A Recent Phytochemical Review – Fruits of

*Tribulus terrestris* Linn

Suresh Reddy Yanala¹*, D. Sathyanarayana², K. Kannan³

Department of Pharmacy,
Annamalai University,
Chidambaram, Tamil Nadu, India

Abstract

The genus *Tribulus*, belonging to family Zygophyllaceae, comprises about 20 species widely distributed across the world, of which three species, viz. *Tribulus terrestris*, *T. cistoides* and *Tribulus alatus*, are of common occurrence in India. Among them, *T. terrestris* commonly known as gokharu or puncture wine is a well known medicinal herb has been used for a long time in both the Indian and Chinese alternative systems of medicine for treatment of various kinds of diseases. This review summarized the current knowledge on the phytochemistry. Fruits of the *Tribulus terrestris* contain a variety of chemical constituents which are medicinally important, such as flavonoids, flavonol glycosides, steroidal saponins, steroidal glycosides, furostanol saponins, furosteroidal saponins, furostanol glycosides, sapogenins and alkaloids. It has diuretic, aphrodisiac, antiurolithic, immunomodulatory, antidiabetic, absorption enhancing, hypolipidemic, cardiotonic, central nervous system, hepatoprotective, anti-inflammatory, analgesic, antibacterial, anthelmintic, larvicidal, and anticarcinogenic activities. For the last few decades or so, extensive research work has been done to prove its pharmacological activities of its various extracts.

Keywords – *Tribulus terrestris* L. fruit, Gokhru, Zygophyllaceae, Phytochemicals

1. INTRODUCTION

1.1 Botany and occurrence.

*Tribulus terrestris* L. is a well known and widely distributed species of the genus *Tribulus*. The genus *Tribulus*, belonging to family Zygophyllaceae, comprises about 20 species in the world, of which three species, viz. *Tribulus terrestris*, *T. cistoides* and *Tribulus alatus*, are of common occurrence in India. Among them, *T. terrestris* (TT) is a well practiced medicinal herb by Ayurvedic practitioners as well as by modern herbalists [1]. It is known with several common names: puncture vine, goat head, devil’s thorn and Gokhru [2]. It is an annual creeping herb found in Mediterranean, subtropical, and desert climate regions around the world, viz. India, China, Southern USA, Mexico, Spain, and Bulgaria [3, 4]. It is a common weed of the pasture lands, road sides, and other waste places, chiefly in hot, dry, and sandy regions in India [5]. It is used as traditional medicine in India, China, South Africa and Bulgaria against oedemas, cardiovascular diseases, and abdominal dysfunction, to increase spermatogenesis, for treatment of eye troubles, leucorrhoea and impotence [6].

1.2 Taxonomical classification

- **Kingdom**: Plantae
- **Division**: Phanerogams
- **Subdivision**: Angiospermae
- **Class**: Dicotyledonae
- **Order**: Zygophyllales
- **Family**: Zygophyllaceae
- **Genus**: Tribulus (puncturevine)
- **Species**: *T. terrestris* (*Tribulus terrestris* L.) [7, 8].

1.3 Common and Vernacular Names

*Tribulus terrestris* has a list of alternative names almost as long as its history. In Traditional Chinese Medicine it is known as Ci Ji Li, Bai Ji Li or just Ji Li [9].

- **Latin Name**: *Tribulus terrestris*-Semen
- **European common names**: Maltese cross, Small caltrops
- **Sanskrit Names**: Gokshura, Shreedhama, Swadukantaka, Trikantaka, Vanashrungata, Chanadhruma, Ikshugandhika [10].
- **Local Names (in India)**: Gokharu (Hindi), Gokuri (Bengali), Kante gokaru (Marathi), Land caltrops (English), Nerinci (Tamil), Palluru Kayalu (Telugu).

1.4 Traditional Uses

The Latin name *Tribulus terrestris* sounds like an earthy Roman emperor. Some people think it rules among muscle-building supplements. The fruits of *T. terrestris* L. have been used in traditional Chinese medicine for the treatment of eye trouble, edema, abdominal distention, emission, morbid leucorrhoea, sexual dysfunction and veiling. Roots and fruits are useful in rheumatism, piles, renal and vesical calculi, menorrhagia, impotency, premature ejaculation. It is indicated for use in treating headaches, dizziness, premature ejaculation and spermatorrhoea (escape of sperm without orgasm) [11]. To Indian Ayurvedic practitioners the herb is called Burra Gokhru and is regarded as a diuretic, demulcent, antiseptic, anti-inflammatory and aphrodisiac. Ancient Greeks used *Tribulus terrestris* as a diuretic and a mood-enhancer. In ancient Chinese medicine, it was used for a variety of liver, kidney, and cardiovascular diseases. More recently, eastern European athletes have used it to improve strength and stamina [12].
1.5 Botanical Description of *Tribulus terrestris* Linn.

![Fig 1: *Tribulus terrestris* Linn natural habitat](image)

- **It is small prostrate, 10-60 cm height; hirsute silky hairy shrub.** It is a tap rooted herbaceous perennial plant that grows as a summer annual in hot and colder climates [13, 14].

- **Stems**
  - The stems radiate from the crown to a diameter of about 10 cm to over 1 m, often branching. They are usually prostrate, forming flat patches, though they may grow more in shade or among taller plants [15].

- **Leaves**
  - The leaves are pinnately compound, in opposite pairs, 3 to 6 pair, up to 8 cm long with leaflets less than a quarter-inch long [16].

- **Flowers**
  - The flowers are 4 to 10 mm wide, with five lemon yellow petals. A week after each flower blooms, it is followed by a fruit that easily falls apart into four or five single-seeded nutlets. Flowers are usually silky, white or yellow, solitary, arises from the axils of leaves. Ovary briskly, style short and stout [17].

- **Fruits**
  - Fruits are globose, spinous or tuberculate; consisting of fine hairy or nearly glabrous, often muriculate and woody cocci, each with two pairs of hard sharp spines, one pair longer than the other. Fruit often cling to clothes and bodies of animals and humans [18].

- **Seeds**
  - The nutlets or "seeds" are hard and bear two to three sharp spines, 10 mm long and 4 to 6 mm broad point-to-point. It is a trailing and spreading herb, densely covered with minute hair. Seeds are many in woody cocci [18].

2. **Secondary metabolites of fruits of *Tribulus terrestris***

2.1 Seven steroidal saponins

Seven previously unidentified steroidal saponins were isolated from fruits of *Tribulus terrestris*. The structures of the saponins were established by using 1D and 2D NMR spectroscopy, mass spectrometry, and chemical methods. The compounds were identified as: 26-O-β-d-glucopyranosyl-(25R)-furost-4-en-22a,26-tetrol-12-one (terrestrinin C), 26-O-β-d-glucopyranosyl-(25R)-furost-4-en-22a,26-diol-3,12-dione (terrestrinin D), 26-O-β-d-glucopyranosyl-(25S)-furost-4-en-22a,26-diol-3,6,12-trione (terrestrinin E), 26-O-β-d-glucopyranosyl-(25R)-5α-furostan-3β,22a,26-triol-12-one (terrestrinin F), 26-O-β-d-glucopyranosyl-(25R)-furost-4-en-12β,22a,26-triol-3-one (terrestrinin G), 26-O-β-d-glucopyranosyl-(1→6)-β-d-glucopyranosyl-(25R)-furost-4-en-22a,26-diol-3,12-dione (terrestrinin H) and 24-O-β-d-glucopyranosyl-(25S)-5α-spirostan-3β,24β-diol-12-one-3-O-β-d-glucopyranosyl-(1→4)-β-d-galactopyranosyl-(terrestrinin I) [19].

2.2 Two oligosaccharides and other compounds

Two oligosaccharides (1, 2) and a stereoisomer of di-p-coumaroylquinic acid (3) were isolated along with five previously known compounds. The structures of the compounds were established by using spectroscopic methods including 1D NMR and 2D NMR experiments. The compounds were identified as: O-β-d-fructofuranosyl-(2→6)-α-d-glucopyranosyl-(1→4)-β-d-fructofuranosyl-(2→6)-β-d-fructofuranosyl-(2→1)-α-d-glucopyranosyl-(6→2)-β-d-fructofuranoside (1), O-α-d-glucopyranosyl-(1→4)-α-d-glucopyranosyl-(1→4)-β-d-glucopyranosyl-(1→2)-β-d-fructofuranoside (2), 4,5-di-p-cis-coumaroylquinic acid (3) [20].

2.3 Distribution of steroidal saponins in various regions

Samples of *T. terrestris* collected in Bulgaria, Greece, Serbia, Macedonia, Turkey, Georgia, Iran, Vietnam and India were analyzed by LC-ESI/MS/MS for the presence and the concentration of Protodioscin, Prototribestin, Pseudoprotodioscin, Dioscin, Tribestin, Tribulosin and the flavonoid Rutin [21].

2.4 Two furostanol saponins

Two new furostanol saponin were identified as 3-O-{β-D-xylopyranosyl(1→3)-[β-D-xylopyranosyl(1→2)]-β-D-glucopyranosyl(1→4){α-L-rhamnopyranosyl(1→2)β-D-galactopyranosyl}-26-O-β-D-glucopyranosyl-5α-furost-12-one-22-methoxy-3β,26-diol (named as terrestrioside A) and 3-O-{β-D-xylopyranosyl(1→3)-[β-D-xylopyranosyl(1→2)]-β-D-glucopyranosyl(1→4){α-L-rhamnopyranosyl(1→2)β-D-galactopyranosyl}-26-O-β-D-glucopyranosyl-5α-furost-22-methoxy-3β,26-diol [22].

2.5 Two new furostanol glycosides

Two new furostanol glycosides, named terrestrinoses A1/A2, were isolated from the fruits of *Tribulus terrestris* L. and their structures were determined by spectroscopic methods, including 2D NMR experiments [23].

2.6 Five new steroidal saponins

Five new steroidal saponins were identified as (23S,25S)-5α-spirostane-24-one-3β,23-diol-3-O-[α-l-rhamnopyranosyl(1→2)O-[β-d-glucopyranosyl(1→4)]β-d-galactopyranoside] (1), (24S,25S)-5α-
galactopyranoside (terrestrosin D) and (25R,S)-xylopyranosyl(1-3)-Tribulus terrestris glucopyranosyl-(1 → 4)-β-d-galactopyranoside (1) and 26-β-d-glucopyranosyl(1 → 2)-O-β-d-glucopyranosyl(1 → 4)-β-d-galactopyranoside (3) [24].

2.7 Two new furostanol glycosides

Two new furostanol glycosides, named as 26-O-β-d-glucopyranosyl-(25S)-5α-furostan-2α,3β,26-tetraol-(3-O-β-d-glucopyranosyl(1 → 2)-O-β-d-glucopyranosyl(1 → 4)-β-d-galactopyranoside (4) and 26-O-β-d-glucopyranosyl-(25S)-5α-furostan-12-one-22-methoxy-3β,26-diol-3-O-[α-L-rhamnopyranosyl(1 → 2)-O-[β-d-glucopyranosyl(1 → 4)]-β-d-galactopyranoside] (5) [24].

2.11 Alkaloids and other constituents

Three new compounds, terrestribisamide, 25R-spirost-4-en-3, 12-dione and tribulisterine, along with 10 known compounds, N-p-coumaroyltyramine, terestriamide, hecogenin, aurantiamide acetate, xanthosine, fatty acid ester, ferulic acid, vanillin, p-hydroxybenzoic acid and β-sitosterol, were isolated and from dried fruits of Tribulus terrestris. Structures of these compounds were determined by using two-dimensional NMR techniques, and chemical reactions [29].

2.12 Flavonoids

Kaempferol, kaemferol-3-glucoside, kaemferol-3-rutinoside and tribuloside (kaempferol-3-β-d-(6"-p-coumaroyl) glucoside) have been isolated from the fruits and leaves of Tribulus terrestris [30].

2.13 Flavonoid glycosides

Twenty-five flavonoid glycosides were identified in Tribulus pentandrus and T. terrestris. The glycosides major glycosides were belonging to the common flavonoids, kaempferol, quercetin, isorhamnetin and 3-gentiobiosides [31].

2.14 Furostanol saponins

Protodioscin, a new saponin (5, 6-dihydroputratoside) and their respective sulfates were detected. The structure of the new compound was elucidated on the basis of NMR and ESI-MS spectral analysis [32].

2.15 Two sapogenins from

Two new steroidal sapogenins, (5α, 25R)-spirostan-3,6,12-trione and 25R-spirost-4-ene-3,6,12-trione, together with five previously known steroidal sapogenins, tigogenin, hecogenin, gitogenin, hecogenone, and 25R-spirost-4-ene-3,12-dione were isolated. The structures of the new sapogenins were elucidated on the basis of chemical and 2D NMR spectroscopic techniques [33].

2.16 Steroidal saponins

Further investigation on the active principles of the fruits of Tribulus terrestris resulted to the isolation of six new furostanol saponins, named as 26-O-β-d-glucopyranosyl (25R)-furostan-2α,3β,22α,26-tetrol-3-O-β-d-glucopyranosyl (1 → 4)-β-d-galactopyranoside (1), 26-O-β-d-glucopyranosyl(25S)-5α-furostan-2α,3β,22α,26-tetrol-3-O-β-d-galactopyranosyl(1 → 2)-β-d-galactopyranoside (2), 26-O-β-d-glucopyranosyl (25R,S)-5α-furostan-3β,22α,26-triol-3-O-β-d-galactopyranoside (3), 26-O-β-d-glucopyranosyl (25R,S)-5α-furostan-12-one-3β,26-diol (4), 26-O-β-d-glucopyranosyl (25R,S)-5α-furostan-12-one-3β,26-diol (5) [24].

2.10 steroidal saponins

The results of Tribulus terrestris led to the isolation of five new steroidal saponins. The structures of the new saponins were elucidated on the basis of various spectroscopical analytical techniques. The compounds were named as (25R,S)-5α-spirostan-3β-ol-3-O-β-d-galactopyranosyl(1 → 2)-β-d-galactopyranoside (terrestrosin A), (25R,S)-5α-spirostan-3β-ol-3-O-β-d-galactopyranosyl(1 → 4)-β-d-galactopyranoside (terrestrosin B), (25R,S)-5α-spirostan-12-one-3β-ol-3-O-β-d-galactopyranosyl(1 → 2)-β-d-galactopyranoside (terrestrosin C), hecogenin 3-O-β-d-galactopyranosyl(1 → 2)-β-d-glucopyranosyl(1 → 3)-β-d-glucopyranosyl(1 → 4)-β-d-galactopyranoside (terrestrosin D) and (25R,S)-5α-spirostan-2α,3β-diol-3-O-β-d-galactopyranosyl(1 → 2)-β-d-glucopyranosyl(1 → 4)-β-d-galactopyranoside (terrestrosin E) [28].
2.18 Three new saponins

Three new steroidal saponins were isolated from fruits of *Tribulus terrestris*. The structures of the new steroidal saponins were identified as hecogenin 3-O-beta-xylpyranosyl(1→3)-beta-glucopyranosyl(1→4)-beta-galactopyranoside (1), hecogenin 3-O-beta-glucopyranosyl(1→2)-beta-glucopyranosyl(1→4)-beta-galactopyranoside (2) and 3-O-[beta-xylpyranosyl(1→2)-[alpha-rhamnopyranosyl(1→3)]-beta-glucopyranosyl(1→4)-[alpha-rhamnopyranosyl(1→2)]-beta-galactopyranosyl] -26-O-beta-glucopyranosyl-22-methoxy-3 beta,5 alpha,25R-furostan-3,26-diol (3) [36].

2.19 Two new sulfated furostanol saponins

Two new sulfated saponins were isolated from fruits of *Tribulus terrestris*. The structures of the new steroidal saponins were determined as methylpicrotriustin (protostriustin) and sodium salt of 26-O-beta-glucopyranosyl-22alpha-methoxy-(25R)-furost-5-ene-3beta,26-diol-3-O-alpha-rhamnopyranosyl(1→2)-beta-4-O-sulfo-glucopyranosyl(25R)-furost-4-en-22-dione (terrestriinin I) and sodium salt of 26-O-beta-glucopyranosyl-22alpha-hydroxy-(25R)-furost-5-ene-3beta,26-diol-3-O-alpha-rhamnopyranosyl(1→2)-beta-4-O-sulfo-glucopyranosyl(25R)-furost-4-en-22-dione (terrestriinin H).

2.20 Terresoxazine, A novel compound with benzoxazine skeleton

Terresoxazine, a novel benzoxazine derivative was isolated from the fruits of *Tribulus terrestris*. Its structure was determined as 7-hydroxy-3,3a-dihydro-5H-pyrrolo-[1,2-a] [3,1] -benzoxazin-1(2H)-one [38].

2.21 A new furostroidal saponin

The structure of the new furostroidal saponin, named tribulisamide C, was elucidated by using 1D, 2D NMR and chemical methods, as 26-O-beta-D-glucopyranosyl-(25R)-5 alpha-furost-3 beta, 22 alpha,26-triol-3-O-[beta-D-Xylopyranosyl(1→3)] [beta-D-xylopyranosyl(1→2)]-beta-D-galactopyranosyl(1→4)-[alpha-L-rhamnopyranosyl(1→2)]-beta-D-galactopyranoside [39].

2.22 One new cinnamic imide derivative

One new cinnamic imide derivative, named tribulistimide C, was isolated from the fruits of *Tribulus terrestris*, together with three known compounds, N-p-coumaroyltyramine, terrestriamidine, N-transcaffeoyltyramine [40].

2.23 A new feruloyl amide derivative

A new feruloyl amide derivative was isolated from the fruits of *Tribulus terrestris*. The structure was characterised by a unit of pyrrolidine-2, 5-Dione. The structure was determined on the basis of spectroscopic analysis [41].

Table 1 Reported Phytochemicals from fruits of *Tribulus terrestris* L.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Compound Description</th>
<th>Ref.</th>
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<tr>
<td>3</td>
<td>Protodioscin (1), Prototribestin (2), Pseudoprotodioscin (3), Dioscin (4), Tribestin (5), Tribulosin (6) and the flavanoid rutin (7).</td>
<td>Dragomir Dinchev et al. Distribution of steroidal saponins in <em>Tribulus terrestris</em> from different geographical regions, Phytochemistry, Volume 69, Issue1, 2008, Pages176-186.</td>
</tr>
</tbody>
</table>
26-O-β-d-glucopyranosyl-(25S)-5α-furost-20(22)-en-2α,3β,26-triol-3-0-β-d-glucopyranosyl-(1→2)-O-β-d-glucopyranosyl-(1→4)-β-d-galactopyranoside (2).


8 (25R)-furost-5(6)-ene-3β,16,26-triol-3-O-α-rhamnopyranosyl-(1→2)-[α-rhamnopyranosyl-(1→4)]β-glucopyranoside (Tribol).


9 26-O-β-d-glucopyranosyl-(1→3)[β-d-xylpyranosyl-(1→3)] [β-d-galactopyranosyl-(1→2)]-β-d-glucopyranosyl-(1→4)-β-d-glucopyranosyl-(1→3)-[β-d-galactopyranosyl-(1→2)]-β-d-glucopyranosyl-(1→4)-β-d-glcucopyranosyl]-5α-furostan-12-one-3β,22α,26-triol.


9 26-O-β-d-glucopyranosyl-(1→3)[β-d-xylpyranosyl-(1→3)] [β-d-galactopyranosyl-(1→2)]-β-d-glucopyranosyl-(1→4)-β-d-glucopyranosyl-(1→3)-[β-d-galactopyranosyl-(1→2)]-β-d-glucopyranosyl-(1→4)-β-d-glcucopyranosyl]-5α-furostan-12-one-3β,22α,26-triol.


10 (25R,S)-5α-spirost-3β-ol-3-O-β-d-galactopyranosyl-(1→2)-β-d-glucopyranosyl-(1→4)-β-d-glucopyranosyl-26-O-β-d-glucopyranosyl-(25R)-3β,25,26-triol-3-0-β-d-galactopyranoside, hecogenin 3-O-β-d-galactopyranosyl-(1→2)-[β-d-xylpyranosyl-(1→3)]-β-d-glucopyranosyl-(1→4)-β-d-galactopyranoside, (25R,S)-5α-spirostane-2α,3β,26-triol-3-O-β-d-galactopyranosyl-(1→2)-β-d-glucopyranosyl-(1→4)-β-d-galactopyranoside

Tian-Shung Wu et al. Alkaloids and other constituents from Tribulus terrestris. Phytochemistry, Volume 50, Issue 8, 1 April 1999, Pages 1411-1415.

11 Terrestroside A, 25R-spirot-4-en-3,12-dione, Tribulusterine


12 Kaempferol, Kaempferol-3-gluicoside, Kaempferol-3-rutinoside, Tribuloside (kaempferol-3β-d-(6”-p-coumaryl) glucoside.


13 Flavonols, Kaempferol, Quercetin and Isorhamnetin, 3-gentiobiosides.

Yi-Xin Xu et al. Two sapogenins from Tribulus terrestris. Phytochemistry, Volume 49, Issue 1, 3 September 1998, Pages 199-201.

14 5, 6-dihydropodotidioscin (neopodotidioscin).


15 (5α, 25R)-spirost-3-6,12-trione, 25R-spirost-4-en-3,6,12-trione

Yi-Xin Xu et al. Two sapogenins from Tribulus terrestris. Phytochemistry, Volume 49, Issue 1, 3 September 1998, Pages 199-201.

16 26-O-β-d-glucopyranosyl-(25R)-furostane-2α,3β,26-tetrol-3-O-β-d-glucopyranosyl-(1→4)-β-d-galactopyranoside (Terrestroside F), 26-O-β-d-glucopyranosyl-(25R)-furostane-2α,3β,26-tetrol-3-O-β-d-galactopyranosyl-(1→2)-β-d-glucopyranosyl-(1→4)-β-d-galactopyranoside (Terrestroside G), 26-O-β-d-glucopyranosyl-(25R)-5α-furostan-3β,22α,26-triol-3-0-β-d-galactopyranoside, 26-O-β-d-glucopyranosyl-(25R)-5α-furostan-12-one-3β,22α,26-triol-3-O-β-d-galactopyranoside, (25R)-5α-furost-5-ene-3β,22α,26-triol-3-O-β-d-glucopyranosyl-(1→2)-β-d-galactopyranosyl-(1→4)-β-d-galactopyranoside (Terrestroside I), 26-O-β-d-glucopyranosyl-(25R)-5α-furost-20(22)-en-12-one-3β,26-diol-3-O-β-d-galactopyranosyl-(1→2)-β-d-galactopyranoside (Terrestroside J). 26-O-β-d-glucopyranosyl-(25R)-5α-furost-20(22)-en-12-one-3β,26-diol-3-O-β-d-galactopyranoside (Terrestroside K).


17 Tribulosamines A and B


20 7-hydroxy-3, 3α-dihydro-5H-pyrrole-[1, 2-a] [3, 1]-benzoazin-1(2H)-one (Terressoxazine).


22 Tribuloside C

LV, AL et al. One new cinnamic imide derivative from the fruits of Tribulus terrestris. Natural Product Research, Volume 22.

23 Pyrrolidine-2, 5-Dione

Fig 3: Steroidal saponins (Terrestrosin F-K)

Scheme 1. Chemical formulas of compounds 1-6 and prosapogenins 15, 25, 35 and 45.

Fig 4: Alkaloids

Terrestribisamide (1)

25R-Spirosterol-4-en-3,12-dione (2)

Tribulusterine (3)
Fig 5: Two oligosaccharides

Fig 6: A flavonoid

Fig 7: 1a /1b; Terrestrinones 1a /1b

Fig 8: Steroidal sapogenins
(5α, 25R)-Spirostan-3, 6, 12-trione, 25R-spirostan-4-ene-3, 6, 12-trione, tigogenin, hecogenin, gitogenin, 25R-spirostan-4-ene-3, 12-Dione.

Fig 9: Steroidal glycosides: Hemogenin 3-O-β-d-glucopyranosyl (1→4) - β-d-glucopyranoside (1), 26-O-β-d-glucopyranosyl-3-O-[β-d-xylopyranosyl(1→3)]β-d-galactopyranosyl(1→2)-β-d-glucopyranosyl(1→4)-β-d-glucopyranosyl]-5α-furostan-20(22)-en-12-one-3β,26-diol (2), 26-O-[β-d-glucopyranosyl-3-O-]-β-d-glucopyranosyl(1→4)-[β-d-galactopyranosyl(1→2)]-β-d-glucopyranosyl(1→4)-β-d-glucopyranosyl]-5α-furostan-12-one-3β,22,26-triol (3).
Fig 10: Tribol (1), Spirostanol saponins 2 and 3

1. \( R_1 = \beta-D-Glc \quad R_2 = -\beta-D-Glc^{4}\beta-D-Glc^{3}\beta-D-Xyl \)
   Ps1. \( R_1 = -\beta-D-Glc \quad R_2 = H \)

2. \( R_1 = -\beta-D-Glc \quad R_2 = -\beta-D-Glc^{4}\beta-D-Glc^{3}\beta-D-Xyl \)

3. \( R_3 = -\beta-D-Glc^{4}\beta-D-Glc \)

Fig 10: Steroidal saponins

1. \( R = H \)
   2. \( H_{12} \)
   3. \( SO_3Na \)

Fig 11: Steroidal saponins
CONCLUSION

In this review many classes of natural secondary metabolites were reported from the fruits of Tribulus terrestris Linn. Mostly saponins and glycosides of various classes were reported. Biological activities such as aphrodisiac, immunomodulatory, antidiabetic, hypolipidemic, cardioactive, hepatoprotective, anti-inflammatory, antispasmodic, anticancer, antibacterial, anthelmintic and anti-geriatric were reported from various fruit extracts. The aim of this review is to create a database for the isolated active principles and to create further investigations of the discovered phytochemicals of this plant to promote research. This will help in its value-added utility, eventually leading to higher revenues from the plant.

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