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Review Article

Traditional Approaches to Treating Erectile Dysfunction in Africa

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Summary: Erectile dysfunction (ED) is an increasingly prevalent global health issue. Although FDA-approved medications like sildenafil are available, their use is often accompanied by undesirable side effects. Consequently, there is growing interest in traditional medicine as an alternative treatment option. This review provides a detailed mechanistic analysis of key African medicinal plants utilised for managing erectile dysfunction. Relevant literature was obtained from authoritative scientific databases, including PubMed, Scopus, Web of Science, and Google Scholar. Search terms such as "erectile dysfunction," "African medicinal plants," "traditional medicine," and "mechanisms of action" were used to identify pertinent studies. A systematic review was conducted to evaluate research on African medicinal plants with reported efficacy in ED treatment. Studies were selected based on scientific rigour, pharmacological investigations, and mechanistic insights into their bioactive compounds and therapeutic pathways. Several African medicinal plants have demonstrated potential in treating ED through mechanisms such as boosting nitric oxide synthesis, modulating enzymatic pathways (e.g., phosphodiesterase-5 inhibition), and enhancing blood circulation. While existing studies highlight their effectiveness, there remains a limited understanding of their precise molecular mechanisms and potential adverse effects. African medicinal plants offer a promising alternative for managing ED. However, further research, including mechanistic studies and clinical trials, is essential to establish their safety, efficacy, and pharmacokinetics. This review emphasises the importance of integrating traditional medicine into ED treatment strategies.

Keywords*: Erectile dysfunction, medicinal plants, herbal remedies, traditional medicine.*

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INTRODUCTION

Erectile dysfunction (ED) is a complex and widespread male sexual disorder that involves alterations in various erectile response components, including relational, psychological, and biological factors (Saffati *et al*. 2025). Also referred to as impotence, ED is characterized by the inability to achieve or sustain an erection sufficient for satisfactory sexual activity (Yafi *et al*. 2016). It remains a significant global health concern, commonly linked to factors such as aging, diabetes mellitus, smoking, cardiovascular diseases, kidney disease, previous surgeries, psychological conditions, and medication use (Birowo *et al*. 2019). Historically, approximately 52% of ED cases were reported among men aged 40 to 70 years (Mobley *et al*. 2017). However, recent studies indicate a growing prevalence of ED among men under 40 years (Nguyen *et al*. 2017).

In Africa, about 71.45% of individuals with diabetes are affected by ED (Shiferaw *et al*. 2020). In Ethiopia, around 60.4% of diabetic patients have been reported to experience varying degrees of ED, with many not receiving any form of treatment (Hurisa *et al*. 2020). The global incidence of ED is projected to rise to 322 million cases by 2025 (Aydin *et al*., 2020). Non-pharmacological approaches for managing ED include controlling blood glucose and lipid levels, avoiding smoking and alcohol consumption, engaging in psychological therapy, participating in physical exercise, and utilizing external devices (Wassersug *et al*., 2017).

Pharmacological treatments for ED involve various drug options, including phosphodiesterase type 5 inhibitors (PDE5-Is) such as sildenafil, vardenafil, and tadalafil, as well as apomorphine, synthetic prostaglandin E1 (alprostadil), phentolamine, and papaverine (Diniz *et al*. 2020). Among these, PDE5-Is are the most commonly recommended first-line treatments worldwide. However, due to the widespread expression of phosphodiesterase type 5 genes in multiple tissues, PDE5-Is are associated with adverse effects such as headaches, myalgia, facial flushing, heartburn, nasal congestion, and vision disturbances. Additionally, conditions that impair nitric oxide pathways have been linked to reduced treatment efficacy (Kim *et al*. 2021).

It is crucial to explore herbal remedies that can help address the limitations of conventional treatments. The causes of erectile dysfunction (ED) vary among individuals and involve nerve impulses from the brain, spinal cord, and areas surrounding the penis, as well as responses from muscles, fibrous tissues, veins, and arteries in and around the corpora cavernosa (NIH 2004). Damage to nerves, arteries, smooth muscles, and fibrous tissues is often linked to diseases such as diabetes, kidney disease, chronic alcoholism, multiple sclerosis, atherosclerosis, vascular disease, and neurological disorders, accounting for approximately 70% of ED cases (NIH 2004). According to the National Institutes of Health (NIH), between 35% and 50% of men with diabetes experience ED (NIH 2004). Additionally, several commonly used medications, including antihypertensives, antihistamines, antidepressants, tranquilizers, appetite suppressants, and cimetidine (a drug used for ulcers), have been reported to contribute to ED as a side effect (NIH 2004).

Psychological factors, including stress, anxiety, guilt, depression, low self-esteem, and fear of sexual failure, are responsible for 10% to 20% of ED cases. Furthermore, men with a physical cause for ED often experience secondary psychological effects such as stress and anxiety (SFHC 2004). Other contributing factors include smoking, which impairs blood circulation in veins and arteries, as well as hormonal imbalances such as testosterone deficiency (SFHC 2004). Modern treatments for ED, including the widely used Viagra (sildenafil), have proven effective, but they are not suitable for all patients. Sildenafil is ineffective in nearly 30% of men with varying causes of ED and is associated with adverse effects (SFHC 2004). Although testosterone therapy can help some men with low testosterone levels, its effectiveness is limited, and it may cause liver damage (SFHC 2004). Other pharmacological options, such as yohimbine, papaverine hydrochloride (administered under strict medical supervision) (Evans, 2009), phentolamine, and alprostadil (marketed as Caverject), work by dilating blood vessels. However, the high cost of modern ED treatments makes them inaccessible to many individuals, particularly in rural areas of developing countries. In contrast, traditional medicine has long relied on medicinal plants to manage ED, yet much of this ethnobotanical knowledge remains undocumented and scientifically unverified in northern African countries, with a focus on ethnobotanical aspects rather than socio-cultural factors.

Certain herbal remedies with established therapeutic benefits, such as Prunus africana, which is used to treat male genital hypertrophy, suggest that some medicinal plants may be potent despite limited research (Kamatenesi-Mugisha & Oryem-Origa, 2005). However, many herbal treatments for male reproductive health remain under-researched and undocumented. If these traditional treatments are not recorded, valuable indigenous knowledge (IK) related to sexual impotence and ED may be lost (Hutchings and Scott 1996). The Convention on Biological Diversity (CBD) highlights the importance of protecting indigenous cultures and traditions (Article 8 of CBD), emphasizing that national policies should respect, preserve, and promote the knowledge, innovations, and practices of indigenous and local communities that contribute to biodiversity conservation and sustainable use. The United Nations Environment Program (UNEP) has urged nations to take immediate action to protect indigenous knowledge and cultural heritage.

Approximately 72% of medicinal plants used to manage ED are harvested from the wild. Despite this, the use of traditional medicine is increasing in developed countries (Abdullahi 2011). The global demand for herbal remedies is expected to continue rising, especially with the World Health Organization (WHO) monitoring alternative medicines under its Traditional Medicine Strategic Plan (2002–2005) (David *et al*. 2015). Many medicinal plants have demonstrated efficacy in treating various diseases or have served as sources for pharmaceutical drug development. These efforts are informed by diverse sources, including rainforest biodiversity, forest-dwelling animals, and insights from traditional healers. However, the uncontrolled harvesting of medicinal plants from forests, national parks, and reserves, such as those in QEBR, is a growing concern, as there are no sustainable mechanisms for propagation. The collection of plant parts, particularly roots and stems from wild medicinal species, threatens the survival of these species unless conservation and domestication strategies are implemented.

There is a need for robust conservation strategies targeting medicinal plants with pharmaceutical potential, drawing on indigenous knowledge from local communities. For example, medicinal plants identified in this study, including Warburgia ugandensis and Cirtopsis articulata, which are used to treat ED and sexual impotence, should be prioritised for conservation due to their high demand and medicinal significance. As biotechnology advances and genetically modified organisms become more prevalent in agriculture, healthcare, and environmental management, many indigenous populations continue to rely on natural products (Abdullahi, 2011). Interest in traditional medicine is increasing worldwide, with both developed and developing nations investing in research on natural remedies.

Medicinal plants used for male reproductive health conditions remain highly relevant for present and future generations. The longstanding use of herbal remedies for managing ED and sexual impotence underscores their significance. Collaboration between modern healthcare professionals and traditional healers, as well as partnerships with NGOs like Rukararwe in Bushenyi, which oversees the use of herbal treatments for ED, is essential. The Uganda Ministry of Health, through its Natural Chemotherapeutics Research Laboratory in Wandegeya, has played a key role in promoting traditional medicine. Additionally, public-private partnerships in healthcare delivery, along with collaboration among researchers in herbal medicine, should lead to the establishment of policies integrating traditional medicine as a viable healthcare option in Nigeria. Herbal remedies suitable for African populations should be explored, provided they receive approval from regulatory bodies such as the National Drug Authority. ED and sexual impotence remain silent health concerns among African men, warranting further research into the safety and efficacy of traditional herbal treatments for these conditions in Nigeria.

Although congenital impotence is rare, the prevalence of erectile dysfunction increases with age. According to Pfizer, approximately 40% of men over 40, 50% of men over 50,

and 60% of men over 60 are affected by ED (David *et al*., 2015). The condition significantly impacts psychological well-being, contributing to low self-esteem, depression, strained relationships, and diminished life satisfaction (David *et al*., 2015). Ageing is a primary risk factor for ED, alongside social determinants such as high unemployment rates and health conditions including diabetes, hypertension, HIV/AIDS, hypercholesterolemia, stress, smoking, and obesity (David *et al*., 2015). ED is increasingly becoming a serious concern in Nigerian households, particularly among middle-aged and older men. Proper diagnosis and treatment are necessary for those affected.

From a conservation perspective, the demand for medicinal plants is expected to grow as more individuals seek natural health solutions (Kessler *et al*. 2019). A study by Iwalewa *et al*. (2019) revealed that over 72% of medicinal plants used for ED treatment are harvested from the wild, highlighting the increasing reliance on traditional medicine, even in developed nations (Iwalewa *et al*., 2019). Numerous African medicinal plants from various genera and families, with diverse chemical constituents, have been documented to exhibit aphrodisiac and sexual-stimulant properties (Koloko, pers. comm.). Each African country has its own collection of locally produced, plant-based sexual stimulants marketed under different trade names, including Impotex, TigerPower, SuperLove, uBangalala, and Burantashi (Sawicka *et al*. 2020). Many such traditional, plant-derived remedies are widely used across African nations to treat erectile dysfunction (ED) effectively. Among them, the Zulu people of South Africa have historically utilized the roots of Eriosema species to manage erectile dysfunction and impotence. Specifically, plants within the Eriosema genus are categorized under the Zulu indigenous term "uBangalala," with most species under this designation being employed for treating impotence (Ojewole 2007).

Traditional preparation involves hot milk infusions or pounded, boiled root decoctions of Eriosema roots, which are consumed in small amounts in the morning and at night for impotence treatment (Hutchings & Scott, 1996). Similar to how consuming oral Viagra with a fatty meal delays its absorption, taking Eriosema root infusions or decoctions with milk may slow the bioactive compound uptake in the gastrointestinal tract, thereby extending their duration of action. It has been suggested that for optimal results, milk infusions and decoctions of Eriosema kraussianum roots should be ingested two to four hours before expected sexual activity, with reported effects—such as achieving and maintaining an erection sufficient for penetration—lasting four to six hours post-administration (Drewes, pers comm.). However, unlike Viagra, the pharmacokinetic parameters of E. kraussianum, including bioavailability, half-life, Tmax, and Cmax, remain largely unknown, as do its effects on cGMP and PDE-5 activity.

In many developing African countries, economic limitations make widespread access to modern medical care difficult. Consequently, herbal medicines and plant-based treatments serve as practical alternatives for managing ED in rural, peri-urban, and some urban communities. Recent research has identified E. kraussianum NE Br. (Fabaceae) as a promising South African plant with potential therapeutic efficacy for impotence and ED (Drewes *et al*., 2002). Experimental studies in a rabbit model have suggested that the bioactive compounds in *E. kraussianum* may provide significant therapeutic benefits for erectile dysfunction. The psycho-social advantages of using such traditional plant-based remedies in rural African communities are considerable. Since men with ED of organic, psychogenic, and mixed origins have shown positive responses to Viagra, it is hypothesized that *E. kraussianum* extracts could serve as an effective Viagra alternative for South African men suffering from erectile dysfunction.

FREQUENTLY USED MEDICINAL PLANTS IN AFRICA

The most frequently cited plant species in the study included *Asparagus africanus Lam*. (8 citations), *Ricinus communis L*. (6 citations), and *Carissa spinarum L*. (4 citations), while *Ferula communis L*., *Aloe macrocarpa Tod*., and *Tragia brevipes* Pax each received three citations. Similar to the findings of this study, the root of *Asparagus africanus Lam*. is traditionally utilized in Nigeria for managing erectile dysfunction (ED) (Yakubu & Afolayan, 2009). The effectiveness of this plant in treating ED may be attributed to its saponin content (Mashele, 2019), as plant species rich in saponins have demonstrated significant effects in promoting erection (Pratap, 2012). Recent in vivo studies on Ricinus communis (castor bean) have confirmed its ability to elevate serum testosterone levels and enhance multiple indicators of sexual activity, reinforcing conventional claims about its efficacy (Tajuddin *et al*., 2003). In South and Central Benin, *Carissa spinarum* root is traditionally used to address sexual weakness, emphasising the need for scientific validation of this species to uncover potential therapeutic leads against ED.

Several plant species, including *Syzygium aromaticum L*., *Zingiber officinale* Roscoe, and *Gloriosa superba L*., are traditionally employed in Ethiopia for their purported aphrodisiac properties (Schmidt, 2017). Research has demonstrated that a 50% ethanolic extract of *Syzygium aromaticum L*. (administered orally at doses of 100, 250, and 500 mg/kg in rats) enhanced libido, erection, intromission frequency, mounting behaviour, and mating performance (Tajuddin *et al*., 2004). Furthermore, hexane extracts of *Syzygium aromaticum (L.) Merr*. and Perry (clove) (oral; 15 mg/kg in mice) increased delta (5) 3-beta and 17-beta-hydroxysteroid dehydrogenase (Δ5, 3β-HSD, and 17β-HSD) activity and raised serum testosterone levels (Mishra and Singh, 2008). Similarly, an aqueous extract of *Zingiber officinale* (oral; 600 mg/kg in male Wistar rats) exhibited androgenic activity by increasing testis relative weight, serum testosterone, testicular cholesterol, and epididymal α-glucosidase activity (Kamtchouing *et al*., 2002). Additionally, aqueous, chloroform, and alcohol extracts of *Gloriosa superba* at a dose of 500 mg/kg body weight displayed aphrodisiac properties by enhancing sexual and orientation behaviour, likely due to the presence of steroids, saponins, and alkaloids (Pare *et al*. 2004). These findings provide scientific support for the traditional use of these plant species in treating sexual dysfunction in Ethiopia.

However, traditional plant-based remedies in Ethiopia face significant threats due to deforestation, overgrazing, environmental degradation, agricultural expansion, and population growth (Yeshiwas *et al*. 2019). These challenges

put medicinal plants at risk of extinction, potentially eliminating valuable compounds crucial for addressing global health concerns. Consequently, early pharmacological investigations into the reported plant species for their efficacy against ED are strongly recommended.

PROMISING MEDICINAL PLANTS FOR THE TREATMENT OF MALE ERECTILE DYSFUNCTION IN NIGERIA

Plants contain a diverse range of phytochemicals, including alkaloids, terpenoids, steroids, and polyphenols (Yadav and Agarwala, 2011). Among these, polyphenols have garnered significant attention for their potential therapeutic effects. Polyphenols are recognized for their antioxidant, antibacterial, antiviral, anticancer, antidiabetic, anti-inflammatory, and antimutagenic properties (Curti *et al*. 2017) and are abundantly found in fruits, vegetables, teas, nuts, seeds, wines, and coffee (Xiao 2018). Examples of polyphenols include tannins, phenolic acids, stilbenoids, catechins, procyanidins, and flavonoids (Xiao 2018). Despite their potential protective effects on the vascular endothelium against reactive oxygen species (ROS)-induced damage (Eleazu *et al*. 2017), research on the role of polyphenols in alleviating erectile dysfunction (ED) remains limited. Various studies have explored the medicinal properties of plants and their mechanisms of action in treating male sexual dysfunction.

Arctium lappa L.: Belonging to the Compositae family, *Arctium lappa L*., commonly known as burdock, has traditionally been used to treat ailments such as sore throat and dermatitis. The plant exhibits several physiological health benefits, including anti-inflammatory, antiviral, antitumor, and antidiabetic properties (Chan *et al*. 2011). Additionally, *A. lappa* has been utilized as a sexual stimulant and for the treatment of infertility and ED (JianFeng *et al*. 2012). A study by Jian Feng (JianFeng *et al*. 2012) assessed the aphrodisiac effects of aqueous root extracts of *A. lappa* (300, 600, and 1200 mg/kg) in adult male Sprague-Dawley rats administered orally for seven days. The extract significantly increased the frequencies of mounting, intromission, and ejaculation, as well as serum testosterone levels. The study attributed the aphrodisiac effects to bioactive compounds, including saponins, lignans, flavonoids, and alkaloids, which act through central and peripheral mechanisms. However, no clinical trials have evaluated the safety, efficacy, and tolerability of *A. lappa* in men with ED.

Anogeissus leiocarpus: *A. leiocarpus*, a member of the Combretaceae family and commonly referred to as African birch (Bello and, Jimoh, 2018), has been traditionally used for treating dermatitis, stomach ailments, cough, snake and scorpion bites, diarrhea, jaundice, liver inflammation, headache, toothache, respiratory diseases, diabetic ulcers, syphilis, and ED (Bello and, Jimoh, 2018; Govindarajan *et al*., 2006). Ademosun *et al*. (2019) investigated the protective effects of *A. leiocarpus* stem bark extract (50 and 100 mg/kg) against paroxetine-induced sexual dysfunction in male Wistar rats over 21 days. The extract inhibited acetylcholinesterase (AChE), phosphodiesterase-5 (PDE5), and arginase activities significantly enhancing antioxidant activity and nitric oxide levels. The findings suggest the potential use of *A. leiocarpus* for ED treatment, though its inhibitory effects on AChE, PDE5, and arginase in human subjects remain unexplored.

Asteracantha longifolia (L.) Nees: *Asteracantha longifolia (L.) Nees*, from the Acanthaceae family, is traditionally used to treat rheumatic arthritis, kidney infections, jaundice, edema, and gout and as an aphrodisiac (Chauhan and Dixit 2010). The plant contains bioactive compounds such as isoflavone glycoside, stigmasterol, lupeol, fatty acids, and alkaloids (Chauhan and Dixit 2010). Chauhan *et al*. (2011) investigated the aphrodisiac effects of ethanolic seed extracts of *A. longifolia* (100, 150, and 200 mg/kg) in albino male rats. , 1After 28 days of oral administration, treated rats exhibited increased mount frequency (MF) and reduced mount latency (ML), indicating enhanced copulatory behavior. The study supports the traditional use of *A. longifolia* in boosting sexual desire; however, clinical trials evaluating its safety and efficacy in men with ED are lacking.

Bulbine natalensis (Baker): *Bulbine natalensis (Baker)*, a member of the Asphodelaceae family, is known as rooiwortel (Afrikaans), ibhucu (Zulu), and ingcelwane (Xhosa). Traditionally, it has been used to treat wounds, rashes, ringworm, chapped lips, diarrhea, vomiting, diabetes, sexually transmitted diseases, and arthritis (Yakubu and Afolayan 2009). Yakubu and Afolayan (2009) examined its aphrodisiac potential, administering aqueous extracts of *B. natalensis* stem (25, 50, and 100 mg/kg) orally for seven days in Wistar male rats. The extract enhanced mating behavior, penile erection, and increased testosterone and luteinizing hormone levels. Another study by Yakubu and Afolayan (2010) found that the extract (administered at 25, 50, and 100 mg/kg for 1, 3, and 7 days) elevated serum gonadotropin (FSH and LH) and testosterone levels, except at higher doses. The plant contains tannins, anthraquinones, phenolics, cardiac glycosides, flavonoids, steroids, alkaloids, caffeine, triterpenes, and phlobatannins (Yakubu and Afolayan 2009). While *B. natalensis* appears promising for sexual dysfunction management, no clinical trials have been conducted to assess its effects in human participants.

Camellia sinensis: *Camellia sinensis (L.) O. Kuntze*, commonly known as the tea plant, belongs to the Theaceae family. Its three main forms—green, black, and oolong tea—have been recognized for their medicinal properties, including antilisterial and aphrodisiac effects (Ratnasooriya and Fernando, 2008). The aphrodisiac activity of *C. sinensis* (black tea) was first validated by Ratnasooriya and Fernando (2008), where aqueous tea extract (84, 167, and 501 mg/mL) administered orally to male rats for three hours enhanced sexual excitement and copulation. Additionally, an 84 mg/mL aqueous extract administered orally for 30 minutes improved penile erection. Further, daily administration of 84 mg/mL extract for three days increased serum testosterone levels in male rats. These findings suggest that *C. sinensis* (black tea) is a safe and effective agent for mitigating sexual dysfunction (Ratnasooriya and Fernando 2008). However, no clinical studies have yet been conducted to evaluate its efficacy and safety in humans.

Cinnamomum cassia: *Cinnamomum cassia*, a member of the Lauraceae family, is commonly used in powdered form as a food flavor enhancer and has traditionally been used to

treat conditions like arthritis, diarrhea, edema, erectile dysfunction (ED), and to improve sexual performance (Zeng *et al*., 2017). Goswami *et al*. (2014) explored the erectogenic and sexual-stimulating effects of a methanol extract from *C. cassia* bark in young Wistar male rats. in vitro, treatment with 50 mg/kg of the methanol extract inhibited arginase enzyme activity in rats, which is essential for penile erection, leading to increased arginine levels in penile smooth muscle and higher cGMP levels, thereby promoting penile erection. The extract (0.1–100 μg/mL) also caused dose-dependent relaxation of isolated rat corpus cavernosum smooth muscle. Moreover, oral administration of 100 mg/kg for 28 days improved smooth muscle content and reduced collagen in penile tissue, enhancing copulation behaviour. The study concluded that *C. cassia* may help alleviate ED and supports its use in Ayurvedic medicine as a sexual stimulant, though clinical studies to validate its efficacy and safety are lacking.

***Crocus sativus L.* – Saffron:** Saffron, derived from the dried red stigmas of *Crocus sativus L.*, is a spice traditionally used as an aphrodisiac to treat erectile dysfunction (ED (Mohammadzadeh-Moghadam *et al*. 2015). A clinical study by Shamsa *et al*. (2009) examined the effectiveness of saffron in 20 male patients aged 26 to 62 years with ED. The participants were given a 200 mg saffron tablet daily for 9 days, followed by a double dose on day 10. The nocturnal penile tumescence and IIEF tests revealed that saffron significantly enhanced tip and base rigidity and tumescence, as well as improved the IIEF score. In another study, the effects of saffron gel on ED were tested in diabetic men; 50 male patients were randomized to receive either saffron gel or a placebo, and the IIEF was used to assess efficacy before and after one month of treatment. In all studies, saffron demonstrated significant improvements in ED. Further research with a larger sample size is necessary to confirm its safety and efficacy.

Curcuma longa Linn: *Curcuma longa Linn*., also known as turmeric, belongs to the Zingiberaceae family and is used in traditional medicine to treat conditions such as stomach pain, cancer, skin diseases, diabetes, and as an appetite stimulant. The active compound curcumin is noted for its effects on penile erectile response (Abdel Aziz *et al*. 2010). Oral administration of pure curcumin (10 mg/kg), water-soluble curcumin (2 mg/kg), and water-soluble curcumin (10 mg/kg) to albino male rats for various periods (24 h, 48 h, and 1 week) resulted in significantly increased cGMP and heme oxygenase-1 (HO-1) activity, both involved in penile erectile mechanisms (Abdel Aziz *et al*. 2010). However, no clinical trials have investigated whether curcumin has the same effect in humans or evaluated its safety and efficacy.

Cyperus esculentus L.: *Cyperus esculentus L*., commonly known as tiger nut or "Hab Al-zulom" in Arabic, is part of the Cyperaceae family (Allouh *et al*., 2015). Traditionally, it has been used as an aphrodisiac to improve sexual activity and treat erectile dysfunction (ED) (Olabiyi *et al*., 2017). Allouh *et al*. (2015) demonstrated that daily oral consumption of 1–2 g/kg of raw *C. esculentus* powder for 30 days significantly increased testosterone levels and sexual activity in male rats. Phytochemical analysis identified vitamin C, vitamin E, quercetin, and zinc in the methanol extract, which may contribute to these effects. Additionally, Olabiyi *et al*. (2017) found that a 20% raw C. esculentus diet for 14 days reduced arginase, AChE, and adenosine deaminase activities, while increasing nitric oxide production and improving erectile responses. However, clinical studies validating its safety and efficacy for ED in humans are absent.

Epimedium sagittatum

Epimedium sagittatum, known as "horny goat weed," is used traditionally in treating conditions like cancer, osteoporosis, cardiovascular diseases, and ED (Hsueh *et al*., 2013). The active compound, icariin, has been shown to help treat ED (Wang *et al*., 2017; Chen *et al*. 2014; Shindel *et al*. 2010). Animal studies, including one by (Liu *et al*. 2005), demonstrated that oral icariin (1 and 5 mg/kg) increased the expression of inducible and neuronal nitric oxide synthase isoforms and inhibited PDE5 activity, suggesting its potential for ED treatment. Moreover, icariin administration (50 and 100 mg/kg) for 35 days in Sprague-Dawley rats significantly elevated testosterone levels and enhanced antioxidant activity (Chen *et al*. 2014). Additional compounds from *E. sagittatum* also showed PDE5 inhibitory effects comparable to sildenafil and tadalafil, supporting its potential as a natural ED treatment (Chen *et al*. 2009). While promising, clinical trials to assess its safety and effectiveness in humans are yet to be conducted.

Eurycoma longifolia Jack, also known as Tongkat ali, belongs to the Simaroubaceae family. It is commonly used to address infertility, act as an adaptogen, and enhance sexual energy (Ismail 2003). Multiple clinical studies have demonstrated that Tongkat ali can improve erectile function by increasing sexual desire and testosterone levels (Thu *et al*. 2017). In a study by Tambi *et al*. (2011), 76 male patients aged 28 to 70 years with low-onset hypogonadism were given a daily dose of 200 mg (2 capsules containing 100 mg each) of Tongkat ali extract for one month. The Aging Male's Symptoms (AMS) rating scale and blood testosterone levels were used to assess the participants. The results showed that Tongkat ali improved the AMS of the patients (71.7% reported no complaints), and 90.8% had normal testosterone levels (6–30.0 nM). In another clinical trial, 26 healthy male participants aged 40 to 65 years received a daily 200 mg (1 tablet) dose of freeze-dried water extract of *E. longifolia* (Physta) for 12 weeks. The treatment significantly improved sexual performance, including erectile function, compared to the placebo. Further clinical studies with larger participant groups are needed to assess its safety and effectiveness (Tambi *et al*. 2011).

Ficus capensis: *ficus capensis Thumb*, from the Moraceae family, has been used medicinally for conditions such as diarrhea, gonorrhea, ulcers, and male infertility (Esievo *et al*., 2018). Akomolafe *et al*. (2016) investigated the potential anti-ED effects of an aqueous extract of *F. capensis* leaves on penile tissue from male Wistar rats. The study found that the extract reduced acetylcholinesterase (AChE), angiotensin-I-converting enzyme (ACE), and arginase activity in a dose-dependent manner. Additionally, the extract inhibited nitric oxide (NO) and hydroxyl radicals and prevented iron-induced lipid peroxidation. Phytochemical analysis revealed the presence of various bioactive compounds, suggesting that *F. capensis* may help mitigate ED. However, clinical trials to assess its safety and efficacy in humans are lacking.

Garcinia kola: *Garcinia kola*, a member of the Clusiaceae family, is known as bitter kola and has been used in treating diabetes, liver diseases, diarrhea, and sexual dysfunction (Yakubu and Quadri 2012). It has also been traditionally used to treat ED (Sewani-Rusike *et al*. 2016). Sewani-Rusike *et al*. (Sewani-Rusike *et al*. 2016). found that oral administration of a 70% ethanolic extract of *G. kola* seeds (100, 200, and 400 mg/kg) for 56 days increased sexual desire, penile erection, serum testosterone levels, and spermatogenesis in male rats. However, clinical trials validating its safety and efficacy in treating sexual dysfunction, including ED, are not available.

Ginkgo biloba: *Ginkgo biloba*, or Maidenhair tree, is traditionally used to treat depression and improve ED by stimulating the release of endothelial nitric oxide (NO), which causes vasodilation and increases blood flow (West & Krychman, 2015). Yeh *et al*. (2008) confirmed the sexual-stimulating effects of Ginkgo (EGb 761) by showing that it increased testosterone production in rat Leydig cells. Oral administration of EGb (50 mg/kg) for 28 days and 100 mg/kg for 14 and 21 days in male rats improved mating performance. However, no changes were observed in serum testosterone or dopamine levels after 28 days. Despite promising animal studies, clinical trials investigating Ginkgo's safety and efficacy in humans remain absent.

Gloriosa superba L.: *Gloriosa superba L*., from the Liliaceae family, has been used to treat gonorrhoea, rheumatic arthritis, ED, and other conditions (Yeh *et al*. 2008). Colchicine and colchicoside alkaloids from *G. superba* are known to heal gout and induce muscle relaxation (Arumugam *et al*. 2015). The aphrodisiac effect of *G. superba* was demonstrated in a study by Pare *et al*. (2004) where oral administration of aqueous and olive oil extracts increased testosterone levels and copulatory performance in male rats. However, no clinical trials have yet assessed the safety and efficacy of *G. superba*'s aphrodisiac activity.

Hunteria umbellate: *Hunteria umbellata*, part of the Apocynaceae family, is used in folk medicine for treating anemia, diabetes, edema, and male infertility (Adeneye *et al*. 2019). Oboh *et al*. (2019) demonstrated that oral administration of *H. umbellata* (50 and 100 mg/kg) for 28 days decreased PDE5, ACE, and AChE activity in Wistar rats. Additionally, a study showed that daily administration of *H. umbellata* for 60 days increased serum LH, FSH, and testosterone levels in male rats, suggesting its potential for treating ED. However, clinical studies are yet to validate its safety and efficacy in humans.

Massularia acuminata: *Massularia acuminata*, from the Rubiaceae family, is used as an aphrodisiac. Yakubu and Akanji (2011) reported that oral administration of aqueous extracts of *M. acuminata* stem (250, 500, and 1000 mg/kg) for 5 days increased libido, copulation, and serum testosterone in male rats. The plant's sexual stimulating effects are attributed to its bioactive compounds, such as flavonoids, saponins, and alkaloids, which possess androgenic and antioxidant properties (Yakubu *et al*. 2008).

Microdesmis keayana: *Microdesmis keayana*, a member of the Pandaceae family, is used as an aphrodisiac (Zamblé *et al*. 2008). The sexual-stimulating activity of its aqueous root extract was demonstrated by Zamblé *et al*. (Zamblé *et al*. 2008), who found that oral administration of the extract (150 mg/kg) and pure alkaloids (3 mg/kg) increased mating performance in Wistar rats. The plant acts as a vasodilator, enhancing NO production for penile erection. However, the safety and effectiveness of M. keayana extracts have not been tested in clinical studies.

Moringa oleifera Lam: *Moringa oleifera Lam*, known as drumstick, is part of the Moringaceae family. Phytochemical analysis of its aqueous leaf extract revealed the presence of compounds such as gallic acid, catechin, and quercetin (Oboh *et al*. 2015). A study demonstrated that *M. oleifera* extract (10, 50, and 250 mg/kg) alleviated stress-induced ED in male rats by reducing PDE-5 activity and improving testosterone levels and mating behavior (Prabsattroo *et al*. 2015). Another study showed that oral administration of *M. oleifera* seed extract (100, 200, and 500 mg/kg) increased libido and copulation in male rats (Zade *et al*. 2013). Clinical studies evaluating its safety and efficacy are yet to be conducted.

Myristica fragnans: *Myristica fragnans*, or nutmeg, from the Myristicaceae family, is used in food and medicine for conditions like stomach pain and rheumatoid arthritis (Izah *et al*. 2018). Nutmeg has been reported to have aphrodisiac effects (Odubanjo *et al*. 2018). A study by Odubanjo *et al*. (Odubanjo *et al*. 2018) showed that oral administration of nutmeg seed extract (100, 200, 300, and 400 µg/mL) suppressed PDE-5, arginase, AChE, ACE, and oxidative damage in penile tissue, indicating potential benefits for ED.

Ocimum gratissimum Linn: *Ocimum gratissimum Linn*, a member of the Lamiaceae family, is used to treat headaches, stomach pain, diarrhea, and other ailments (Fofie *et al*. 2014). It is also used to address male sexual dysfunction. Ojo *et al*. (2019)] found that aqueous extracts of *O. gratissimum* leaves (20–100 µg/mL) reduced arginase and AChE activities in the penile and testicular tissues of male rats, suggesting its potential in treating ED.

Panax ginseng: *Panax ginseng* is a member of the Araliaceae family, with its root and rhizome extract traditionally used as an aphrodisiac to enhance penile erection and sexual activity (Wang *et al*. 2010). Patients with erectile dysfunction (ED) were advised to take 350 mg of standardized Korean ginseng berry (SKGB) tablets four times daily for 8 weeks. Penile response and early ejaculation were measured after four and eight weeks, respectively. The results showed minor improvement in penile erection and early ejaculation, confirming that ginseng can support male sexual function (Choi *et al*., 2013). Andrade *et al*. (2007) further supported this in their study, in which they evaluated Korean Red Ginseng (KRG) in 60 patients with mild-to-moderate ED. Patients who took 1000 mg of KRG three times daily showed significant improvements in their IIEF scores and overall erectile function (Andrade *et al*., 2007). However, more extensive research with a larger sample size is required to fully confirm its safety and efficacy.

Pseudopanax arboreus: *Pseudopanax arboreus*, or five fingers, from the Araliaceae family, has biological properties such as anti-inflammatory, antioxidant, and aphrodisiac effects (Maghsoumi-Norouzabad *et al*. 2016). Besong *et al*. (2019) showed that oral administration of

methanol extract of *P. arboreus* leaves (46.5 and 93 mg/kg) for 21 days increased testosterone levels, testicular weight, and copulatory behavior in male rats, indicating its aphrodisiac potential. The effects were attributed to the plant's bioactive compounds, including flavonoids, alkaloids, and saponins.

Telfairia occidentalis: *Telfairia occidentalis*, also known as fluted pumpkin, is a member of the Cucurbitaceae family and has long been used in traditional medicine to treat conditions such as spasms, anemia (Akindele *et al*. 2013), cancer, diabetes, malaria, and infertility (Eseyin *et al*. 2014). Ademiluyi *et al*. (2019) demonstrated the potential anti-erectile dysfunction (ED) properties of *T. occidentalis* seeds. In their study, water extracts of pumpkin seeds (2–50 µL) cultured with isolated corpus cavernosum from adult Wistar albino male rats inhibited the activity of key enzymes, including arginase, AChE, ACE, and PDE5, which are important markers of ED.

Tribulus terrestris: *Tribulus terrestris*, part of the Zygophyllaceae family, has been used medicinally for various health issues, including high blood pressure, stomach ailments, and urinary infections (Hussain *et al*. 2009). It is also recognized for its potential to enhance male sexual desire and behavior (Neychev and Mitev 2005). Gauthaman *et al*. (2008) investigated the androgenic effects of TT in primates, finding that intravenous administration of TT extracts at doses of 7.5, 15, and 30 mg/kg over 8 weeks increased plasma testosterone, dihydrotestosterone, and dehydroepiandrosterone sulfate, with the 7.5 mg/kg dose being the most effective. Oral administration of TT extract in rabbits and rats also raised dihydrotestosterone levels, particularly at 5 and 10 mg/kg body weight. Protodioscin, a compound from TT extract, is believed to trigger the release of luteinizing hormone, which stimulates testosterone production (Gauthaman *et al*. 2008). A clinical trial involving daily oral intake of 30 tablets (450 mg) of TT for 30 days showed significant increases in serum testosterone across age groups (18–45 years, 46–49 years, and >60 years), with improvements in ED. The study concluded that TT may be a safe and effective remedy for enhancing sexual desire and erectile function, but further trials with larger sample sizes are necessary for broader recommendations (Russo *et al*. 2019).

VigRx plus: VigRx Plus is a formulation combining various natural herbs, including *Panax ginseng*, *Ginkgo biloba*, *Serenoa repens*, *Crataegus laevigata*, *Ptychopetalum olacoides*, *Erythroxylum catauba*, *Cuscuta chinensis*, *Erythrina sagittatum*, *Tribulus terrestris*, *Turnera diffusa*, and Bioperine® to enhance erectile function. Shah *et al*. (2012) conducted a double-blind, placebo-controlled study to assess the safety and efficacy of VigRx Plus in 78 men aged 25–50 years with mild to moderate ED. Participants were given two capsules twice daily for 12 weeks. The results showed significant improvement in erection function, with tolerability rated as good. The most common side effect was mild fever (2.3%). However, further trials with larger participant groups are needed to validate its safety and efficacy (Shah *et al*. 2012)

Yohimbine: Yohimbine, derived from *Pausinystalia Yohimbe* (K. Schum.) Pierre, is used therapeutically for ED and to enhance sexual activity (Fabricant and Farnsworth 2001). Guay *et al*. (2002) established its efficacy and safety in a study with 18 male patients aged 34–69. Participants were given 5.4 mg of Yohimbine hydrochloride three times daily for 4 weeks, followed by a 10.8 mg dose for another 4 weeks. Results indicated higher sexual health questionnaire scores, slight increases in serum testosterone, and improved penile rigidity in patients with less severe ED. Minimal side effects, including mild hot flashes and anxiety, were reported. Yohimbine did not affect blood pressure or pulse rate, and the study concluded that it is effective for treating ED, especially in men with organic ED (Guay *et al*. 2002). However, further studies with a larger group of patients are needed to confirm its safety and efficacy prior to FDA approval.

Conclusions

Erectile dysfunction (ED) is a multifaceted condition influenced by various pathophysiological factors, including nitric oxide synthase, insulin resistance, superoxide production induced by glucose oxidation, the renin-angiotensin system, and acetylcholinesterase. The adverse effects associated with PDE inhibitors, alprostadil, penile prostheses, and hormone replacement therapies have sparked increased interest in exploring medicinal plants and their active natural compounds as potential treatments for ED. Although few clinical trials have assessed the safety and efficacy of these plants for ED, animal and in vitro studies have demonstrated their promising therapeutic effects. Further comprehensive clinical research could pave the way for the development of novel and effective treatments for ED

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