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Tribulus terrestris L. in traditional Mongolian medicine: Medicinal Applications, Phytochemistry, Pharmacology

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ABSTRACT

Background: *Tribulus terrestris* L. has traditionally been used in Mongolian medicine for its effects on kidney protection, promotion of urination, and boosting of physical energy. This study investigated the plant's historical use, chemical composition, biological effects, and medicinal significance. **Methods:** A literature review was conducted using classical medical texts, pharmacopoeias, and peer-reviewed articles from international research databases to explore the properties and uses of *T. terrestris*. **Results:** Traditional sources, such as book "Essence of spring water, root of the eight-part secret" ("*Rashaan Shim Naiman Gishuun't Nuuts Uvdisiin Undes"*), describe *T. terrestris* as having sweet and warm properties, mainly used for treating kidney diseases and wind-related disorders (*khi*). It has traditionally been used to relieve kidney ailments caused by cold, kidney rheumatism, urinary retention, leg and back pain, edema, and male reproductive weakness. Additionally, it is believed to promote urination and enhance the overall vitality. Modern research confirms that *T. terrestris* exhibits kidney-protective effects owing to its antioxidant, anti-inflammatory, and antimicrobial properties. It also has mild diuretic effects, supports sex hormone production, and enhances sexual functions. Furthermore, their antioxidant properties have potential anti-aging effects. **Conclusion:** Modern research confirms the traditional use of *T. terrestris* to support kidney health, promote urination, and boost physical energy intake.

Keywords: *Tribulus terrestris L.*, Traditional Mongolian medicine, Nephroprotective effect, Diuretic activity, Physical performance.

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INTRODUCTION

Mongolia, which is located at the intersection of Northern and Central Asia, has a diverse range of ecosystems that are influenced by its unique geographical location and climate. The country features a wide variety of landscapes including mountainous regions, deserts, steppes, forest steppes, and semiarid steppes. Mongolia's flora consists of 1,522 plant species, classified into 19 orders, 39 classes, 116 families, and 392 genera.[1]

T. terrestris L. (TT) is an annual herbaceous plant of the *Zygophyllaceae* family that is predominantly found in regions with warm, dry climates, particularly steppe and arid desert areas.

The Mongolian people, who originated in the highlands of Central Asia, have developed the art of living and medical practices over the course of their history, making it a significant part of their cultural heritage. This knowledge, shaped by their mind-set, environment, and daily life, was refined through natural selection. Mongolian medicine is not only about treating illnesses, but also a comprehensive field of knowledge that promotes healthy lifestyles. Throughout its development, the interconnection between practical actions, philosophy, and understanding has led to the creation and evolution of various branches of medicine. Additionally, differences in concepts and contradictions have emerged.[2] The study of Mongolian medicine aims to scientifically analyze these issues and assess the stages of its development from a historical perspective.

Traditional Mongolian medicine incorporates various raw materials derived from animals, plants, and minerals. One such species is *T. terrestris L.*, locally known as sima. It has been used for its diuretic properties, support of kidney function, and enhancement of physical stamina.[3]

In traditional Mongolian medicine, medicinal plants are categorized based on their essential qualities such as taste (*amtlag*), potency (*chadal*), and absorption (*shingeelt*). These plants are believed to exert therapeutic effects by influencing the balance of five elements in the body, leading to specific tastes: sweet (*amtlag*), sour (*isgelen*), salty (*davslag*), bitter (*gashuun*), pungent (*ekhün*), and hot (*khaluun*). Sweet taste is linked to actions such as expelling excess gas, reducing yellow bile (*khi, shariig darakh*), eliminating phlegm (*badganig arwijulakh*), stimulating blood production (*tsus töljülekh*), enhancing appetite (*khoolny durshil nemegduulekh*), promoting wound healing (*sharkhyg anagaakh*), and detoxification (*bieyg khorgüizhuulekh*). From a modern scientific viewpoint, these medicinal effects can be explained by the absorption of nutrients, such as proteins, carbohydrates, and fats.[4]

In 2024, a study was conducted to compare the medicinal formulas, ingredients, tastes, and properties of traditional medicines in Inner Mongolia and Mongolia. This study found that Mongolia has 510 traditional formulas, 581 types of taste, and 376 medicinal properties, whereas Inner Mongolia has 445 formulas, 667 tastes, and 430 medicinal properties. These medicinal materials were classified into 12 disease categories, 10 of which

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showed similarities in taste and properties. The study also identified 23 common medicinal plants that grow in both regions, with Mongolia using 142 species and Inner Mongolia using 131 species of medicinal raw materials for creating medicines.[5]

The traditional use of *T. terrestris has* been described in the context of traditional Mongolian medicine and in ethnographic research.

Modern scientific studies have confirmed that *T. terrestris* possesses a range of therapeutic effects, including diuretic, immune-boosting, antidiabetic, cardiovascular and hepatoprotective effects. In addition, it has demonstrated anti-inflammatory, analgesic, muscle-relaxing, anticancer, antibacterial, and antiparasitic effects.[6]

It contains a variety of biologically active compounds including steroid saponins, flavonoids, glycosides, phytosterols, tannins, terpenoids, amide derivatives, amino acids, and proteins. These compounds have a wide range of medicinal effects in plants. For example, protodioscin, a steroid saponin, has been shown to improve sexual function and to exhibit antidiabetic effects. Additionally, flavonoids in *T. terrestris L.* have antioxidant and anti-inflammatory properties.[6–10] *T. terrestris L.* has a long history of use in traditional Mongolian medicine. However, there is a lack of thorough research on its traditional applications and relationship between its use and pharmacological evidence, particularly in the field of Mongolian ethnology. Therefore, it is crucial to expand research on *T. terrestris L.* to validate the scientific basis of its traditional uses and further investigate its pharmacological and clinical importance.

OBJECTIVE OF THE STUDY

The goal of this study was to review the use of *T. terrestris L.* in traditional Mongolian medicine, assess phytochemical and pharmacological studies that support its traditional use, evaluate its clinical relevance, and establish a scientific foundation for its application.

MATERIALS AND METHODS

To investigate the traditional use of *T. terrestris*, ancient Mongolian medical manuscripts, books, and manuals were analyzed. A comprehensive review of phytochemical and pharmacological studies was conducted using peer-reviewed articles from international scientific databases including PubMed, ScienceDirect, and Google Scholar**.** The search period was from 2002 to 2024, to expand the scope of research on the phytochemical, pharmacological, and clinical aspects of *T. terrestris*.

RESULTS/ DISCUSSION

Morphological description and distribution of *T. terrestris* in Mongolia

Figure 1. *T. terrestris* is an annual herbaceous plant that can grow up to 50 cm in length. It is spread across the ground and has branched stems. The leaves were pinnately arranged, with 5-6 pairs of leaflets and short petioles. The flowers were yellow with five petals located in the leaf axils. The fruit is star-shaped, divided into five segments with sharp tips, and ripens between July and August.[11] In autumn, when the fruits are fully mature, plants are harvested. After drying in the sun, the fruits are gathered and debris or contaminants are removed. The dried plants were stored in a cool, dry environment and used to the prepare of complex medicinal formulations.[12]

Plants are known by various names in different countries. In Mongolian, it is called "Nokhoi zanguu," "Yamaan zanguu," "Naangi zanguu" and "Hevtee zanguu." In Tibetan, it is referred to as "Sima," in Russian as "Якорцы" in English as "Caltrops," in Sanskrit as "Gokshur" and in Chinese as "Ji li".[13] Plant seeds are generally used as raw materials

Figure 1: *Tribulus terrestris* plant, Dundgovi Province, Erdenedalai Soum.

in traditional medicine, although the upper parts of the plant and its flowers are sometimes used.

T. terrestris L. is widely distributed across Mongolia's semi-arid and desert steppe regions, including Khangai, Central Khalkh, Eastern Mongolia, the Great Lakes Basin, Olon Nuuriin Khundii, Dornogovi, Dundgovi, Govi-Altai, foothills of the Altai, Alashaa Desert, and eastern Gobi. It typically grows on rocky, gravelly slopes, sandy riverbeds, spring and stream banks, livestock enclosures, and roadside.[14]

Traditional Use of *T. terrestris L.* in Mongolian Traditional Medicine

To investigate the traditional use of *T. terrestris*, ancient Mongolian medical manuscripts, books, and manuals were analyzed to gather information about its usage. In the book "Essence of spring water, root of the eight-part secret" (*Rashaany Shim Naiman Gishünt Nuutsyn Uvdasyn Ündes*), *T. terrestris L.* is described as having a sweet taste, a mildly bitter taste (slightly sharp), light (khöngön) and warm (büleen) properties, as well as pungent (khurts) and fluid (shingen) qualities. [3] Similarly, the "Four Tantras of Medicine" highlights its diuretic effects, role in supporting kidney function, and therapeutic value in treating rheumatic conditions.[15]

T. terrestris L. has been traditionally used to treat a variety of conditions, including elimination kidney cold (*boernii khuiten*), suppressing and strengthening wind (*khiig darakh, khüchjüülekh*), promoting urination (*shees khöökh*), difficulty urinating (*shees chavdagsikh*), leg and back pain (*khöl, nuruuni övdölt*), kidney rheumatism (*boernii khërkh*), diseases caused by wind (*khii büreldsen övchin*), dribbling urination (*dusal dusagnakh*)**,** weakening of male reproductive function (*er belgiin sulral),* and edema (*usan khawan*).[12]

The first joint Soviet-Mongolian expedition in 1957 led to significant advances in the research on Mongolian medicinal plants. Key works such as V. I. Grubov's "Summary of the Flora of the Mongolian People's Republic" and A. A. Yunatov's "Forage and Grazing Plants of the Mongolian People's Republic" have made substantial contributions to documenting medicinal plant species in the country. Between 1955 and 1980, 375 new plant species were added to the Mongolian medicinal plant catalog. In the present study, *T. terrestris L.* was noted for its diuretic and anti-edema properties, and for its use in supporting kidney and bladder function. It has also been mentioned for its potential in treating conditions, such as anuria (*shees chavadagshikh*).[16]

T. terrestris L. seeds are widely used in both Mongolian and Tibetan medicine for anti-aging purposes and to improve physical strength, particularly in rejuvenating therapies (*judlen*).[4]

Tribulus Terrestris is commonly used in formulas to treat edema, particularly in conditions related to the kidneys such as mild kidney edema. The key formulations containing Tribulus sp. are Sima-3

Table 1: Traditional formulas and their primary uses.

Formula Name	Amount of Tribulus in the Formula		Primary Use
	Cen	Grams	
Sima-3, Sima-4	1 cen	0.37 g	Used for treating kidney and urinary tract disorders.
Sojid	3 cen	1.11 g	It is used to treat various types of edema, kidney heat, dropsy, urinary retention, weakness, bloating, and other cold gastrointestinal conditions.
Yuna-4	5 cen	1.85 g	Used for treating diabetes and bladder disorders.
Vanlag-37	3 cen	1.11 g	It is used to treat cold-related diseases such as bloating, stomach heat, lung issues, hearing loss, urinary retention, and dry skin, and to improve vitality while reducing coldness in the kidneys.
Ar Ur-17	4 cen	1.48 g	Used to treat dropsy, urinary issues, and bloating.
Khalam-8	3 cen	1.11 g	Used for treating kidney-related swelling and pain.
Barayv-15	2 cen	0.74 g	Used to treat diabetes.

and Sima-4. This plant has also been incorporated into medicinal preparations. Table 1 illustrates this.

These formulations are primarily used to treat kidney and urinary tract disorders (*bööriin bolon sheesnii zamyn emgeguud*), kidney-related heat and cold imbalances (*bööriin khaluun bolon khüiten tentseveriin aldagdal*), diabetes (*shijingiin övchin*), edema (*usan khavdar*), bloating (*khavagknah*), and for the general improvement of physical vitality (*biyeiin tenkhee, tamir saijruulakh*).[4]

This study found that *T. terrestris* is widely used in traditional Mongolian medicine (TMM) for treating kidney and urinary tract diseases, enhancing male sexual function, and improving overall physical strength. A comparison of its traditional uses in Ayurvedic medicine (AM) and traditional Chinese medicine (TCM) suggests a historical connection between TMM and AM. The fact that *T. terrestris* is utilized in all three medical systems (TMM, AM, and TCM) highlights its global significance as a medicinal plant.

In Ayurvedic Medicine, *T. terrestris L.* is primarily used to support urinary function, improve sexual health, prevent kidney stone formation, and strengthen the immune system.[6] Additionally, it is known for its benefits in slowing brain aging, enhancing memory, and treating conditions, such as diabetes and stroke.[17]

In Traditional Chinese Medicine, *T. terrestris L.* is widely used to boost physical strength and treat various ailments including inflammation, cardiovascular and cerebrovascular diseases, cancer, hormonal imbalances, and muscle injuries.[18] It is also valued for its diuretic properties, ability to enhance sexual function, immune-boosting effects,[6] and ability to treat conditions such as eye inflammation, skin irritation, high blood pressure, and bloating.[19] The similarities in the medicinal uses of *T. terrestris* across these traditional healing systems suggest a common origin. While its core applications remain consistent, some specialized uses are more developed in Ayurvedic and Traditional Chinese Medicine.

To validate these traditional uses through modern scientific research, it is important to identify the active compounds in plants and to understand their mechanisms of action. Phytochemical research serves as a foundation for bridging traditional knowledge with modern medicine to ensure the safe and effective use of plant-based treatments. Therefore, studying the phytochemical composition of *T. terrestris* is crucial for confirming its traditional uses, elucidating its therapeutic mechanisms, and its therapeutic efficacy.

Phytochemical Composition of *T. terrestris*

T. terrestris L. contains a variety of bioactive compounds, including steroids, saponins, flavonoids, sterols, harman alkaloids, minerals, lignan amides, and cinnamic acid amides.[20,21]

According to the "Monograph of Raw Materials and Medicinal Pharmacopoeia Used in Mongolian Traditional Medicine" (0190-2014), issued by the traditional Mongolian medicine and Technology Institute in 2014, the total flavonoid content in TT raw material should not be less than 0.4 %.[14]

Steroid saponins are the main bioactive compounds responsible for the biological effects of *T. terrestris* extracts. However, saponins alone do not exert a complete therapeutic effect. The combined actions of other bioactive compounds enhance the medicinal properties of plants. Vinay et al. used HPLC-QTOF-MS/MS to identify 55 compounds in *T. terrestris* that may help treat heart diseases. In silico molecular docking and dynamic simulation studies have identified kaempferol 3-rutinoside 7-glucuronide, keioside, rutin, moupinamide, aurantiamide, quercetin-3-O-α-rhamnoside, tribuloside, and 3″,6″-di-O-p-coumaroyltrifolin as promising compounds that target key proteins in the treatment of heart disease.[22]

Protodioscin is the primary bioactive compound found in *T. terrestris*. The plant predominantly contains furostanol and spirostanol steroid saponins. Furostanol saponins include protodioscin, geoproto-dioscin, prototribestin, neoprototribestin, and terrestrins A, B, D, and J-T, whereas spirostanol saponins include dioscin, tribestin, diosgenin, tribulosin, and tigogenin. Furostanol saponins serve as precursors in the biosynthesis of spirostanol compounds. Additionally, the plant contains flavonoids, such as kaempferol, rutin, and quercetin.[23]

Studies have shown that saponins in TT have various aglycone structures including tigogenin, gitogenin, hecogenin, diosgenin, and ketone variants. Steroid saponin glycosides are typically glycosylated at positions 3 and 26, most commonly in the form of 3-O-glycosides. The inner sugar was typically galactose, whereas the outer sugars were rhamnose, xylose, and glucose.[8]

The analysis of TT plant samples from regions such as Beijing, Xinjiang, and Rome using UHPLC/Q-TOF MS and other data platforms identified 141 chemical compounds, including 35 isomeric groups and 39 novel compounds. The chemical compositions of samples from Beijing and Xinjiang were similar, with 81 common compounds, primarily flavonoids and steroidal saponins. However, TT samples from Rome showed notable differences, revealing the presence of ginsenosides and suggesting the region's unique medicinal properties. Terrestrosins compounds I, J, and H, which are characteristic of TT, have been identified as potential plant biomarkers.[24]

A study analyzing T. terrestris L. plant samples from various European and Asian countries using LC-ESI/MS/MS identified six major saponins: protodioscin, prototribestin, pseudoprotodioscin, dioscin, tribestin, tribulosin, and the flavonoid rutin. The concentrations of these compounds vary depending on the plant part, growth stage, and geographical region.[20] The list of bioactive compounds found in plants is presented in Table 2.

A total of 141 chemical compounds were identified, including 120 types of steroid saponins, 13 flavonoids, and more than 20 alkaloids.

Table 2: Chemical compound of *T. terrestris L.*

№	Compound Name	Authors
1	Protodioscin	Ivanka Kostova et al.[25]
2	Methylprotodioscin	
3	Methylprototribestin	
4	Prototribestin	
5	Terrestroside A	Jeu Wang et al.[26]
6	Terrestroside B	
7	Chloromaloside E	
8	Terrestrin B	
9	Terestroneoside A	
10	Steroidal saponins 120 types	Xin Meng et al.[27]
11	Flavonoids 13 types	
12	Alkaloids 20 types	
13	Ferulic acid 2 types	
14	Flavonoids	
15	Alkaloids	
16	Ferulic acid	
17	Neohecogenin-3-O-β-D-glucopyranosyl (1→2)-β-D-glucopyranosyl (1→4)-β-D-galactopyranoside	YJ Xu et al.[28]
18	Neohecogenin-3-O-β-D-glucopyranosyl (1→4)-β-D-galactopyranoside	
19	(22S,25S)-16β,22,26-trihydroxy-cholest-4-en-3-one-16-O-β-D-glucopyranosyl-(1→3)-β-D-xylopyranoside (1)	El-Sayed et al.[29]
20	(22S,25S)-16β,22,26-trihydroxy-cholest-4-en-3-one-16-O-β-D-glucopyranosyl-(1→3)-β-D-glucopyranoside (2)	
21	3β-hydroxy-5α-pregn-16(17)-en-20-one-3-O-β-D-xylopyranosyl-(1→2)-[β-D-xylopyranosyl-(1→3)]-β-D-glucopyranosyl-(1→4)-[α-L-rhamnopyranosyl-(1→2)]-β-D-galactopyranoside (5)	
22	Terrestrinin C	Li-Ping Kang et al.[19]
23	Terrestrinin D	
24	Terrestrinin E	
25	Terrestrinin F	
26	Terrestrinin G	
27	Terrestrinin H	
28	Terrestrinin I	
29	84 steroidal saponins, including 20 newly reported compounds.	Qi et al[30]

The six primary marker saponins are protodioscin, prototribestin, pseudoprotodioscin, dioscin, tribestin, and tribulosin, and the flavonoid rutin is also present.

The medicinal properties of plants are often associated whit saponins; however, these compounds are not the sole contributors to their therapeutic effects. *T. terrestris* has a complex phytochemical composition, containing various bioactive compounds that work together to enhance its medicinal benefits. The methanolic extract of *T. terrestris*, which contains phenolic compounds (341.3 mg GAE/g) and flavonoids (209 mg QE/g), exhibited antioxidant activity. Moreover, the methanolic extract demonstrated significant anti-inflammatory effects both in vitro and in vivo. It showed anti-inflammatory activity at concentrations of 400 μg/mL in vitro and 200 mg/kg in vivo. Through RP-HPLC analysis, four subfractions (TBTMF1-TBTMF4) were identified, with TBTMF3 exhibiting the highest biological activity. The major compounds identified in TBTMF3 include myricetin, rutin, liquiritigenin, physcion, and protodioscin.[31] These findings highlight the importance of considering key phytochemicals when assessing the therapeutic potential of *T. terrestris*, because the combined effects of various bioactive compounds contribute to its medicinal properties.

Recent studies on *T. terrestris* have focused on understanding the pharmacological actions of its bioactive compounds. This research is crucial for validating its traditional medicinal uses and deepening our understanding of the therapeutic potential of the plant.

Pharmacological investigation of *T. terrestris*

Pharmacological studies on *T. terrestris* in Mongolia have investigated its biological activity, particularly in relation to its traditional medicinal uses. One study has focused on the aqueous extract of TT and its ability to protect against cisplatin-induced kidney damage. In this study, cisplatin was administered at a dose of 5 mg/kg for five days, leading to kidney injury. Subsequently, TT extract was administered at doses of 20 and 40 mg/kg for 14 days. The results showed a significant reduction in blood urea nitrogen (BUN) and serum creatinine levels, along with a considerable reduction in kidney tissue damage. The most effective dose was found to be 40 mg/kg.[32]

The nephroprotective activity of T. terrestris is associated with its anti-inflammatory, antioxidant, and antimicrobial activities. Isolation of the saponin fractions plays an important role in determining the therapeutic effects of *T. terrestris L.*. Ultrasonic extraction parameters, including 30% ethanol concentration, 55 min extraction time, solvent-to-material ratio of 35:1 mL/g, and extraction temperature of 46°C, resulted in 5. extraction efficiency of 5.49 %. The obtained saponin fraction demonstrated significant anti-inflammatory effects by reducing phagocytic activity, mitigating lung edema, protecting RAW 264.7 cells and lung tissue structure, and decreasing levels of nitric oxide (NO) and TNF-α. Additionally, the saponin extract inhibited the TLR4-TRAF6-NF-κB signaling pathway, further enhancing its anti-inflammatory effects.[33]

The antimicrobial activity of the T. terrestris L. fruit extract against uropathogenic bacteria was evaluated. The 15% ethanol extract exhibited the highest antimicrobial activity, and inhibited the growth of Escherichia coli, Pseudomonas aeruginosa, Proteus mirabilis, Klebsiella pneumoniae, and Enterococcus faecalis.[34] A comparison of the diuretic effects of TT and furosemide showed that TT demonstrated moderate diuretic activity, suggesting its potential as a diuretic agent for preventing pulmonary and other forms of edema.[35]

Table 3: Pharmacological Actions of *T. terrestris L.*: Study Overview.

Mechanism of Action	Type of Study	Dose	Active Ingredients	Results	Authors, Year
Pharmacological Research					
Kidney Protection	In vivo study	300 mg/kg, 600 mg/kg	T. terrestris L., Sorafenib	Antioxidant activity, reduction of oxidative stress, protection from nephrotoxic damage	SA Rahim, A. Al-Nahi[43]
Kidney Protection	In vitro study	Not specified	T.terrestris L.	Increased regulation of miR-155-5p, decreased expression of H2AC6 in negative correlation	Pei HJ[44]
Kidney Protection	In vitro	50 µg/ml (eTT)	Ethanol extract (eTT), α-tocopherol	Chelating metal ions, antioxidant effects	B. Rajendar[45]
	In vivo	5 mg/kg body weight (eTT) daily, 75 mg/kg (α-tocopherol)	Ethanol extract (eTT), α-tocopherol	Reducing cadmium levels in the body, antioxidant and metal chelation effects	
Kidney Protection	Animal study	200 mg/kg	T.terrestris L.	Protects kidney cells, protects from kidney damage induced by GNT chemotherapy	Kilany et al.[46]
Kidney Protection	Animal study	200 mg/kg	T. terrestris L.	Protects kidney cells, protects from Cd-induced nephrotoxicity	Farhan et al.[47]
Diuretic	Animal study	5 g/kg	T. terrestris L.	Diuretic effect by increasing the levels of urinary ions (Na+, K+, Cl+) and was found to induce muscle contraction in guinea pig ileum	Al-Ali M. [48]
Diuretic	In vivo, In vitro	0.12-12 мг/кг		The antihypertensive effect may be related to direct relaxation of smooth muscle, nitric oxide release, and membrane hyperpolarization	Sharifi et al.[49]
Erectile Dysfunction	Animal study	7.5-30 mg/kg	Saponins, flavonoids	Increased testosterone (T) by 52%, dihydrotestosterone (DHT) by 31%, and dehydroepiandrosterone sulfate (DHEAS) by 29%	Gauthaman et al.[50]
Clinical Research					
Supporting the physical activity of men	Human studies (men)	900-1800 мг	Gitonin, protodioscin, tribulosaponin A and B, and other steroid saponins from TT	Increased physiological biomarkers, including hematological, lipid, kidney, and liver biomarkers, were within the normal ranges. No effect on muscle damage, inflammation, or oxidative stress biomarkers	Fernandez-Lazaro et al[44]
Erectile Dysfunction	Clinical study	250 mg/day (Androsten®)	Protodioscin, saponins	Increases testosterone and DHT, promotes secretion of sexual hormones	Sellandi et al.[51]
Erectile Dysfunction	Prospective, randomized, double-blind, placebo-controlled study	800 mg, twice a day, for 30 days	Protodioscin	There was no significant difference in the improvement of erectile dysfunction symptoms or serum total testosterone levels compared with placebo. The IIEF-5 scores showed significant improvement, but there was no significant difference between the groups (P = .7914).	Santos et al.[52]

The plant's traditional use includes the treatment of kidney rheumatism or rheumatoid arthritis. In studies examining the effects of total saponins (GSTT) on rheumatoid arthritis (RA)-related fibroblast-like synoviocytes (RA-FLS), GSTT promoted apoptosis, reduced the Bcl-2/Bax ratio, and inhibited JNK and p38 phosphorylation. In vivo studies have shown that GSTT reduces synovial infiltration and lowers serum pro-inflammatory cytokine levels, suggesting its potential benefits in the treatment RA.[36]

The anti-aging effects of *T. terrestris* extracts, which grow in Mongolia, have been evaluated. The extract increased the levels of antioxidant enzymes such as CAT, SOD, and GSH-Px, and decreased the levels of malondialdehyde (MDA), a marker of oxidative stress. This suggests that *T. terrestris L.* may have antioxidant properties that help combat the effects of aging.[37]

T. terrestris is nutrient-rich medicinal plant. Research has shown that TT contains significant amounts of fiber (24.28 %) and fat (14.49 %). Sensory evaluation of cookies made with 2-5 % TT powder revealed that consumers accepted the cookies well, suggesting that TT can be used as a food supplement or functional ingredient. Additionally, TT enhances the texture, fiber content, and fat content of the baked goods.[9] Its antioxidant activity suggests its potential benefits in combating aging. Therefore this plant can be used as a high-quality food source. These properties imply that *T. terrestris* might have been used in traditional Mongolian medicine, to improve physical performance and health.

Based on the above and as seen in Table 3, *T. terrestris* exerts protective effects on the kidneys through its anti-inflammatory, antioxidant, and metal-chelating properties. It suppresses the TLR4-TRAF6-NF-κB signaling pathway, reducing TNF-α and NO levels to alleviate inflammation. Additionally, it regulates miR-155-5p and H2AC6, neutralizes free radicals, and facilitates the removal of heavy metals, thereby protecting kidney cells and enhancing their functions. As shown in Table 3, experimental studies have been conducted with doses ranging from to 5-600 mg/kg, but the key marker substances are still not clearly defined. As a result, recent research has actively focused on selecting standardized extracts, identifying the main active compounds, and elucidating the mechanisms of action of these compounds. This type of research has intensified in recent years.

Clinical Research on Plant-derived Products from *T. terrestris L.*

Bioactive products derived from *T. terrestris* are used worldwide to enhance sexual desires, performance, and physical endurance. The therapeutic effects of *T. terrestris* are directly related to the concentrations of its active components, emphasizing the importance of isolating these compounds and confirming their therapeutic efficacy. However, the pharmacological effects observed in vitro, in animal models, and in clinical trials have shown discrepancies. In addition, the proposed pharmacodynamic mechanisms have not been fully validated by molecular biologicaly studies.[38]

The effectiveness of tribestans in treating erectile dysfunction (ED) and hypoactive sexual desire disorder (HSDD). This randomized, double-blind, placebo-controlled study involving 180 men found that the TT group showed significant improvement in International Index of Erectile Function (IIEF) scores compared to the placebo group ($P<0.0001$). Additionally, TT supplementation resulted in higher scores for Intercourse Satisfaction, Orgasmic Function, Sexual Desire, Overall Satisfaction, and the GEQ.[39]

A study on the effects of TT supplementation on body composition, hormonal response, and recovery in CrossFit® athletes found that although there was no significant impact on body composition or performance, TT supplementation increased testosterone levels, reduced fatigue, and promoted faster recovery after exercise.[40]

Another study investigated the effects of *T. terrestris L.* supplementation on oxidative stress and inflammation following aerobic exercise. The results indicated that TT supplementation improved antioxidant activity and reduced oxidative stress, although it did not significantly alleviate delayed-onset muscle soreness (DOMS).[41]

Therefore, the mechanisms by which TT enhances physical performance and overall health are multifaceted. Therefore, TT supplementation might increase testosterone levels and improve muscle strength and performance. Additionally, it may support cardiovascular health by improving lipid profiles, which could further enhance the performance. TT also exerts moderate effects on inflammatory biomarkers, contributing to improved recovery and physical performance. Its antioxidant properties help mitigate oxidative stress caused by exercise, and TT may aid muscle growth and recovery by enhancing growth hormone and IGF-1 levels. Moreover, TT appears to influence hematological biomarkers and improve oxygen delivery and endurance. Although TT shows promise for improving physical performance through various mechanisms, the results of studies on this topic remain conflicting, indicating the need for further research to confirm its benefits.[42] A list of pharmacological and clinical studies on this plant is presented in Table 3.

T. terrestris has a protective effect on kidney function through its anti-inflammatory, antioxidant, antibacterial, and metal-chelating properties. It also exhibits mild diuretic effects. Furthermore, *T. terrestris* supports sex hormone synthesis, thereby enhancing sexual function. The plant helps regulate blood parameters, lipid profiles, and markers of kidney and liver functions, providing both protective and balancing effects. Thus, *T. terrestris* contributes to improved physical strength and sexual performance.

CONCLUSION

Tribulus terrestris is widely used in traditional Mongolian medicine because of its beneficial effects on renal function, urinary health, libido, and physical function. A total of 141 chemical compounds have been identified, most of which are steroid saponins, flavonoids, and alkaloids. Studies have demonstrated that the bioactive components of *T. terrestris*, including saponins and flavonoids, can trigger various biological responses. The traditional use of this plant is similar to that of Ayurvedic and Traditional Chinese Medicine. This suggests that traditional Mongolian medicine is derived from Ayurvedic and Tibetan medicine. The positive effects of this plant on kidney health are attributed to its antioxidative properties, capacity to alleviate oxidative stress, antimicrobial activity, metal ion chelation ability, and protective action against nephrotoxicity and renal damage. In addition, it has mild diuretic effects. Moreover, research has shown that *T. terrestris* promotes sex hormone synthesis, thereby improving sexual function. The antioxidant characteristics of the plant, combined with its potential nutritional value, suggest its possible anti-aging effects.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest associated with this study.

ETHICAL APPROVAL

Decision of the Ethics Review Committee of the Health Sciences University of Mongolia, dated February 17, 2023, under the reference number 2023/3-02.

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DATA AVAILABILITY

The data supporting this research are available in the NN repository at www.NNN.org/download.

AUTHOR CONTRIBUTIONS

1. Baigalmaa Dovchinsuren and Enkhjargal Dorjbal contributed to the development of the research design.
2. Baigalmaa Dovchinsuren, Ariunaa Damdinsuren, Bolor Bayarkhuu, Mandakhnaran Purevkhuu, Otgonbat Batjargal, and Boditsedeg Badarch contributed to writing the manuscript and reviewing the results.

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