



REVIEW ARTICLE

Typha capensis (Rohrb.) N.E.Br. (Typhaceae): morphology, medicinal uses, biological and chemical properties

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ABSTRACT

Typha capensis (Rohrb.) N.E.Br. is a robust, monoecious, perennial marshy herb that belongs to the family Typhaceae. The current research aims to provide a comprehensive analysis of the biological and chemical properties, botany and medicinal uses of *T. capensis*. Comparative analysis of literature showed that *T. capensis* is a medicinal plant that has multiple benefits such as food for humans, feeds for animals and medicines to treat various diseases. All the parts including the leaves, seeds, rhizomes and pollen can be used in making decoction to improve male potency and libido, cures genital problems, boosts circulation, enhance female fertility, strengthens uterine contraction in childbirth and facilitates placenta removal. It is also used for the treatment of dysmenorrhea, diarrhoea and dysentery venereal diseases. The plant contains several flavones and phenolic compounds which have been reported to possess anti-inflammatory activity. Scientific studies have shown that *T. capensis* has a broad range of biological activities such as antibacterial, antioxidants, fertility-promoting effect and apoptosis effect. *T. capensis* should be subjected to comprehensive phytochemical, pharmacological and toxicological assessments projected at assessing its efficacy and safety as herbal medicine.

Introduction

The family Typhaceae is composed of approximately 10 to 15 species which are tall and capable of reproducing clonally through submerged rhizomes forming dense stands (1). *Typha capensis* (Rohrb.) N.E.Br. is a vigorous, herbaceous perennial plant known as bulrush (English), *Lesehu* (Sepedi / North-Sotho), *papkuil or matjiesriet or palmiet* (Afrikaans.), *Ibhuma* (Zulu, Swazi), *Ingcongolo* (Xhosa) and *Motsitla* (Sesotho) which belongs to the family Typhaceae (2, 3). The word *Typha* is derived from *typhos*, a Greek word which means marsh, referring to the habitat, or *typhe*, which is a cat's tail, alluding to their inflorescence (1). Its specific name *capensis* is derived from its abundance in the Cape (1).

A study on the morphology, medicinal uses, phytochemistry and biological activities of *T. capensis* was carried out using material from existing scientific databases such as Google Scholar, Science Web, SciFinder, Scopus, Science Direct, PubMed, Scielo,

Springer Link, Google Patents, BioMed Central (BMC) and Medline. To avoid too much filtering of literature, the search terms were done individually. Keywords of the quest include the scientific name and synonyms, common English names, biological activity, medicinal uses, ethnobotany, ethnopharmacology, pharmacology, phytochemistry of *T. capensis* and therapeutic value. Complementary information was gathered from related scientific publications collected from the University of Fort Hare Library, Alice campus in South Africa.

The economic value and intrinsic benefits of medicinal plants have gained widespread recognition, as is their potential for development from use as traditional into future medicines. *T. capensis* is an example of these plants. In this study, its medicinal applications, phytochemistry and pharmacological activities are critically reviewed. This study documents the existing indigenous/traditional knowledge related to the use of *T. capensis* that can be used for future research.

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Fig. 1. The leaves (a), staminate flower (b), rhizome (c) of *Typha capensis*.
Source: (7)

Results and Discussion

Morphological Description

Typha capensis is a monoecious, perennial marshy herb, and it colonises its habit proficiently through its creeping rhizomes (3, 4). It is a robust plant with a reed-like appearance and grows up to three metres in height with thick, fleshy, spongy and creep rhizomes (Fig. 1) (4). The most distinguishing characteristic of *T. capensis* is the erect and simple, strappy and hairless, amphibious with long, grey-green stems that obtrude from the rhizomes into thick stands. The leaves are linear, long braided, hairless, bluish-grey to green, strap-shaped with parallel veins and varying in length from 0.5–1.5 m and more. The inflorescence is a thick spike of densely packed flowers, at first pink, and then turning brown (4). They are usually contiguous but may be separated by as much as 2 cm (4, 5). This has unisexual minute flowers lacking tepals, reduced to 1 carpel or 2–5 stamens and filled with hair (4). The characteristic stalk of the flower bears minute male flowers towards the top, with the female flowers (12–32 cm long) packed in a dense brown mass under the male part (5). The male spike is 8–15 cm long and when mature falls off; leaving the 'bean' bulrush, which is the plant's fruiting component (6). The fruit is one-seeded follicle with stigma and hairs of the female flower forming a pappus that aid in dispersal (5). *T. capensis* flowers from December to January (3, 4). The thick fibrous roots emerging from the rhizomes assist in the plant's anchorage, allowing it to withstand heavy winds without being washed into the water (3, 4).

Distribution and Habitat

Typha capensis is an indigenous perennial aquatic C_3 plant which grows in the wetlands of South Africa and can tolerate both acidic and alkaline environments and some degree of salinity (2). The plant primarily inhabits marshes, stream banks, dams and lakes and their muddy substratum allows the plant to anchor its rhizomes firmly (8). The rhizome structure shows both hydric and xeric adaptations due to variation in the water content of marsh ecosystems (4). Mechanical and conductive tissue is common in *T. capensis* and signifies the mesophytic ability of the plant due to ample parenchyma, aerenchyma and hydrophytic tissue storage (4). *Typha capensis* is primarily distributed in most South African provinces (Eastern Cape, Free

State, Gauteng, KwaZulu-Natal, Limpopo, Mpumalanga, North West and North Western Cape) (2). Bulrushes are found in southern African countries such as Angola, Botswana, Namibia, the DRC, Kenya, Tanzania, Uganda, Malawi, Mozambique, Zambia, Zimbabwe and Swaziland and it is known to spread very quickly and form large clumps (3, 4).

Medicinal Uses

Traditional use of medicines is increasingly recognised as potential future medicines. All the parts of *Typha capensis* including the leaves, seeds, rhizomes and pollen are used in making the decoction and used in the treatment of various diseases.

The fleshy rhizomes of *T. capensis* are used traditionally in South Africa, Chinese, Japan, Germany and Turkish to make decoctions for the treatment of venereal diseases, dysmenorrhea, diarrhoea and dysentery. It enhances male potency and libido, cures genital disorders, boosts circulation, promotes female fertility, strengthens uterine contraction during childbirth and facilitates placenta removal (9–13).

The leaves of *T. capensis* are diuretic and used to treat dysentery and sexually transmitted diseases (14); the pollen is astringent, desiccant, diuretic, haemostatic and vulnerary (8) and the seed are haemostatic. It has been reported to have antibacterial properties (*E. coli*) and known for treating nose bleeds, haematemesis, inflammation, haematuria, uterine bleeding, scrofula (Mycobacterial cervical lymphadenitis), painful menstruation, postpartum, abdominal and stomach pain, abscesses and uterine bleeding (15–17).

In addition, the spongy rhizomes of *T. capensis* are rich in starch and can be crushed to a meal, whereas the pollen is used as high protein-based food. The leaves are often used in making hand-brooms as well as in weaving and thatching in Sekhukhune land, South Africa (8). Other benefits include papermaking, torch making (female inflorescences dipped in kerosene), water purification, green manure and home making (leaves were used to insulate roofs of early houses). The immature flowering spikes-raw are cooked or made into a soup, and the seeds can be ground into a flour and used in making cakes (18).

Pharmacological Properties

Several activities have been reported from the leaves and rhizome extracts of *Typha capensis*, and they include anti-inflammatory, antibacterial, antioxidants, fertility-promoting effect and apoptosis effect. The effect of the aqueous, hexane, acetone, ethanol and methanol leaves and rhizomes extracts of *T. capensis* are discussed below.

Anti-inflammatory properties

The anti-inflammatory activity of hexane, acetone, ethanol, methanol and aqueous leaf extracts of *T. capensis* was examined through the inhibition of 15-lipoxygenase (15-LOX) and nitric oxide (NO) by lipopolysaccharide (LPS)-activated RAW 264.7 murine macrophages, and quercetin as the positive control (17). Among the extracts, the hexane extract inhibited 15-LOX inhibitory with the IC₅₀ values of 4.65 µg / mL, which was significantly higher than quercetin at the IC₅₀ values of 24.60 µg / mL. Following fractionation, the methanol/water (35%) and hexane fractions of *T. capensis* exhibited good activity against 15-LOX with the IC₅₀ values of 9.15 and 10.19 µg / mL respectively. Besides, the acetone extract demonstrated strong inhibitory activity (86%) against NO production and cell viability of 97% at 50 µg/mL. The most active fraction of the extract was butanol, inhibiting 94.6% and 77.39% of NO production at 100 and 50 µg / mL respectively, with 100% of cell viability at 12.5 µg / mL. The plant extracts with strong inhibitory activity in terms of nitric oxides production and lower toxicity are useful in reducing inflammation, thus supporting the plant's medicinal use against inflammation (17).

Phenolic compounds have been reported to possess anti-inflammatory properties through the inhibition of reactive nitrogen species, 15-LOX, reactive oxygen species and cyclooxygenase pathways. The reactive nitrogen species and reactive oxygen species serve as secondary messengers and are closely related to acute and chronic inflammation (19–21). Also, flavonoids have good anti-inflammatory activity, improve the body's normal functioning against viruses and carcinogenic agents. This activity is due to the connection between the phenolic hydroxyl groups and the structures of flavonoid (22, 23). Thus, *T. capensis* may contain good activity against free radicals.

Antioxidant properties

The antioxidant activity of the hexane, acetone, ethanol, methanol and aqueous leaf extracts of *T. capensis* was examined using free radical scavenging 2, 2-diphenyl-1-picrylhydrazyl (DPPH) and electron reducing 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid (ABTS) assays (17). The acetone extract exhibited the strong activity against DPPH with the IC₅₀ values of 7.11 and 1.91 µg / mL against ABTS, which was comparable to the positive controls, trolox and ascorbic acid with 2.13 and 2.49 µg / mL IC₅₀ levels respectively. Ethyl acetate and butanol fractions of the plant showed good antioxidant activities with the IC₅₀ values of 5.61 and 9.98 µg / mL against DPPH and ABTS respectively. Study on the antioxidant activity of the leaves and rhizome

extracts using DPPH radical scavenging and vitamin C as the positive control (8), revealed that the extracts showed low antioxidant activity (12.8%) after spraying the chromatogram with 0.2% DPPH; however, the positive control had 100% scavenging activity.

The capability of *T. capensis* leaves and rhizomes extracts to scavenge reactive oxygen species was examined (24) by making use of chemiluminescent ABEL, peroxy nitrite anion-specific antioxidant kits and free radicals like superoxide anion containing Pholasin at concentrations of 0.1, 0.5 and 1.0 mg / mL. The extract showed significant dose-dependent scavenging of superoxide formation varying from 10.2% for 1.0 mg / mL rhizome extract to 57.5% for 1 mg / mL leaves extract and peroxy nitrite ranging from 45.1% for 0.1 mg / mL rhizome to 98.6% for 1 mg / mL leaves extract. Hence, the leaves demonstrated a greater scavenging activity for both superoxide and peroxy nitrite formation compared to the rhizome extract. Also, further study showed that the extracts had a higher inhibiting capacity for the inhibition of collagenase activity in a dose-dependent manner; thus, the plant could possibly have anti-cancer effects (24). This is significant as collagen inhibition can decrease the invasive ability of cancer cells and affect the formation of the basement membrane *in-vivo* (25).

Antimicrobial activity

The antibacterial potential of the hexane, dichloromethane, acetone and methanol leaves and rhizomes extracts of *T. capensis* were evaluated using microplate dilution method (8). All the extracts had antimicrobial activity with the rhizomes and leaf methanol extracts exhibiting greater activity against *P. aeruginosa*, *S. aureus*, *E. coli* and *E. faecalis*, with the average minimum inhibitory concentration (MIC) of 0.75 and 0.21 mg / mL respectively, whereas the MIC of the positive control (ampicillin) ranged from 0.08–0.16 mg / mL. The study further revealed that the leaf extracts were more active than the rhizome extracts; thus, validates in a systemic way, the antibacterial properties of *T. capensis*.

Fertility-promoting effect

The fertility-promoting effects of the aqueous rhizomes extract of *T. capensis* in a rat model of cadmium-induced infertility was evaluated (26), which showed that it does not improve ($p > 0.05$) testicular and epididymal weights at the doses used in the study, but, it slightly raised the sperm count by 14%, 31% and 35% respectively, in the experimental groups treated with the extract at doses 100, 200 and 400 mg / kg compared to the CdCl₂ control group. The authors concluded that *T. capensis* in an animal model of cadmium-induced infertility, could not provide protective effects against oxidative stress or promote fertility.

The *in-vitro* effects of aqueous leaves and rhizome extracts of *T. capensis* was investigated on male fertility on human sperm functions (24). The findings revealed that at 1 hr, the rhizome extract significantly reduced the values of all measured sperm parameters namely motility, vitality, sperm

production of reactive oxygen species and sperm with intact mitochondrial membrane potential. This could be because of the direct toxic effect of some *T. capensis* extract components on the mitochondria resulting in a respiratory breakdown, or an indirect effect due to the complete scavenging of the free radicals generated in any cell during aerobic respiration, where approximately 1–5% of the oxygen consumed is transformed into free radicals (27), or as a result of ROS which has been reported to be harmful and causes cell death, male infertility and reduced sperm motility (28–30). The study concluded that in contrast to the proposed use by traditional healers as a natural remedy for treating male fertility disorders, the extracts have detrimental effects on sperm functions *in-vitro*. Hence, further studies are needed using the animal model in an *in-vivo* testing to ascertain the beneficial effects of *T. capensis* on male reproductive functions.

Another study investigated the effects of rhizome extract F1 fraction of *T. capensis* obtained during autumn, winter, spring and summer harvests on TM3-Leydig cells at different concentrations of 0.01, 0.02, 0.1, 1, 10 and 100 µg / mL for 24, 48 and 96 hrs (31). After 48 h of exposure, F1 fraction of all four seasons strongly increased the production of testosterone in TM3 cells with maximal impact at 0.1 µg/mL, in a dose-dependent manner. Lesser testosterone production was observed at higher concentrations. Thus, it was concluded that the F1 fraction of an aqueous extract of *T. capensis* rhizomes greatly increased the production of testosterone and may be useful to treat male infertility and male ageing problems (31). From the above results, further *in-vivo* and clinical studies are required in order to thoroughly investigate the aqueous rhizome extract of the plant for its ability to treat male infertility as claimed by the traditional healers.

Cytotoxic effects

The early apoptotic events by means of Annexin V-Cy3 (AnnCy3) binding to TM3 cells was determined in a study (31). The result revealed that the rhizome extract F1 fraction of *T. capensis* showed no cytotoxic effects including cell viability, induction of apoptosis and DNA fragmentation at concentrations used in the study. There are limited literature on the cytotoxicity effect of this plant. Thus, further toxicological assessment of the plant is required in order to ascertain the safety of the plant.

Chemical Properties

The *Typha* genus has been reported to contain numerous flavones, phenolic compounds (32), long-chain hydrocarbons and various triterpenoids with a steroidal skeleton of typhasterols (16, 32). Research has also shown that the presence of phytosteroids in *Typha capensis* can be metabolised by the body resulting in the creation of an androgen or oestrogen-like substances that are beneficial to male sex drive and performance (8).

Phenolic compounds such as typhaphthalide, typharin, sitosterol, the flavonoids afzelekin, epiafzelekin, (+)-catechin and (-)-epicatechin were isolated and identified from *T. capensis* rhizomes

(33). Some of these compounds, for instance, sitosterol, have been reported to prevent chronic inflammation caused by obesity, with a clear negative Pearson correlation between pro-inflammatory cytokines such as TNF-α and IL-6 and the serum sitosterol tested in animal and clinical studies (34). Also, (-)-epiafzelekin, a flavan-3-ol compound has antioxidant and anti-inflammatory activities (35, 36), (-)-epicatechin reduced the expression of pro-inflammatory cytokines (TNF-α, IL-6) and showed protection against LPS-induced renal dysfunction, reducing the inflammatory damage.

Also, the total phenolic content of 45.29 ± 0.86 mg GAE / g was obtained in ethanol crude extract of *T. capensis* and the values of 37.79 ± 1.94 mg GAE / g in ethyl acetate fraction of the extract (17). In addition, Ilfergane (37) identified quercetin and naringenin from an aqueous rhizome extract of *T. capensis*. These compounds showed increased production of testosterone in TM3-Leydig cells at low concentration. They might probably be useful in the treatment of infertility and ageing male malfunctions.

The presence of mineral elements such as Ca, Mg and Fe have reported in *T. capensis*, *Centella asiatica* and *Cyperus longus* (38). The highest concentration of Ca and Fe were observed in *T. capensis* with the values of 7246.22 mg / kg and 268.17 mg / kg during spring respectively. However, the highest Mg concentration of 118.78 mg / kg was also found in *T. capensis* during autumn. It was reported that *T. capensis* contains Ca, K, Mg, Na, Fe and Zn which are essential nutrients and have reportedly been used for the treatment of infertility and sexual performance enhancement (39). Calcium has been reported to play an important role in bones and teeth formation, proper heart and muscles functioning, penile erection and sustenance or triggering sexual desire in males (40–43).

In addition, several biochemical and physiological processes including muscle coupling, contraction and excitation, spermatozoa motility, nerve excitable regulation, egg fertilisation and cell reproduction require calcium (44). A high concentration of magnesium could enhance the production of androgen, estrogens, hormones and neurotransmitters through numerous mechanisms to trigger sexual desire in males. (41, 42, 45). Sodium and potassium helped in the maintenance of human body tissues excitability, ionic balance, gastric juice formation in the stomach and contraction of muscles. The erectile function in penile tissue is enhanced with potassium induction on vascular smooth muscle (41, 42, 46). Iron helps in the formation of haemoglobin (47) while zinc plays a key role in the primary functioning of cellular processes in all living organisms and helps with restoring the human immune system after illness (48).

Conclusion

Typha capensis, a monoecious, rhizomatous, perennial herb is widely distributed throughout southern Africa. The study reviewed the medicinal

uses, chemical and pharmacological properties of *T. capensis* emphasising its antimicrobial, fertility promoting effect, anti-inflammatory, antioxidant and cytotoxicity effects. The empirical evidence for its phytochemical and pharmacological properties suggests the species therapeutic potential. *T. capensis* is one of the medicinal plants that have multiple uses including the treatment various diseases in tropical Africa. However, detailed studies on the clinical assessment of crude extracts and compounds derived from the *T. capensis* using *in-vivo* models are required. To evaluate the effectiveness and safety of this plant as herbal medicine, *T. capensis* should be subjected to comprehensive phytochemical, pharmacological and toxicological assessments, since, there are little information on these aspects.

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Authors' contributions

The authors contributed equally to the writing, reading and approved the final manuscript.

Conflict of interests

The authors declare that they have no conflict of interests.

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