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Bioactivity of plants used traditionally in the treatment and management of men's sexual health

Authors:
Tsumbedzo Nemandalali[1]
Monde A. Nyila[1]
Thilivhali E. Tshikalange[2]

Affiliations:
[1]Department of Life and Consumer Sciences, College of Agriculture and Environmental Sciences, University of South Africa, Florida, South Africa

[2]Department of Plant and Soil Sciences, Faculty of Natural and Agricultural Sciences, University of Pretoria, Pretoria, South Africa

Corresponding author:
Thilivhali Tshikalange,
emmanuel.tshikalange@up.ac.za

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Background: In many African societies, men still rely on the long cultural history of utilising medicinal plants to treat and manage their sexual health.

Aim: The study evaluated biological activities of 10 ethnobotanically selected medicinal plants.

Setting: These plants are used traditionally to treat and manage men's sexual health in villages under the Thengwe Tribal Authority, Limpopo province.

Methods: Acetone extracts were investigated for their antioxidant activity, anti-inflammatory activity against 15-lipoxygenase, inhibition of nitric oxide production on RAW 264.7 macrophages and antimicrobial activity against *Neisseria gonorrhoeae* and *Candida albicans*. Phytochemical analysis was performed by determination of total flavonoid and total phenolic content.

Results: All the extracts investigated showed moderate to high content of flavonoids and total phenolic content. Cytotoxicity of the extracts was assessed using the XTT reduction assay against Vero monkey kidney cells. *Diospyros mespiliformis* extract was less toxic and showed significant antioxidant (IC_{50} = 8.34 µg/mL), anti-inflammatory (IC_{50} = 63 µg/mL) and antigonococcal (MIC = 0.39 mg/mL) activities. Extracts from *Garcinia livingstonei* and *Rhoicissus tridentata* also exhibited promising bioactivity. While these three extracts seem to inhibit the production of nitric oxide, the rest of the extracts seem to promote its production.

Conclusion: The findings of the study revealed that the selected plants possess biological activities directly and indirectly associated with men's sexual health.

Contribution: The investigated plants have potential therapeutic effects and can be used as leads in the development of new pharmaceuticals to manage men's sexual disorders.

Keywords: medicinal plants; nitric oxide; *Neisseria gonorrhoea*; *Candida albicans*; sexual health.

Introduction

In many African communities, the use of ethnobotanical indigenous knowledge is of vital importance in the management of men's sexual health. Because of the long history of use in various cultures and the present resurgence of interest in using natural products to maintain health globally, the use of medicinal plants in managing men's sexual disorders is beneficial. More investigation into the effectiveness of herbal treatments for men's sexual disorders is important as a method to acknowledge the benefits and functions of traditional medical knowledge in the delivery of healthcare (Kamatenesi-Mugisha & Oryem-Origa 2005). Medicinal plants are preferred over synthetic pharmaceutical drugs because of their availability, abundance, low cost and cause fewer or no side effects (Nasim, Sandeep & Mohanty 2022).

Erectile dysfunction (ED) is a major health issue forming a major part of sexual function disorders. According to Ajoa, Sibiya and Moteetee (2018), sexual dysfunction is 'characterized by the inability to achieve, keep and maintain a penile erection enough for stimulating coitus'. The drugs (e.g. sildenafil) that are currently used for the treatment of ED may cause serious side effects such as headaches, dizziness, indigestion, heartburn, and stuffy nose (Hatzimouratidis 2006). Medicinal plants are important natural sources of alternative treatment options for the management of male sexual health. These plants can be used in the discovery and development of drugs containing natural bioactive compounds with fewer or no side effects (Masuku, Unuofin & Lebelo 2020).

The optimal male sexual health includes the desire for sex and the ability to get and sustain erection. However, many risk factors such as sexually transmitted infections (STIs), diabetes,

surgery, smoking, alcoholism, high blood pressure, drugs, among others cause sexual dysfunction in males of all ages. Other endocrine disorders such as adrenal insufficiency, atherosclerosis, hypogonadism, and hypothyroidism are also responsible for ED (Goel & Maurya 2020).

Risk factors such as diabetes, hypertension and smoking adversely affect the activity of nitric oxide (NO) in penile tissue, which can lead to ED. Sexually transmitted infections such as chlamydia infect the prostate gland, leading to prostatitis, which can cause ED (Henkel 2021). Nitric oxide is thought to play a very critical role in penile erection physiology (Brunetti et al. 2020). This study aimed to investigate the biological activities of ethnobotanically selected medicinal plants in order to validate their traditional use and identify lead plants that could be further investigated for their potential benefits in men's sexual health.

Research methods and design

Sample preparation

The plant material (leaves, bark, and roots) was collected from villages in Thengwe (Coordinates: 22.6718° S, 30.5557° E). The voucher specimens were placed in the HGWJ Schweickerdt Herbarium of the University of Pretoria, where the identity of the plant species was confirmed. The plant material collected was air-dried in a well-ventilated room at room temperature and then finely ground into a powder using a laboratory mechanical grinder.

Preparation of extracts

Five grams of fine powder of each plant material was extracted using 100 mL of acetone for 48 h at room temperature. The extracts were filtered using Whatman No. 1 filter paper on a Buchner funnel. The collected filtrate was concentrated to dryness (under vacuum) using a rotary evaporator. The dried extracts were weighed, their percentage yield was determined, and stored in glass vials at 4 °C until use.

Determination of total flavonoid content

To determine total flavonoid content, a volume of 300 µL of ethanol was added to 100 µL of extract solution of 1 mg/mL concentration. After that, 20 µL of 10% aluminium chloride solution was added. Distilled water was then added to make up the solution up to 1 mL and incubated at room temperature. After 30 min of incubation, the absorbance was measured using a spectrophotometer at a wavelength of 450 nm. The total flavonoid content of the extracts was determined using a standard curve prepared with different concentrations of quercetin. The results were expressed as mg/g equal to quercetin.

Determination of total phenolic content

To determine total phenolic content, the Folin–Ciocalteu method was used as described by Adebayo et al. (2015). A volume of 250 µL of Folin–Ciocalteu reagent was added to 25 µL of extract solution of 1 mg/mL concentration. The mixture was incubated at room temperature for 5 min and thereafter 750 µL of 20% anhydrous sodium carbonate was added to terminate the reaction. Distilled water was added to make the volume up to 5 mL and the solution was incubated at room temperature (in the dark) for 2 h before the absorbance was then read at a wavelength of 760 nm. The total phenolic content of the extracts was determined using a standard curve prepared with different concentrations of Gallic acid. The results were reported as mg/g equivalent to Gallic acid.

Measurement of antioxidant activity

The DPPH (2,2-diphenyl-l-picrylhydrazyl) radical scavenging potential was measured as described by Lawal et al. (2020). The extracts and ascorbic acid (positive control) stock solutions were prepared to make concentrations of 10 and 2 mg/Ml, respectively. Thereafter, 20 µL of these samples were added to the first wells of a 96-well plate containing 200 µL of distilled water before serial dilution was performed to obtain a final concentration ranging from 3.9 µg/mL – 500 µg/mL for the extracts and 0.78 µg/mL – 100 µg/mL for the positive control. Methanol was also prepared in the same manner as the extracts to serve as a vehicle control. In each well, 90 µL of DPPH solution in methanol (0.04 M) was added; however, in those wells that serve as blanks (colour controls) methanol was added instead. The 96-well was then left in a dark room for 30 min before the absorbance was read using a microplate reader at 517 nm. The radical scavenging percentage was calculated using the following Equation 1:

$$(\text{Absorbance vehicle control} - \text{Absorbance sample})/\text{Absorbance vehicle control} \times 100 \quad \text{[Eqn 1]}$$

The GraphPad Prism 4 software was used to calculate IC_{50} values from percentage radical scavenging values.

Inhibition of nitric oxide production and viability of *lipopolysaccharide*-activated RAW 264.7 macrophages

The Murine RAW 264.7 macrophage cells obtained from the American Type Culture Collection (Rockville, Maryland, United States) were cultured in plastic culture flasks containing Dulbecco's modified Eagle's medium (DMEM) with L-glutamine, supplemented with 10% foetal calf serum (FCS) and 1% penicillium, streptomycin, and fungizone (PSF) solution. The cells were maintained at 37 °C under 5% CO_2 and split twice a week. The cells were seeded in a 96-well plate (40 000, well density) and incubated in a medium containing 5 µg/mL concentration of lipopolysaccharides (LPS). Thereafter, various concentrations of plant extracts were dissolved in 0.2% Dimethylsulfoxide (DMSO) and diluted with DMEM. Quercetin was used as a positive control while the untreated cells served as a negative control.

Determination of nitrate production

The NO produced by treated macrophages was assessed by determining the nitrate concentration in the culture supernatant with the use of Griess reagent. The 96-well plates were covered and incubated in the dark for 15 min. After incubation for 24 h, 100 µL of supernatant from each well was transferred into a new 96-well plate and Griess reagent of equal volume was added. The absorbance of resultant solutions in the plates was determined using a BIOTek Synergy Multi-Detention microplate reader after 10 min at 550 nm. The percentage inhibition by the extracts was calculated based on its ability to inhibit NO production by the cells. The cells in the media without the extracts (containing triggering agents and DMSO) were considered as 0% inhibition. The following equation was used to calculate the percentage inhibition of NO by the plant extracts (Equation 2):

$$100 - (\text{Absorbance}_{\text{extract}} - \text{Absorbance}_{\text{blank}}) / (\text{Absorbance}_{\text{negative control}} - \text{Absorbance}_{\text{blank}}) \quad \text{[Eqn 2]}$$

Determination of antimicrobial activity

The antimicrobial activity of the plant extracts was determined against a bacterial and a fungal pathogen associated with STIs. To ensure sterility, both pathogens were cultured in a fume hood and standard protocols were adhered to. The standard American Type culture collection strains (ThermoFisher, South Africa) of *Neisseria gonorrhoeae* (ATCC14018) and *Candida albicans* (ATCC 10231) were used. To make primary cultures, *N. gonorrhoeae* on GC chocolate Agar for 48 h at 37 °C in 5% CO_2. Tryptone Soya agar was used to culture *C. albicans* which was incubated for 24 h at 37 °C. For each pathogen, 24 h inoculum suspensions are prepared using Mueller-Hinton (MH) broth for *N. gonorrhoeae* and Tryptone Soya (TS) broth for *C. albicans*. To standardise the final concentration of the inocula, a spectrophotometer at wavelength of 600 was used. Both pathogens were inoculated in a sterile broth and prepared to a density of 1.5×10^5 colony forming units per mL (CFU/mL), which correspond to 0.5 McFarland Standard.

To determine the antimicrobial activity of the extracts, the microdilution method as described by Eloff (1998) was used to get the minimal inhibition concentrations (MIC) of extracts against Neisseria gonorrhoea and C. albicans. Briefly, 25 mg of each plant extracts was dissolved in 100 µL of 10% DMSO before adding 900 µL of broth to make a final concentration of 25 mg/mL (stock solution). The extracts and controls (samples) were tested in triplicate using a 96-well plate. Ciprofloxacin was used as the positive control while the negative controls included broth with microorganisms and 10% DMSO to ascertain if it does not affect the growth of the pathogen. In all the wells, 100 µL of a broth used to prepare inoculum suspension was added. A 100 µL of extract stock solution was added to the first row of the plate, where after two-fold serial dilutions were prepared. In each well, 100 µL of inoculum was then added. The plate was covered and incubated for at 37 °C for 24 h. The final concentrations of the extracts ranged from 0.004 mg/mL to 6.25 mg/mL, while the final concentration of the positive controls ranged from 0.005 mg/mL to 0.625 mg/mL. Microbial growth was determined a pink colour change after addition of 15 µL of PrestoBlue (viability reagent) to microplate wells and 15 min incubation periods. A blue colour indicated microbial inhibition (antimicrobial activity). The MIC values were determined visually and recorded for each extract and positive controls.

Nitric oxide scavenging

The extracts were investigated for their Nitric Oxide (NO) scavenging capacity using as described by Mayur et al. (2010) modified slightly. Twenty microliters of extract or ascorbic acid (positive control) reconstituted in ethanol was prepared to make a stock solution of 10 mg/mL concentration. Twenty microliters of stock solution were then added to the first well of a 96-microtitre plate to make serial dilutions to the final concentrations of 3.91 µg/mL – 500 µg/mL. Ten per cent of ethanol was in negative control in place of the extracts. Thereafter, a 50 µL of 10 mM sodium nitroprusside solution, which was prepared in distilled water, was added to all the wells. The plates were incubated at room temperature for 90 min before 100 µL of Griess reagent was added. Similarly control wells of extracts were prepared, but Griess reagent was replaced with distilled water. The plates absorbance was read at 546 nm using a 96-well plate reader. The percentage of scavenging capacity was calculated using Equation 3:

$$100 \times (A_c - A_s)/A_c \quad \text{[Eqn 3]}$$

where:

A_c = The absorbance of control
A_s = Is that of the samples.

Statistical data analysis

The experiments were conducted in triplicate and the results were expressed as mean ± standard deviation (s.d.). A GraphPad Prism 4 software was used to subject all data to one-way analysis of variance (ANOVA). Tukey's multiple comparison test was used to separate the means where a significant difference was observed ($p < 0.05$).

Ethical considerations

An application for full ethical approval was made to the University of South Africa, General Research Ethics Review Committee and ethics consent was received on 08 December 2017. The ethics approval number is 2017/CAES/078.

Results and discussion

Extracts yield and phytochemical analysis

The highest and the lowest percentage yield was observed with *Elaeodendron transvaalense* and *Rauvolfia caffra* with 26% and 2.2%, respectively. The rest of the plant extracts yields ranged between 2.7% and 23%. All the plant extracts investigated were found to be rich in flavonoids compounds

TABLE 1: Plant extract yield, phytochemical analysis, antioxidant and anti-inflammatory activity.

Plant extracts	Voucher specimen	Plant part	Yield (%)	TFC (mg/g QE)	TPC (mg/g GAE)	DPPH assay IC_{50} (µg/ml)	LOX assay IC_{50} (µg/mL)	NO assay IC_{50} (µg/mL)
Diospyros mespiliformis	PKT0094	Leaves	7.7	170	93.0	8.34 ± 2.18	63 ± 2.17	148.5
Elaeodendron transvaalense	PKT0071	Bark	26.0	116	197	106 ± 0.61	> 83	163.0
Garcinia livingstonei	MPT0021	Bark	23.0	60	420	6.86 ± 0.85	> 83	77.94
Pseudolachnostylis maprouneifolia	TE0218	Leaves	4.8	107	260	5.48 ± 2.17	67 ± 4.34	422.9
Rauvolfia caffra	MPT0080	Bark	2.2	25	170	14.39 ± 1.02	> 83	> 500
Rhoicissus tridentata	MPT0029	Roots	4.8	16	130	42.9 ± 2.16	> 83	450
Securidaca longepedunculata	PKT0152	Roots	14.0	17	142	117 ± 0.19	> 83	> 500
Strychnos madagascariensis	TE0222	Fruits	2.7	56	230	14.2 ± 0.68	> 83	> 500
Tabernaemontana elegans	MPT0079	Bark	2.8	90	374	131.3 ± 1.07	> 83	> 500
Wrightia natalensis	MPT0041	Roots	16.0	14	82	69.96 ± 1.07	> 83	> 500
Ascorbic acid	-	-	-	-	-	9.96 ± 2.04	-	30.0
Quercetin	-	-	-	-	-	-	29 ± 1.21	-

TFC, total flavonoid contents; TPC, total phenolic contents; DPPH, 2,2-Diphenyl-1-picrylhydrazyl; LOX, lipoxygenase; NO, Nitric oxide.

with values ranging from 16 to 170 mg/g QE. Similarly, the total phenolic content of all the plant extracts were significantly high with values ranging from 82–420 mg/mL GAE as shown in Table 1. A study by Cassidy, Franz and Rimm (2016) indicated that consuming more foods rich in flavonoids on a regular basis is linked to a lower occurrence of ED. Assessment of flavonoid classes showed that anthocyanins, flavanones, and flavones are associated with ED, indicating a specific characteristic of these particular subclasses.

Antioxidant activity

The antioxidant potential of the plant extracts was evaluated using the DPPH method. Extracts of *Garcinia livingstonei* and *Pseudolachnostylis maprouneifolia* exhibited the highest antioxidant activity with IC_{50} values of 6.86 ± 0.85 µg/mL, 5.48 ± 2.17 µg/mL, respectively (Table 1). Moderate antioxidant activity was observed in extracts from *Diospyros mespiliformis* (8.34 ± 2.18 µg/mL), *R. caffra* (14.39 ± 1.02 µg/mL) and *Strychnos madagascariensis* (14.39 ± 0.68 µg/mL), whereas the remaining plant extracts had low activity comparatively (varying from 42.9 ± 2.16 to 131.33 ± 1.07 µg/mL). The study conducted by Muriithi, Bojase-Moleta and Majinda (2016) reported a better than vitamin C antioxidant activity of benzophenone isolated from the twigs and stem wood of *G. livingstonei*. Oxidative stress and inflammation, which disrupt NO production directly or by causing resistance to insulin, are central determinants of vascular diseases including ED.

The majority of cases of ED are linked to risk factors for oxidative stress including diabetes, smoking, hypercholesterolaemia, and hypertension (Meldrum et al. 2012; Zhang et al. 2011). The use of antioxidant supplements is common in clinical settings and is considered a viable treatment for ED. According to a study by Su et al. (2022), the effect of antioxidant therapy alone on ED may be modest. However, the use of antioxidant compounds, the combination of PDE5 inhibitors, and antioxidants were linked to improve ED and can be viewed as an adjunctive therapeutic approach for ED. The combination of PDE5 inhibitors and antioxidants significantly improved the International Index of Erectile Function (IIEF) score (SMD = 1.1; 95% CI: 0.51, 1.68; *P* 0.001) and the sexual satisfaction score (SMD = 1.28; 95% CI: 0.06, 2.51; $p = 0.4$) when compared to the PDE5 inhibitors alone. Therefore, antioxidants may be helpful in treating disorders related to infertility in both men and women, including ED, according to a growing body of research.

Antioxidant-rich plants may benefit men's sexual health, while the association is not always clear-cut and may change based on personal circumstances. Antioxidants are substances that assist in shielding the body's cells from harm resulting from free radicals, which are unstable molecules that can cause a number of health problems, including problems related to sexual health. By lowering oxidative stress and protecting blood vessels, antioxidants can aid in enhancing blood flow. An erection can only be achieved and maintained with proper blood flow. Antioxidants shield the endocrine system, which helps maintain hormonal equilibrium. Hormone balance is essential for preserving sexual function and libido. By shielding sperm from oxidative damage, antioxidants may increase the fertility and quality of sperm. Antioxidants are beneficial to general health and well-being, both of which have a positive effect on sexual health (Ajao et al. 2018; Chauhan et al. 2014; Kyarimpa et al. 2023; Saikia et al. 2024).

15-lipoxygenase inhibition activity

Inflammation is a natural response of the body to injury or infection. It is characterised by redness, swelling, and pain. When inflammation occurs in the body, it can cause a variety of health problems, including ED. This is because inflammation can damage the blood vessels that supply the penis with blood, leading to reduced blood flow and difficulty achieving or maintaining an erection. Additionally, inflammation can cause hormonal imbalances that can lead to ED.

In this study, the plant extracts were evaluated for their inhibition activity against 15-lipoxygenase enzyme and their results are expressed in Table 1 as IC_{50} values. Extracts of *E. transvaalense*, *G. livingstonei*, *R. caffra*, *Rhoicissus*

tridentata, *Securidaca longepedunculata*, *S. madagascariensis*, *Tabernaemontana elegans* and *Wrightia natalensis* did not inhibit or show significant inhibition against 15-LOX as their IC_{50} values were greater than 83 µg/mL. Only *D. mesipiliformis* (63 ± 2.17 µg/mL) and *P. maprouneifolia* (67 ± 4.34 µg/mL) showed good inhibition against 15-LOX in comparison with positive control quercetin, which had IC_{50} value of 29 ± 1.21 µg/mL. Inhibition of 15-Lipoxygenase enzyme could potentially alleviate symptoms of ED by modulating inflammation and oxidative stress, which are known to contribute to ED. Oxidative stress has recently been found to play an important role in ED, which can be alleviated by antioxidant enzymes (Sheweita et al. 2020).

Plants with anti-inflammatory properties may have a positive impact on sexual health in men, indirectly, by addressing certain underlying health issues that can affect sexual function. Inflammation in the body can contribute to a variety of health problems, including those related to sexual health (Saeed et al. 2024).

Nitric oxide production inhibitory activity

LPS-activated RAW 264.7 macrophages were used to evaluate the NO production inhibitory activity of the plant extracts. As presented in Table 1, five of the plant extracts tested (*S. longepedunculata*, *S. madagascariensis*, *T. elegans*, *W. natalensis* and *R. caffra*) did not show NO inhibition capacity as their IC_{50} values were greater than 500 µg/mL. Extracts from *D. mespiliformis* (148.5 µg/mL), *E. transvaalense* (163 µg/mL), *G. livingstonei* (77.94 µg/mL), *P. maprouneifolia* (422 µg/mL) and *R. tridentata* (450 µg/mL) showed moderate to poor suppression of NO production when compared with positive control quercetin with IC_{50} value of 30.01 ± 0.7 µg/mL.

In men, NO reduction may exacerbate ED. A naturally occurring substance in the body, NO is essential to the physiological mechanisms that lead to and sustain an erection. It relaxes the blood vessels in the penis, increasing blood flow, by acting as a vasodilator. The erection is dependent upon this increased blood flow (Davies 2015). Low NO levels can cause the penis' blood vessels to dilate improperly, which would limit blood supply to the penile tissues. One common sign of ED is difficulty in getting or keeping an erection, which can be caused by decreased blood flow (Burnett 2006).

TABLE 2: Antimicrobial activity and cytotoxicity of plant extracts.

Plant extracts	Antimicrobial activity, MIC (mg/mL)		Cytotoxicity assay (IC_{50} µg/mL)
	N. gonorrhoeae	*C. albicans*	
Diospyros mespiliformis	0.39	6.25	Nd
Elaeodendron transvaalense	> 6.25	3.12	88 ± 1.04
Garcinia livingstonei	0.39	6.25	> 100
Pseudolachnostylis maprouneifolia	> 6.25	6.25	> 100
Rauvolfia caffra	> 6.25	> 6.25	Nd
Rhoicissus tridentata	0.39	6.25	> 100
Securidaca longepedunculata	> 6.25	> 6.25	Nd
Strychnos madagascariensis	> 6.25	> 6.25	Nd
Tabernaemontana elegans	6.25	> 6.25	21.5 ± 14.80
Wrightia natalensis	6.25	> 6.25	> 100

MIC, minimal inhibition concentrations; Nd, not detected.

Antimicrobial activity

Acetone extracts of the 10 medicinal plant samples were tested for their ability to inhibit *N. gonorrhoeae* and *C. albicans* using a microdilution method in order to determine their minimum inhibitory concentration (Table 2). According to the results, extracts from *D. mespiliformis*, *G. livingstonei* and *R. tridentata* have the highest antigonnococal with MIC of 0.39 mg/L, followed by extracts from *T. elagans* and *W. natalensis* with MIC of 6.25 mg/mL, respectively. The rest of the extracts exhibited an MIC greater than 6.25 mg/mL. When tested against *C. albicans*, all the plant extracts showed an MIC of greater or equal to 6.25 mg/mL except for *E. transvaalense* (3.12 mg/mL).

In a study by Sara et al. (2018), aqueous extracts of leaf and stembark of *D. mespiliformis* revealed high sensitivity against some pathogenic microorganisms including *Escherichia coli*, *Pseudomonas aeruginosa*, *Streptococcus pneumonia*, *Shigella* spp., *Staphylococcus aureus*, *Salmonella typhi* and *Streptococcus pyogenes*. Similarly, Adeniyi, Odelola and Oso (1996) reported broad spectrum antimicrobial activities of *D. mespiliformis* against Gram-positive, Gram-negative bacteria, and fungal strains. However, this study reports for the first antigonococcal activity of *D. mespiliformis*. Although myriad factors contribute to the development of ED, recent research has indicated that STIs may play a significant role in the onset of this condition.

Antimicrobial plants may provide a number of several health advantages, including an indirect benefit to men's sexual health. It is crucial to remember that there are a variety of intricate relationships between sexual health and antimicrobial plant qualities and not all antimicrobial plants will directly enhance sexual health. The prevention and treatment of illnesses is aided by antimicrobial plants, which is beneficial to general health. Sexual health problems or pain can occasionally result from infections, such as urinary tract infections or STIs. These plants can cure sexual health disorders indirectly by controlling and avoiding such illnesses (Lawal et al. 2019). In addition, several plants may include substances that affect circulation or hormone balance, which may have an impact on sexual health. For instance, ginseng and maca are two plants that are frequently linked to enhanced sexual performance and possible aphrodisiac properties. They may not have predominantly antibacterial modes of action, but they can nevertheless improve sexual and general health. It is critical to realise that a healthy lifestyle, stress reduction, regular exercise, and a balanced diet are all important components of sustaining excellent sexual health. Although certain plants possessing antimicrobial qualities can contribute

to a more comprehensive health strategy and indirectly enhance sexual health, they do not provide a direct or exclusive remedy for issues related to sexual health. It is best if you have particular queries or concerns about your sexual health.

Cytotoxicity assessment

The results indicated that extracts of *G. livingstonei*, *P. maprouneifolia*, *R. tridentata* and *W. natalensis* had the lowest cytotoxicity (IC_{50} > 100 µg/mL) on Vero Monkey kidney cell lines among those tested (Table 2). Extracts of *T. elegans and E. transvaalense* exhibited some toxicity with IC_{50} values of 21.5 and 88 µg/mL, respectively. Although extracts were not tested, previous studies have shown that these plants have relatively low to moderate toxicity on Vero cells (Canga et al. 2022; Lawal et al. 2019, Mohammed et al. 2016; Moroole et al. 2022; Tlhapi et al. 2020).

Conclusion

For ages, traditional remedies have been used to treat issues with male sexual health, such as ED, early ejaculation, and poor libido. It has been discovered that medicinal herbs used historically to treat and maintain male sexual health also contain bioactive chemicals that can enhance male sexual health. To promote overall sexual health, increase desire, and enhance male sexual performance, these botanicals may be used alone or in conjunction with other treatments. Further research is needed to fully understand the mechanisms of action of these bioactive compounds and their potential benefits for male sexual health.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

The authors, T.N., M.A.N. and T.E.T. designed the study, collected and analysed the data, and drafted the manuscript.

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Data availability

The data that support the findings of this study are available on reasonable request from the corresponding author, T.E.T.

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