). Bulb decoctions are also used against infertility and urinary complaints (Hutchings et al., 1996). A number of *Clivia* species are reported to contain typical Amaryllidaceae alkaloids (Evidente et al., 1999).

4.5. Crinum

About 20 species of the genus *Crinum* (Amaryllidaceae), of which 130 species are spread over the world, are endemic to southern Africa (Snijman and Linder, 1996). This perennial genus characteristically produces large bulbs with umbel-like flowers (Hutchings et al., 1996). Its widest diversity occurs through the tropical and temperate areas of sub-Saharan Africa, mainly in the eastern and southern parts of Africa (Nair et al., 2000).

Extracts of *C. macowanii* Bak., also known as the 'bush lily' or 'March lily', and referred to as 'dururu' or 'umduze' by Shona or Ndebele communities, has a wide range of traditional medicinal applications, including the treatment of sexually transmitted diseases and backache (Nair et al., 2000). It is used by the Zulu as an expectorant, to treat scrofula (TB type) and urinary rheumatic diseases, as well as cleansing of internal organs, the skin and blood (Hutchings et al., 1996). *Crinum bulbispermum* (Burm. F.) Milne-Redh. and Schweick. is indigenous to KwaZulu Natal, Gauteng, the Western Cape and Northern Province (Elgorashi et al., 1999), and very popular among the traditional people. The bulbs can be roasted and applied in the Zulu, Sotho and Tswana tradition to treat aching joints, septic sores, rheumatism, varicose veins, kidney or bladder infections (Roberts, 1990; Hutchings et al., 1996) and colds (Kelmanson et al., 2000). Leaves and flowers are also used occasionally on sprains, swellings, earache, rheumatic fever and malaria (Fennell and Van Staden, 2001).

Some other species with reported medicinal use include *C. firmifolium* L. (Madagascar), which is used externally against various parasitic skin diseases (Razafimbelo et al., 1996); *C. latifolium* L., an immunostimulant (Machocho et al., 1999); *C. papillosum* Nordal, as an antiseptic (Kamuhabwa et al., 2000) and *C. asiaticum* L. (India), for injury, inflated joints, sprains, to relieve rheumatic and local pain, as antidote against poisoned arrows (Samud et al., 1999), as an emetic, diaphoretic (Etkin, 1986) and to treat scabies in cattle (Begum and Nath, 2000). Some species are used externally only; others are considered toxic and can cause dermatitis if used without caution (Hutchings et al., 1996).

The *Crinum* genus receives considerable research attention due to its high alkaloidal content (Elgorashi et al., 1999; Ramadan et al., 2000), an indication of its antimicrobial, anti-inflammatory, analgesic, antitumour, antimalarial and antiviral activity (Duri et al., 1994; Viladomat et al., 1995; Samud et al., 1999; Nair et al., 2000). Various *Crinum* species have yielded around 170 different compounds to date, of which most are alkaloids (Fennell and Van Staden, 2001).

4.6. Drimia/Urginea

These two genera are often considered synonyms. Both genera are typically geophytes with scaly bulbs (Hutchings et al., 1996), and characteristically contain bufadienolides (Pohl et al., 2001). Hot water infusions from pounded bulbs of *D. robusta* Bak. are used as enemas and an ingredient of protective mixes. They are also used as expectorants, emetics (vomiting agents), diuretics, to treat bladder and uterus diseases, feverish colds (Hutchings et al., 1996), and promote the healing of broken bones (Pohl et al., 2001).

4.7. Urginea

A heterogeneous, poorly understood genus, needs to be revised (Speta, 1998). *Urginea sanguinea* Schinz was traditionally used as a blood purifier, abortifacient (Watt and Breyer-Brandwijk, 1962), a treatment for venereal diseases, abdominal pain and backache (Foukaridis et al., 1995), whereas *U. altissima* (L.f.) Bak. was used in African communities against skin problems, bruises, aches and rheumatism (Oliver-Bever, 1986). *Urginea maritima* Bak. bulbs were also used traditionally as fish poison in Spain (Arias, 2000). Some alkaloids found in *U. altissima* have shown potential as antifungal agents (Miyakado et al., 1975)

Despite their various medicinal uses, there were some reports of toxic compounds such as cardiac glycosides, particularly of the bufadienolide type (Iizuka et al., 2001), and caustic saps in the bulbs of *Urginea* (Foukaridis et al., 1995; Krenn et al., 2000) and *Drimia* species (Pohl et al., 2001). These compounds could be responsible for poisoning of animals (Basson, 1987; Nel et al., 1987; El Bahri et al., 2000) and humans with symptoms such as vomiting, nausea and seizures in patients (Tuncok et al., 1995). Some species were also reported to cause skin irritations (Hutchings et al., 1996), supposedly due to the presence of calcium oxalate crystals or raphides (Cogne et al., 2001).

4.8. Eucomis

The genus name is the Greek translation for 'beautiful hair', which describes the typical ≈ 60 cm long spikes with numerous green flowers arranged at the top. It also resembles the structure of a pineapple, hence the common name 'pineapple flower'. Of the 10 recorded species, 9 are indigenous to South Africa (Rood, 1994). Large, ovoid bulbs are produced by these perennial plants (Hutchings et al., 1996).

Leaves of *E. autumnalis* are still used externally to treat sores, boils and fever (Roberts, 1990). Bulb decoctions are widely used as enemas for stomach and bladder problems (Cunningham, 1991). It serves as an enema after operations, for fracture healing, low back

pain, fever, hangovers, syphilis, colic and urinary diseases (Rood, 1994; Hutchings et al., 1996). Studies conducted on *E. autumnalis* has proven its antibacterial activity, both in the leaves and underground parts (Zschocke et al., 2000; Louw, 2002).

4.9. Gethyllis

The fruit pods of *Gethyllis* (Amaryllidaceae) are boiled or administered as an alcohol infusion of brandy for stomachache. Flower decoctions are also used for toothache (Rood, 1994). The genus is currently endangered, and little is known regarding its chemical constituents or bioactivity (Van Wyk et al., 1997).

4.10. Haemanthus

Several alkaloids are produced by *Haemanthus*, a genus belonging to the Amaryllidaceae (Watt and Breyer-Brandwijk, 1962; Ghosal et al., 1985). These perennial plants are used against coughs, dropsy, asthma and as topical antiseptics (Hutchings et al., 1996). Some species have shown antiviral activity on RNA viruses, e.g. Poliovirus (Husson et al., 1993), as well as antitumour (Hutchings et al., 1996) and antineoplastic (Charlson, 1980) activity, but are also reported for their toxicity, probably due to the presence of alkaloids (Watt and Breyer-Brandwijk, 1962).

4.11. Scilla

The essentially Eurasian genus *Scilla* (Hyacinthaceae) represents 80 taxa worldwide. In South Africa, it is represented by at least 6 species (Crouch et al., 1999), including *Scilla natalensis* Planch., *S. kraussii* Bak. and *S. dracomontana* Hilliard and Burtt (Reid, 1993). This endangered species, associated with *Drimia* and *Urginea*, produces bulbs above or below the ground. *S. natalensis* is the most well-known and frequently used species in South Africa (Silayo et al., 1999).

Scilla species are widely used as medicinal plants: the Zulu people use them as purgatives and to facilitate labour. The Sotho eat the cooked bulbs as aperients, use bulb decoctions as enema for internal tumours and cattle lung sickness, or rub powdered bulbs over sprains, boils, sores, fractures, joints and back problems, to name a few (Hutchings et al., 1996; Crouch et al., 1999). The bulb of *S. natalensis* is used against dysentery, as a laxative (cooked with food), for internal tumours and applied topically on boils and sores (Rood, 1994). It is regarded as a cure for strains, sprains, fractures and cancers (Watt and Breyer-Brandwijk, 1962). Preliminary studies conducted by Matthe (1988) on *S. natalensis* indicated its antimicrobial activity against pus-forming organisms in vitro. Aqueous extracts accelerated healing of eczema and abscesses in humans. Members of the subfamily Scilloideae have also shown antitumour activity (Mimaki et al., 1994).

Other *Scilla* species considered medicinally valuable include *Scilla nervosa* (Burch.) Jessop and *Scilla maderensis* Menezes (Dias et al., 2000). Diluted bulb decoctions of *S. nervosa*, a species known to occur in Botswana, are generally used as analgesics against rheumatic fever (Silayo et al., 1999). The Tswana use cooked bulbs in porridge for infertility, and Sotho people add crushed bulbs to their food as aperients. The species is known for its anti-inflammatory and antihistaminic properties. It was previously noted as poisonous, especially to livestock, due to the production of glycosides (Mimaki et al., 1993); however, it is an important medicine to local people, who even mix the cooked bulbs into food (Bangani et al., 1999). *S. maderensis* was originally used in Madeira by erysipelas sufferers (Dias et al., 2000).

5. Future perspectives

An increasing worldwide interest in natural medicines has caused pharmaceutical companies from abroad to exploit African, and particularly South African medicinal plants, due to its wide biodiversity. During the last century, significant correlation was found between traditional remedies and scientific proof of their pharmacological action (Theunis et al., 1992). Only an estimated 15% of the world's known plant resources have been screened for their therapeutic values (Scott, 1993). Natural products provide mankind with more environmentally friendly alternatives to commercially produced medicines.

Bulbous plants, though studied less intensively than herbs and trees regarding their medicinal potential, have proven to contain a range of unique biologically active compounds. Valuable uses include their analgesic, anticancer, antimutagenic, immune stimulating, anti-infective, antimalarial, cardiovascular and respiratory system effects (Hutchings et al., 1996; Fennell and Van Staden, 2001). Traditional uses of some bulbous species, mainly belonging to the Amaryllidaceae and Hyacinthaceae, could provide useful leads in novel pharmaceutical developments. Since the biochemical content and pharmacological action of several of these species still remain poorly understood, future research should be a valuable aid in this respect.

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