WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Review Article: A Comprehensive Overview of *Tribulus terrestris* (Gokshura) – Traditional Uses, Phytochemistry, and Pharmacological Activities

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ABSTRACT :

Tribulus terrestris Linn., commonly recognized as **Gokshura**, is an esteemed annual plant extensively used in traditional healing systems like Ayurveda, Unani, and Chinese medicine . Historically, Gokshura has been valued for its diverse therapeutic attributes, particularly in addressing conditions related to the urinary system, sexual health, and cardiovascular function. This review aims to consolidate existing scientific literature on *Tribulus terrestris*, covering its historical importance, botanical classification, physical characteristics, rich chemical composition, and confirmed pharmacological effects. Particular attention will be given to its well-documented roles as a **diuretic, aphrodisiac, anti-inflammatory, antioxidant, and cardioprotective** agent, substantiated by findings from in vitro, in vivo, and human clinical studies. Despite its widespread traditional application and growing scientific validation, more rigorous research is necessary to fully clarify its precise mechanisms of action and to establish standardized therapeutic protocols .

Keywords: *Tribulus terrestris*, Gokshura, Traditional medicine, Phytochemistry,

Introduction

For thousands of years, plants have been important sources of medicine because they contain many compounds that can help heal [1]. Tribulus terrestris is one of these plants, and it is in the Zygophyllaceae family[2]. Many cultures have used this medicinal herb for a long time, and it is well known. The thorny fruits of this plant are shaped like cow's hooves, which is why Ayurvedic texts from ancient India call it "Gokshura" [4]. It has been used for many things for a long time, such as treating urinary tract infections and kidney stones [5, 6], as well as increasing libido and athletic performance [7, 8].
More and more people around the world are interested in using natural products to improve their health and well-being. This has caused scientists to look into the old claims about Tribulus terrestris [9]. Scientists are beginning to understand the complex mix of biologically active compounds in this plant, with a focus on its steroidal saponins, flavonoids, alkaloids, and lignanamides [10, 11]. People think that these parts are what give it its many health benefits, which include being a diuretic, an aphrodisiac, an anti-inflammatory, a pain reliever, an antioxidant, an anticancer, and a heart-protective agent [3, 4]. This review puts together everything we know about Tribulus terrestris at this time. It shows that it could be a useful medicine by connecting old knowledge with new scientific knowledge.

Table 1:Taxonomical Classification

Accurate taxonomic classification of *Tribulus terrestris* is essential for its correct identification and scientific study [12]. Its classification hierarchy is as follows:

Rank	Classification
Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta

Rank	Classification
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Zygophyllales
Family	Zygophyllaceae
Genus	*Tribulus*
Species	*Tribulus terrestris* L.

Table 2: Vernacular Names

The wide recognition and usage of *Tribulus terrestris* are reflected in its numerous names across different regions and linguistic groups [13].

Language/Region	Vernacular Name(s)
Sanskrit	Gokshura, Gokharu, Trikanta, Shvadamshtra, Ikshugandha
Hindi	Gokhru, Chota Gokhru, Gokhuri
English	Puncture Vine, Caltrop, Goat's Head, Devil's Thorn
Marathi	Gokharu
Gujarati	Betha Gokharu
Bengali	Gokhura
Telugu	Palleru Kaaya
Tamil	Nerinjil
Kannada	Negalu
Malayalam	Nerinjil
Punjabi	Bhakhra
Persian	Khare Khasak
Arabic	Qutub, Hasak
Chinese	Ci Ji Li

Botanical Description

Tribulus terrestris is either an annual or perennial herbaceous plant, characteristically growing prostrate with spreading stems and easily identifiable spiny fruits [14].

- **Habit:** It typically grows as a low-lying, annual or perennial herb, featuring numerous slender, hairy branches that radiate outwards, often forming dense ground cover. The stems can extend up to 10-60 cm in length [15].
- **Leaves:** Its leaves are arranged oppositely and are **pinnately compound**, each bearing 4-8 pairs of leaflets. These leaflets are oblong, have smooth edges, and are covered with fine hairs, giving them a grayish-green hue. Their typical length ranges from 0.5-1.5 cm [16].

- **Flowers:** The flowers are small, yellow, and solitary, emerging from the leaf axils, usually measuring around 0.7-1 cm in diameter. They possess five sepals, five petals, ten stamens, and an ovary divided into five cells. The plant typically flowers between July and October [17].

- **Fruits:** The most distinctive feature of the plant is its fruit, a tough, woody **schizocarp** that divides into five individual nutlets (cocci) upon maturity. Each nutlet is typically equipped with two prominent, sharp, outward-pointing spines and two shorter, blunter spines, giving it a resemblance to a goat's head or a caltrop. These spines assist in seed dispersal by attaching to animal fur or vehicle tires [18].

- **Roots:** The root system is relatively shallow but fibrous and well-developed, enabling the plant to thrive in arid and semi-arid conditions [19].

Phytochemistry

The diverse pharmacological effects observed in *Tribulus terrestris* are ascribed to its rich assortment of **secondary metabolites** [10, 20]. Extensive phytochemical investigations have identified several classes of compounds, among which **steroidal saponins** are the most thoroughly researched and are considered the primary active constituents [11, 21].

Table 2: Key Phytochemical Constituents of *Tribulus terrestris*

Class of Compound	Examples of Specific Compounds
Steroidal Saponins	Protodioscin, Protribestin, Tribulosin, Dioscin, Diosgenin, Gitogenin, Hecogenin, Neohecogenin, Terrestrosins A-Z [22, 23]
Flavonoids	Kaempferol, Quercetin, Rutin, Astragalin, Isorhamnetin [11, 24]
Alkaloids	Harmane, Norharmane, Tribulusterine, β-Carboline alkaloids [11, 25]
Lignanamides	N-p-coumaroyltyramine, N-feruloyltyramine [26]
Glycosides	Tribuloside, Tribulusamide [27]
Terpenoids	β-sitosterol, Stigmasterol, Campesterol [11, 28]
Other Compounds	Polysaccharides, amino acids, fatty acids, vitamins (e.g., Vitamin C), minerals [29]

Pharmacological Activities

Many studies have looked at the pharmacological effects of *Tribulus terrestris* in vitro, in vivo, and in clinical settings [3, 30]. Most of these effects are due to the plant's different phytochemicals, especially its steroidal saponins [11, 21].

1. Aphrodisiac and Libido-enhancing Activity

- This is one of the most well-known traditional uses and scientifically studied effects of *Tribulus terrestris* [31].
- **Mechanism:** It is thought that protodioscin, a well-known steroidal saponin, changes into dehydroepiandrosterone (DHEA) in the body. DHEA then becomes a building block for testosterone and other sex hormones. This process may cause levels of luteinizing hormone (LH) to rise, which in turn may cause the Leydig cells in the testes to make more testosterone [32, 33]. The plant may also help with erectile function by making more nitric oxide and getting more blood to the genital tissues [34, 35].
- **Evidence:**
    - **Animal Studies:** Many studies on rats and rabbits have shown that T. terrestris extracts improve erectile function, increase mating frequency, and improve other sexual behaviors, often in line with higher testosterone levels [33, 36, 37]. For example, research on castrated rats showed that they had more sex and higher intracavernosal pressure [33]. .
    - **Human Studies:** Early studies on humans, especially men with sexual problems, showed promising results for higher libido and better erectile function. However, some larger, well-controlled clinical trials have shown mixed results when it comes to a direct increase in testosterone levels in healthy people [38, 39]. However, both men and women with hypogonadism or sexual dysfunction have reported big improvements in their sexual desire, satisfaction, and erectile function, even when their testosterone levels didn't change much. This suggests that other mechanisms, like neurotransmitter modulation, may be at work [40, 41].
      Application: Many people advertise it as a natural testosterone booster and male enhancement supplement, but there is still debate about how it affects testosterone levels in healthy people [39, 42].

2. Diuretic and Anti-urolithiasis Activity

Scientific evidence strongly supports the traditional use of Gokshura to treat urinary problems [2, 43].

- **Mechanism:** It makes you urinate more, which helps your body get rid of waste. It is thought to have an effect on renal tubule reabsorption and possibly on renal blood flow [44]. The anti-urolithiasis effect is thought to work by stopping the formation of stones by lowering the amount of minerals in urine that cause stones to form (like calcium oxalate) and by making it easier for stones to dissolve and be expelled through its diuretic action and possible ability to stop crystallization [45, 46].
- **Evidence:**
    - **Animal Studies:**Extracts have shown strong diuretic effects in animal models, which means they make more urine and get rid of more electrolytes like sodium and potassium [47, 48]. Studies on urolithiasis models, which are caused by things like ethylene glycol, have shown that the stones get smaller and fewer, and that they protect the kidneys from damage caused by stone formation by lowering serum creatinine and BUN levels [46, 49].
    - **Human Studies:** Clinical observations and some smaller trials have confirmed its effectiveness in treating urinary tract infections and as an additional treatment for kidney stones, helping them pass by increasing urine flow and possibly stopping them from coming back [50, 51].
    - **Application:** It is used in traditional medicine to treat kidney stones, painful urination (dysuria), and different urinary tract

infections [52].

3. Anti-inflammatory and Analgesic Activity

Tribulus terrestris has strong anti-inflammatory and pain-relieving effects [53].

- **Mechanism:** It is thought that these effects happen because they block pro-inflammatory mediators like nitric oxide (NO), tumor necrosis factor-alpha (TNF-α), and interleukin-6 (IL-6) [54, 55]. It might also change the nuclear factor-kappa B (NF-κB) pathway, which is very important for immune and inflammatory responses [56, 57].

- **Evidence:**
  - **In vitro Studies:** In vitro studies show that extracts stop macrophages from making nitric oxide and inflammatory cytokines when they are stimulated with lipopolysaccharide (LPS) (RAW 264.7 cells) [54, 58]. Studies also show that it can stop the expression of cyclooxygenase-2 (COX-2) [59].
  - **Animal Studies:** Studies on rodents have shown that carrageenan-induced inflammation models cause a significant decrease in paw swelling and that tests like the hot plate test and the acetic acid-induced writhing test show pain-relieving effects in both the central and peripheral nervous systems [60, 61].
  - **Application:** Used for arthritis, painful conditions, and other inflammatory diseases in the past [53, 62].

4. Antioxidant Activity

The plant has a lot of compounds that fight oxidative stress by acting as antioxidants [63, 64].

- **Mechanism:***T. terrestris* has flavonoids, polyphenols, steroidal saponins, and other chemicals that can directly scavenge free radicals (like DPPH, ABTS, and superoxide radicals), lower lipid peroxidation, and boost the activity of intrinsic antioxidant enzymes (like superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx)) [64, 65]. This action helps protect the parts of cells from damage caused by oxidation [66].
- **Evidence:**
  - **In vitro Studies:** Extracts have shown strong DPPH radical scavenging and ferric reducing antioxidant power, similar to known antioxidants [64, 67].
  - **Animal Studies:** Giving *T. terrestris* extracts has been shown to protect the liver, kidneys, heart, and other organs from oxidative damage by lowering levels of oxidative stress markers (like malondialdehyde (MDA)) and raising levels of antioxidant enzymes [68, 69].
  - **Application:** : It could help prevent and treat chronic diseases that are linked to oxidative stress, like heart disease, neurodegenerative disorders, and some types of cancer [70].

5. Cardioprotective Activity

Tribulus terrestris has shown promise in protecting the heart and blood vessels [71]. **Mechanism:** It may protect the heart by lowering blood pressure (because it acts as a diuretic and may block ACE or vasodilation mediated by nitric oxide), improving lipid profiles (by lowering total cholesterol, LDL-cholesterol, and triglycerides), stopping platelets from sticking together, and directly protecting heart muscle cells from oxidative damage and too much growth [72, 73].

- **Evidence:**
  - **Animal Studies:** Extracts have been shown to lower blood pressure in animal models that naturally have high blood pressure [74]. In hyperlipidemic rats, they can also lower total cholesterol, LDL-cholesterol, and triglycerides while raising HDL-cholesterol levels [75]. Some studies show that reducing the size of an infarct and improving heart function may protect against myocardial ischemia-reperfusion injury [76, 77].
  - **Application:**Traditionally used to treat high blood pressure and cholesterol, and possibly to help prevent heart disease [78].

6. Antidiabetic Activity

New studies suggest that *Tribulus terrestris* may be able to help with diabetes management [79].

- **Mechanism:** It may work by making peripheral tissues more sensitive to insulin, making pancreatic beta cells secrete more insulin, stopping alpha-glucosidase (which lowers blood sugar levels after meals), and lowering oxidative stress that comes with diabetes and its complications [80, 81].

  Evidence:
  - **Animal Studies:** Extracts have been shown to lower blood glucose levels in diabetic animal models that were given streptozotocin and make them better able to handle glucose [82, 83]. In some experimental models, they have also been shown to help restore the function of pancreatic beta cells [84].
  - **Human Studies:** There isn't much research on people yet, but some early trials have shown that using *T. terrestris* as an add-on therapy can lower fasting blood glucose and HbA1c levels in people with type 2 diabetes [85]. .
  - **Application:** A possible add-on treatment for type 2 diabetes that needs more clinical testing [86].

7. Anticancer Activity

- Some studies have looked into whether *Tribulus terrestris* can fight cancer [87]. **Mechanism:** The anticancer effects are thought to come from its ability to cause apoptosis (programmed cell death), stop cell growth, stop angiogenesis (the formation of new blood vessels that feed tumors), and change the immune system in ways that make the body better able to fight cancer cells [88, 89].

  Evidence:
  - **In vitro Studies:** : Extracts and isolated compounds have been shown to kill cancer cells from breast (MCF-7), liver (HepG2),

prostate (PC-3), and colon cancers, often by causing apoptosis through caspase activation and changes to the mitochondrial pathway [89, 90, 91].

- **Animal Studies:** A small number of studies done on living animals have shown that some xenograft or chemically induced cancer models have a slower tumor growth and spread [92].
- **Application:** This kind of research is still in its early stages, and it is not yet a standard cancer treatment. More research is needed to find out if it can be used safely and effectively in the clinic [93].

8. Hepatoprotective Activity

Tribulus terrestris has shown protective effects on the liver [94].

- **Mechanism:**It can protect liver cells from damage caused by different toxins (like carbon tetrachloride, paracetamol, and ethanol), lower inflammation, and improve liver function by stabilizing liver enzymes (ALT, AST, ALP) and encouraging cell regeneration [95, 96]. Its antioxidant and anti-inflammatory properties are very important for this protective action [55, 97].
- **Evidence:**
  - **Animal Studies:** Animal studies have shown that extracts can help heal liver damage caused by different hepatotoxins. This is shown by lower levels of liver enzymes and bilirubin, as well as better histopathological parameters, such as less necrosis and fatty degeneration [96, 98].
  - **Application:** It may help keep the liver healthy and treat a number of liver diseases, such as non-alcoholic fatty liver disease, but more human clinical trials are needed [99].

9. Immunomodulatory Activity

The plant may exert an influence on the immune system [100].

- **Mechanism:** It has been seen that *T. terrestris* extracts change how immune cells work, make macrophages better at phagocytosis, and change the production of cytokines (for example, they increase IL-2 and decrease IL-4). This suggests that they have an immunomodulatory effect that could either boost or control immune responses [101, 102].
- **Evidence:**
  - **In vitro and Animal Studies:** Some studies suggest that it can boost both humoral and cell-mediated immunity in animals with weak immune systems [103].

Application: Possible use in boosting overall immunity and in situations where immune modulation is needed [104].

Conclusion

Gokshura, or *Tribulus terrestris,* is a strong medicinal plant with a long history of use in traditional medicine and growing evidence of its healing properties. Modern phytochemical and pharmacological studies have mostly confirmed its traditional uses for treating urinary, reproductive, and cardiovascular problems. The plant has a wide range of effects because it has a lot of different bioactive compounds. The steroidal saponins are what give it its well-known aphrodisiac, diuretic, anti-inflammatory, and antioxidant effects. Also, new evidence suggests that it might be useful for managing diabetes, protecting the liver, and fighting cancer, but more research is needed in these areas.

Even though there is strong evidence, more rigorous, well-structured clinical trials using standardized extracts are needed to fully understand how *Tribulus terrestris* works, find the best doses, check its long-term safety, and definitively prove its effectiveness for certain health conditions. Differences in chemical makeup based on where the plant comes from, how it is grown, and how it is extracted show how important it is to create strict quality control standards to make sure that therapeutic results are always the same. As more and more people around the world want natural and alternative medicines, *Tribulus terrestris* looks like a very promising safe and effective plant-based medicine. More research is needed to fully understand its potential health benefits.

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