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Review of studies on *Bulbine natalensis* Baker (Asphodelaceae): Ethnobotanical uses, biological and chemical properties

Collen Musara, Elizabeth Bosede Aladejana*
Department of Botany, University of Fort Hare, Alice, South Africa.

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ABSTRACT

Bulbine natalensis Baker is a native succulent herb that belongs to the family Asphodelaceae, and is regarded as precious, highly valued, and extensively used throughout the continent for medicinal purposes and in treating male impotency due to the aphrodisiac and invigorating effect. This study reviews the status of *B. natalensis* ethnobotanical uses, biological and chemical properties. This review was conducted from April 2019 to February 2020 by applying the mixed-method review approach, and in the framework of a complete description of *B. natalensis* species, data on morphology, distribution, and economic importance were discussed. Pharmacological screening reported that *B. natalensis* possesses anti-inflammatory and broad-spectrum antimicrobial properties. The bulbous plant vapour contains substances such as tannins, anthraquinones, cardiac glycosides, saponins, and alkaloids. Scientific evaluations from various researchers have substantiated the use of *B. natalensis* in the enhancement of male sexual disorders, cure of wounds, rashes, itches, ringworm, diabetes, rheumatism, cracked lips and herpes, diarrhea, and paroxysms among other diseases.

INTRODUCTION

Derivation of name and historical aspects

There are about 90 species of the genus *Bulbine*, which are found in the southern and western provinces of South Africa and Australia (Van Jaarsveld, 2017). Most of the species in the genus have found traditional medicinal applications for the treatment of different diseases that possibly arise from microbial infections (Bezabih *et al*., 1997), among them is *Bulbine natalensis* Baker. *B. natalensis* (synonym *Bulbine latifolia* (L.f.) Spreng.) is a member of the family Asphodelaceae and a predominant species in the genus (Van Wyk and Gericke, 2000). It is an indigenous succulent herb, widely dispersed in the eastern and northern provinces of South Africa, and locally known as ibhucu (Zulu), ingcelwane in Xhosa, broad-leaved *Bulbine* (English), and rooiwortel (Afrikaans) (Pather *et al*., 2011; Yakubu and Afolayan, 2010). The ability of the plant to display a distinct orange color whenever the lower stem is damaged and exposed to sunlight made the Afrikaans call it rooiwortel, meaning red root (Van Wyk *et al*., 1997). *Bulbine* is bulb-like in nature, and all the members of this genus are succulent herbs, many of which are used for horticultural purposes while others are widely cultivated, for instance, *Bulbine frutescens* (stalked *Bulbine* or *rankkopieva*) is a popular groundcover (Eggli, 2001). A conclusion has been drawn based on the chemotaxonomic investigation on the presence of knipholone and its derivatives in *Bulbinella*, *Bulbine*, and *Kniphofia* species, and it was concluded that these three genera form a monophyletic unit within the family Asphodelaceae (Yenesew *et al*., 1994).

Botanical description

Bulbine natalensis is a hardy, evergreen, drought-resistant, nonedible, perennial succulent herb with bright green, soft fleshy leaves that form the basal rosette (Van Jaarsveld, 2005). It is a perennial, fast-growing, succulent plant, whose appearance closely resembles the aloe species, forming solitary rosettes up to 20 cm high and possesses fleshy roots that are yellowish and circular in cross-section (Eggli, 2001). *Bulbine natalensis* has frost-tender, evergreen, perennial, broad, sharp-pointed, fleshy,

*Corresponding Author
Elizabeth Bosede Aladejana, Department of Botany, University of Fort Hare, Alice, South Africa. E-mail: efamewo @ ufh.ac.za

yellowish green leaves that are triangular-lanceolate (190–400 × 30–60 mm), green with faint lines; the firm, ascending, older leaves become recurved; the upper surface is flat and slightly channelled toward the end; the lower surface is flat to a somewhat acute rounded margin, bearing a minute fringe of hairs (Eggli, 2001). *Bulbine natalensis* has clusters of star-shaped yellow flowers (7–12 mm in diameter) that are held in densely packed spikes at the ends of long, gracefully arching, flowering stems throughout the year as shown in Figure 1 (Eggli, 2001). The plant's inflorescence consists of 1–4 densely flowered racemes that are 400–1,017 mm tall, with flower stalks that are 12–14 mm long and terete, and they flower in spring. *Bulbine natalensis* has six petals that are yellow, spread out, and 7 mm long with bearded stamens that differentiate it from *Bulbinella* (Eggli, 2001). The plants have 6 mm long styles and most species can reach a size of up to 60 cm (Eggli, 2001). *Bulbine natalensis* has pollen and nectar-rich flowers that attract pollinating insects to the garden, making it a worthwhile container plant for landscaping (Eggli, 2001; Van Jaarsveld, 2005).

Distribution and habitat

Bulbine natalensis is indigenous to South Africa, and is usually found in dry river valleys, rocky grassland, and gorges. The plant is generally dispersed in the southeastern province of South Africa (the KwaZulu Natal and Eastern Cape), and Knysna in the Western Cape (Eggli, 2001). *Bulbine natalensis* grows quickly, hence perfect for new gardens, and thrives well in shale and sandstone-based soils and on well-drained sites (Eggli, 2001; Van Jaarsveld, 2005). The species is widespread in hot areas, prefers rainfall from 600 to 1,000 mm per annum, and is well adapted to disturbances, such as grazing and trampling, as the plants regenerate easily from the seed (Eggli, 2001; Van Jaarsveld, 2005). The plant has pointed, thickset leaves that can reserve water, thus making it drought-tolerant and an ideal water-wise garden plant. Moreover, its ability to adapt to wind dispersal depends on the presence of the climbing inflorescence, with fruiting capsules and winged seed (Eggli, 2001).

Research methodology

The literature search was conducted from April 2019 to February 2020, where a mixed-method review approach, which included combining quantitative and qualitative research, was used to compile the review. An assessment of all the information on *B. natalensis* and a systematic and comprehensive literature search was conducted using electronic research-based databases, such as Scopus, ScienceDirect, PubMed, Google Scholars, books, and theses. Important words, such as taxonomy, botany, distribution, ethnobotanical uses, and biological and chemical properties, in relation to *Bulbine* plants were used for the search. A detailed appraisal of the existing knowledge and literature on *B. natalensis* morphology, ecology, distribution, and economic importance were discussed. Although *B. natalensis* are highly valuable, they face rapid depletion. It is, therefore, imperative to document the indigenous knowledge, medicinal use, and pharmacological properties of this plant.

Ethnopharmacology and utilization

Chemical compounds

The phytochemical investigation has displayed many bioactive constituent(s) of plant extracts (Yakubu *et al*., 2007), and the first chemical analysis of the *B. natalensis* stem revealed the presence of chrysophanol, 10, 7′-bichrysophanol, knipholone, and isoknipholone (Van Wyk *et al*., 1995) as shown in Table 1. Similarly, the study of Nigussie (1999) revealed that the root extract of *B. natalensis* contained chrysophanol, knipholone anthrone, isoknipholone, knipholone, aloe-emodin, 8-hydroxy-1-methylnaphtho [2,3-c] furan- 4, 9- dione, and 5,8-dihydroxy-1-methylnaphtho[2,3-c] furan-4,9-dione. Research has shown that the *B. natalensis* tuber has some phytochemical constituents, such as saponins, anthraquinones, tannins, alkaloids, and cardiac glycosides (Table 2; Yakubu and Afolayan, 2009). Also, the study of Mosa *et al*. (2011) reported the total phenolic and flavonoid contents of the extracts of *B. natalensis* as shown in Table 3. *Bulbine natalensis* (rooiwortel) has a high content of sterols and sterolins and are inappropriately used in the treatment of HIV/AIDS in South Africa (Plessis-Stoman *et al*., 2009). Furthermore, an additional six compounds, namely Bulbnatalonoside A, Bulbnatalonoside B, Bulbnatalonoside C, Bulbnatalonoside D, Bulbnatalonoside

Table 1. Distribution of anthraquinones in *B. natalensis* (Asphodelaceae).

Compounds	*B. natalensis*
Chrysophanol	+
Asphodeline	–
lO,7'-bichrysophanol	+
Chryslandicin	–
Knipholone anthrone	–
Knipholone	+
Isoknipholone	+

Key + = Present; – = Absent.
Adapted from Van Wyk *et al*. (1995).

Table 2. Phytochemical analysis of *B. natalensis*.

Phytochemical	*B. natalensis*
Saponins	++
Terpenoids	–
Flavonoids	+-
Tannins	++
Phlobatannins	–
Cardiac glycosides	++
Steroids	–
Anthraquinones	++
Alkaloids	++
Phenolics	–
Caffeine	–

Key + = Present; – = Absent.
Adapted from Mosa *et al*. (2011) and Yakubu and Afolayan (2009).

E, and Bulbnatalone, have been isolated and characterized from the methanol extract of *B. natalensis* (Bae *et al*., 2019).

Traditional uses of B. natalensis

The infusions of the roots of *B. natalensis* and other species of *Bulbine* are used orally for the management of illnesses, such as diabetes, diarrhea, blood disorders, convulsions, nausea (vomiting), rheumatism, urinary complaints, and venereal diseases (Table 4) (Erasto *et al*., 2005; Oyedemi *et al*., 2009; Van Wyk, 2011). The leaves or leaf sap of *B. natalensis* is applied directly to the skin and conventionally it is used topically to stop bleeding, thus it is widely used in the management of wounds, cracked lips, cuts, grazes, itches, mosquito bites, rashes, ringworm, sores, and herpes (Pather *et al*., 2011; Van Wyk, 2011). Furthermore, the leaves sap or root is employed in the treatment of dermatophytosis, burns, venereal diseases, and assists in the healing of postoperative scars (Pujol, 1990). Since 1995, the leaf gels' branded products were developed and commercially exploited, such as the Montagu Museum Bulbine Crème and the Bulb Aloe Levine products. In a clinical study of nearly 300 patients, a patented product consisting of microporous paper tape infused with a combination of bulbine gel (12.5%–25%) with panthenol and asiaticoside exhibited some wound healing properties and accelerated scar maturation (Widgerow *et al*., 2000). The healing effects are probably due to the presence of polysaccharides and/or glycoproteins in the leaf gel, as well as the hydrating effects (Widgerow *et al*., 2000). The gel of *B. natalensis* is frequently utilized by both traditional healers and the local population, as well as the European descendants, in South Africa for its wound healing properties, especially for the treatment of bruises, sunburn, fever blisters, and sores among others (Pather *et al*., 2011). Similarly, the gel from the fresh leaf can be applied directly onto the wound to help recovery or it can be used in the form of a warm poultice in traditional medicine, particularly for quick relief when used on stings and bites (Pather *et al*., 2011).

Antimicrobial activity

The steroids, saponins, and tannins of *B. natalensis* exhibited antibacterial properties (Oyekunle *et al*., 2006) through the inhibition of enzymes, iron deprivation, and reduction in oxidative phosphorylation (Parekh and Chanda, 2007). Yakubu and Quadri (2012) investigated the antimicrobial activity of different extracts of the *B. natalensis* tuber at concentrations ranging between 0.1, 0.5, 1.0, 5.0, and 10 mg/ml. Accordingly, the ethanolic extracts showed significant inhibition against all the Gram-negative bacteria tested with 75% of the bacterial strains inhibited; likewise, the n-butanol fraction repressed almost 87.5% of the bacteria at MIC ranging from 3 to 10 mg/ml. While the ethyl acetate fraction produced 100% growth inhibition against all the test organism at MIC of 1 and 5 mg/ml, the water extract produced no growth inhibition (Yakubu and Quadri, 2012). According to Parekh and Chanda (2007), the stronger the extraction capability of organic solvents the more range of phytoconstituents responsible for the observed antibacterial activity.

An *in vivo* study by Pather *et al*. (2011) on the effects of leaf gel extracted from *B. frutescens* and *B. natalensis* on wound healing in pigs showed notable effects. The leaf gel extracts of both *B. frutescens* and *B. natalensis* displayed a beneficial effect on collagen synthesis and on wound contraction, hence resulting in faster healing than in untreated wounds (Pather *et al*., 2011). The study of Coopoosamy (2011) reported that the acetone and ethyl acetate extracts of the leaf, root, and rhizome of *B. natalensis* had more antibacterial activities against both Gram-positive and Gram-negative bacteria tested when compared to the water extracts. The phytosterols, such as ergosterol, stigmasterol, and sitosterol, from the chloroform extract of *B. natalensis* showed that the antifungal potential is more fungistatic rather than fungicidal against *Aspergillus flavus*, *Penicillium digitatum*, and *Fusarium verticilloides* (Mbambo *et al*., 2012).

Stimulant effect

Due to the positive impact of *B. natalensis* on penile erection and sexual behavior parameters, the stem of this plant is

Table 3. Total phenolic and flavonoid content of the extracts of *B. natalensis* (mg/g dry plant material).

Extract	Phenolic	Flavonoid
Hexane	5.03 ± 0.04	3.29 ± 0.05
Chloroform	4.55 ± 0.67	2.42 ± 0.07
Ethyl acetate	4.63 ± 0.15	2.84 ± 0.10
Methane	3.40 ± 0.15	1.78 ± 0.06
Water	1.15 ± 0.02	1.89 ± 0.02

The total phenolic and flavonoid content decreased with an increase in polarity. Adapted from Mosa *et al*. (2011).

Figure 1. *Bubline natalensis*. (A) Whole plant; (B) matured flower; and (C) root. Source: Top Tropicals (2020).

Table 4. Uses of *B. natalensis.*

Parts used	Uses	References
Leaves, roots, and leaf sap	Applied directly to skin for wound healing.	Mabona and Van Vuuren, 2013
	Used to treat burns, rashes, itches, ringworm, and cracked lips.	Ghuman and Coopoosamy, 2011; Van Wyk, 2011
Roots	Back pain, kidney diseases, venereal diseases, diabetes, stomach ailments, rheumatism, and blood purification.	Van Wyk *et al*., 2009
	Administer orally to suppress vomiting, diabetes, diarrhea, convulsions, venereal diseases, and rheumatism.	Pujol, 1990
	Fresh roots are boiled and the infusion is taken orally to treat diabetes.	Erasto *et al*., 2005
Stem	Mix the powder from the stem with milk and take orally for the treatment of male sexual dysfunction.	Abdillahi and Van Staden, 2012

extensively used in the treatment of male sexual dysfunctions (Ajao *et al*., 2019; Malviya *et al*., 2011; Yakubu and Afolayan, 2009). An ethnobotanical survey has documented the traditional uses of *B. natalensis* plants as an aphrodisiac which can be used to arouse sexual instinct, induce general desire, and increase pleasure and performance (Malviya *et al*., 2011). *Bulbine natalensis* is commonly called as "testosterone booster", and this is presented in the study of Yakubu and Afolayan (2010), where the effect of aqueous stem extracts of *B. natalensis* and its anabolic and androgenic effects in male Wistar rats were investigated. An experiment of 60 rats was equally clustered into four (A–D), with group A being the control receiving 0.5 ml of distilled water and groups B–D was administered 0.5 ml of distilled water containing 25, 50, and 100 mg/kg of body weight of the extract (Yakubu and Afolayan, 2010). The findings revealed that, at doses 25 and 50 mg/kg body weight, there was a significant increase in the serum testosterone and luteinizing hormone concentrations. Moreover, the frequencies of mount, intromission, ejaculation, and ejaculatory latency in the rats increased (Carlos, 2020; Yakubu and Afolayan, 2010). Penile reflexes and copulatory performance of male rats were significantly enhanced, which may be attributed to the increase in serum testosterone concentration. Testosterone is considered to contribute to the improvement in sexual function, libido, and penile erection (Carlos, 2020; Gauthaman *et al*., 2002), thus *B. natalensis* is being sold as various brands of health supplements because of its effect on boosting the testosterone level in men (Hofheins *et al*., 2012; Patel, 2018; Widgerow *et al*., 2000). Bioactive agents, such as saponins and alkaloid, are responsible for aphrodisiac activity (Yakubu *et al*., 2005). While saponins enhance androgen production (Gauthaman *et al*., 2002), alkaloids increase the dilation of blood vessels in the sexual organs (JianFeng *et al*., 2012).

Anti-platelet aggregation

Bulbine natalensis is mostly used by Zulu traditional healers in South Africa because of its notorious anti-platelet aggregation bioactivity and its aptitude to impede thrombin, ADP, and epinephrine-induced aggregation of platelets (Lazarus, 2012; Mosa *et al*., 2011). The extracts of *B. natalensis* exhibited a concentration-dependent anti-platelet aggregation activity, with the chloroform extract of *B. natalensis* exhibiting the highest activity (IC_{50} of 0.43mg/ml), which was observed on the epinephrine-induced platelet aggregation (Mosa *et al*., 2011). A previous study by Mosa *et al*. (2011) supports the use of *B. natalensis* in folk medicine and in the management of blood-clotting-related diseases. Likewise, the study of Lazarus (2012) revealed that the chloroform extract of *B. natalensis* exhibited 100% inhibition of ADP-induced clotting at doses of 1 and 3 mg/ml with IC_{50} values of 5.32 mg/ml.

Free radicals are known to stimulate platelet aggregation by interfering with several key steps of platelet functions (Bakdash and Williams, 2008). *Bulbine natalensis* has been validated as more effective anti-platelet aggregation agents of natural origin (Mosa *et al*., 2011) and literature reports that the presence of tannins must be responsible for the anticoagulant or anti-platelet aggregation activity (Kee *et al*., 2008; Kim and Choi, 2008). However, Mosa *et al*. (2011) suggested that the anti-platelet aggregation activity of the plant could be attributed to its high phenolic and flavonoid contents.

Apoptosis

Different parts of the *Bulbine* species, such as the stems, corms, leaves, and roots are known to contain anticancer compounds, namely anthraquinones, chrysophanol, and knipholone. These compounds have been proven by various studies to be cytotoxic against cancer cell lines and antibacterial against various bacterial strains (Coopoosamy, 2011; Kasumbwe and Reddy, 2010; Padayachee and Reddy, 2009). Singh and Reddy (2012) reported that the aqueous and organic fractions of *B. natalensis* induced the expression of *caspase-3*, which plays a significant role in apoptosis. The variation in *bax* gene expression that regulates apoptosis indicated that HEp-2 cell death was due to apoptosis and other unknown forms of cell death that may or may not activate *caspase-3* gene expression.

Anti-diabetic activity

Bulbine natalensis has been reported through the ethnomedicinal survey to possess anti-diabetic properties (Afolayan and Sunmonu, 2010; Odeyemi and Bradley, 2018), but till date, the anti-diabetic activity of the plant has not been scientifically proven.

CONCLUSION

Bulbine natalensis has displayed a broad-spectrum of antimicrobial potential and this review has summarized its traditional use in male reproductive healthcare, wound healing, and treatment of various ailments in South Africa. Since primary healthcare in most communities in South Africa is dependent on traditional healers and herbalists, it is, therefore, imperative to validate the herbal remedies, as well as preserving the indigenous heritage for the benefit of these communities. Even though the effectiveness of *B. natalensis* in traditional medicine is well known, supplementary studies are required to isolate and characterize the active components of the extracts and to elucidate their mechanisms of action. In order to strengthen the total body of evidence, more research needs to be carried out in terms of scientifically assessing the traditional medicine and learning how to combine these therapies with modern medicine and exploration toward producing low cost-effective topical medications for various ailments.

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AUTHORS' CONTRIBUTIONS

Both the authors contributed in experimentation, data collection, analysis of the data, writing, and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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