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A Review on Phytochemical Profile and Biological Activities of Three Anti-Inflammatory Plants used in Sudanese Folkloric Medicine

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ABSTRACT

Plants are potent biochemical factories and have been components of phytomedicine. Since time immemorial man is able to obtain from them a wondrous assortment of industrial chemicals. Plant-based natural constituents can be derived from any part of the plant like bark, leaves, flowers, roots, fruits, seeds, etc., which may contain active components. Sudan with its uniquely variable climatic conditions possesses a huge wealth of flora. *Capparis decidua* Family (Capparidaceae), *Cyperus rotundus* Family (Cyperaceae) and *Tribulus terrestris* Family (Zygophyllaceae) were used successfully in Sudanese folkloric medicine for treatment of inflammatory disorders. The present review described Botanical description, biological activities and phytochemical profile of these three plants.

Keywords: *Capparis decidua*, *Cyperus rotundus*, *Tribulus terrestris*, inflammatory disorders

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INTRODUCTION

Many hope traditional herbal medicine research will play a critical role in global health. China, India, Nigeria, the United States of America and WHO have all made substantial research investments in traditional herbal medicines¹. Industry has also invested millions of dollars looking for promising medicinal herbs and novel chemical compounds^{2,3}.

Traditionally, people have been using powerful anti-inflammatory plants for thousands of years as part of their diet and pharmaceutical arsenal, which have been found to have anti-inflammatory properties⁴, though relatively little knowledge about their mechanism of action⁵. Recently, the public is becoming increasingly aware of problems with the over prescription and misuse of traditional anti-inflammatory drugs. In addition, many people are interested in having more autonomy over their medical care⁶.

Sudan with its uniquely variable climatic conditions possesses a huge wealth of flora, cultivated or wild. These found their way to folk medicine and are used widely and effectively for the treatment of various human and animal ailments, especially by natives in rural areas. *Capparis decidua* Family (Capparidaceae), *Cyperus rotundus* Family and *Tribulus terrestris* Family (Zygophyllaceae) are three plants used successfully in Sudanese traditional medicine for treatment of inflammatory disorders.

***Capparis decidua* Family (Capparidaceae) :**

Armed; much-branched shrubs or small trees up to 3m high. Bark smooth green turning whitish grey when old. Branches with stipules prickly up to 0.5 cm long. Petioles about 1mm long, glabrous, leafless except on young shoots. Inflorescences are lateral and terminal fascicles or corybose racemes. Flowers pink, about 2-2.5cm, 2-5cm. Pedicels about 1cm long. Sepals unequal, anterior outer sepals larger and deeply saccate, slightly imbricate or subvavate, gynophore 1-2cm long. Fruits globes, pointed, pink, 0.5-1.5cm across, edible, seeds many⁷.

Capparis decidua is widely distributed in typical of deserts and semi- deserts of northern and central Sudan especially on sandy soils and in low rainfall savanna on clays⁷. It is also found in Blue Nile, Upper Nile, western and eastern Sudan besides northern areas of the country⁸. It is known by various names, e.g. Caper (English), Kabbar (Arab), Alcaparro (Spain), Gollaro (Pakistan)⁹, Al Tundub (Sudan)¹⁰.

Ethnomedical uses :

Roots, leaves, buds, fruits, barks and seeds of *C. decidua* were used by ancient people for medicinal purposes, to treat some diseases such as rheumatism, stomach problems, headache and

toothache ⁹.

In ancient time, roots were consumed by ancient Egypt and Arab for treatment of scorpion's stings and they used leaves for skin disease and to treat earache ⁹. Ancient Romans used flowers to serve as a stimulant to increase erection and soothe pains ⁹. Fruits were used by ancient Greek to treat convulsions. Seeds served as a medication by ancient Arab and to accelerate menstruation by ancient Egypt and ancient Greek ⁹. In Pakistan, people use all parts of *C. decidua* as anti-rheumatic, to cure arteriosclerosis and migraine; as analgesic and as anti-hemorrhoid agent ⁹.

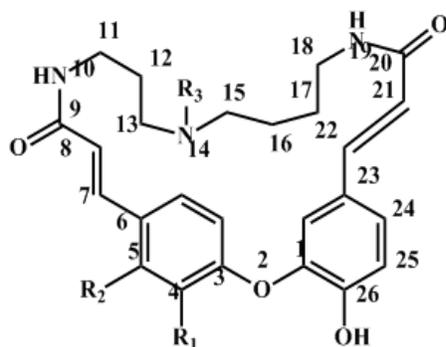
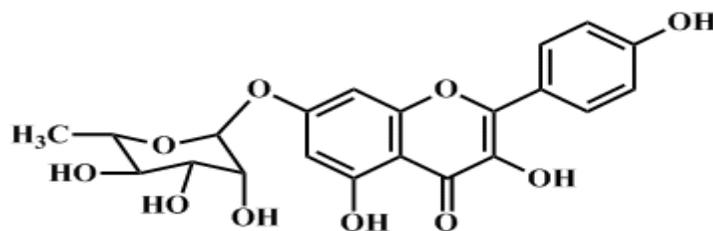
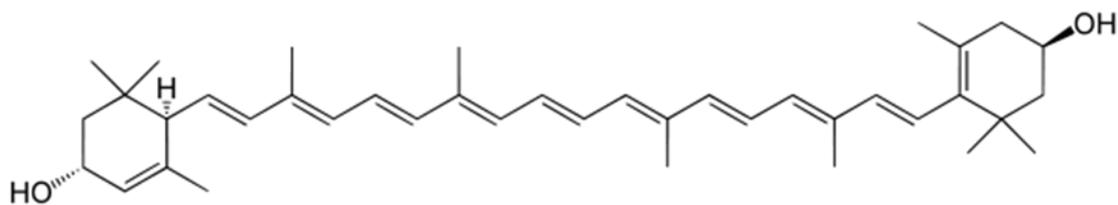
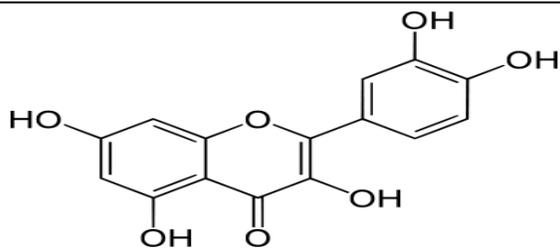
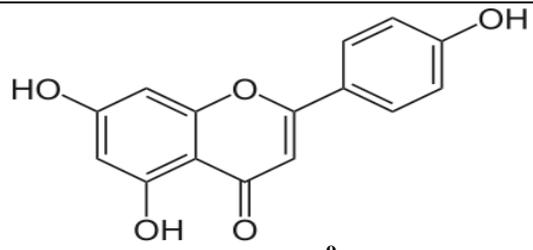
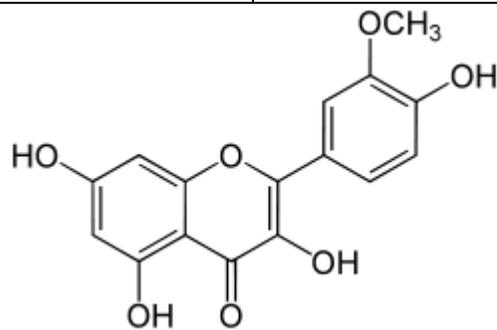
C. decidua is one of the most common aromatic plants found in the Mediterranean Basin. The fresh aerial parts, specially the pickled flower buds, unripe fruits and shoots, are stored in salt, vinegar or brine and used as an appetizer with olives, cheese, and nuts or as a complement to meat, salads, pasta, and other foods ⁹.

In Sudan *C. decidua* is used as anthelmintic, analgesic, aphrodisiac, carminative, diaphoretic, emmenagogue and laxative. The bark extract is used in asthma and cough. The paste of young leaves and branches are applied as plaster on boils and swelling ¹⁰, anti-inflammatory, astringent, stomachic, laxative, antidote, and used for skin diseases ¹¹. The decoction of fresh twigs is kept for 2 – 3 days and then taken against jaundice, the fumigation of the stems are used as anti-rheumatic ¹². The water extract of the stems is used against jaundice. The stems are used as a poultice for swelling and joint pains ⁸ the poultices of the twigs are used against head-ache ¹³. A decoction prepared from the roots is used to relieve fever and is also used for jaundice. As fumigation, roots are used to treat fever and rheumatism ¹⁴. The aerial part is used for rheumatism, gout; externally the infusion is used for boils, eruption and ulcers, while internally as antidote to poisons ¹⁵.

Phytochemical profile and biological studies:

A spermidine alkaloid, isocodonocarpine, one is 14-Nacetylisocodonocarpine and the second is 15-N-acetylcapparisine were isolated from roots, while oxygenated heterocyclic constituents were isolated from the alcoholic extract of root-bark. Seed oil is also rich in tocopherols (as vitamin E) with the presence of three isoforms: α -tocopherol, γ -tocopherol and δ -tocopherol, Carotenoids (lutein and β -carotene), Glucosinolates (main glucosinolate is glucocapperin), and 2-Hydroxyethyl glucosinolate. flavonoid glycosides were isolated from the aerial parts and identified ⁹.

Name	R1	R2	R3
Isocodonocarpine	OCH ₃	H	H
14-Nacetylisocodonocarpine	OCH ₃	H	CH ₃ -CO-
15-N-acetylcapparisine	H	CH ₃ -O-	CH ₃ -CO-

Spermidine alkaloid from *Capparis decidua*⁹Kaempferol-7-rhamnoside⁹Lutein⁹Quercetin⁹Apigenin⁹Isorhamnetin⁹

The powdered fruit of *C. decidua* possesses a positive action against alloxan-induced oxidative stress and diabetes in rat; these results were possibly due to the action of these alkaloids on various targets for the treatment of diabetes and their multiple therapeutic effects. These facts explain their use by old people to treat diabetic disease⁹.

Unripe fruit of *C. decidua* reduce plasma triglycerides, total lipids and phospholipids concentration. This is probably due to the vitamins, alkaloids and phenolics especially flavonoids. It was reported that these compounds induce a significant lipid lowering activity and improves dyslipidemia to hypercholesterolemic and hypertriglyceridemic rats. This finding supports its use to cure arteriosclerosis by people⁹.

C. decidua seeds extract showed antibacterial activity, agglutinated and killed the parasites Leishmani. Moreover, it has antifungal activity against *Trichophyton mentagrophytes* and *Trichophyton violaceum*⁹. Different extracts isolated from *C. decidua* can significantly kill or influence the egg delivery response of *Bruchus chinensis* a serious pest of stored food grains and causes damage to cow pea, gram, soybean, and pulses⁹, these activities were probably due to the quaternary ammonium and glucosinolates. Other authors suggested that many plants increase their secondary metabolites including glucosinolates in response to attack by insects and microbes. These results can explain the use of this plant by people to kill worm in the ear⁹.

C. decidua buds extract caused a dose-dependent inhibition of lipid auto-oxidation in heated red meat, incubated with simulated gastric fluid. The extract exhibited a dose-dependent peroxy radical scavenging activity; this protective effect may be due to the richness of phenolic compounds, tocopherols and carotenoids. Many authors suggested that these compounds have an excellent anti-oxidative property⁹.

C. decidua extract was found to possess significant anti-inflammatory activity against carrageenan induced oedema in rats, it's probably due to the anti-inflammatory effect of phenolic compounds, and hence ethanolic extract has a central nervous system depressant and anticonvulsant activities⁹. The leaf oil is composed of isothiocyanates, n-alkanes, terpenoids, a phenyl propanoid, an aldehyde and a fatty acid. The distribution of minerals in buds and fruits shows high content of potassium, phosphorus, magnesium and calcium with the presence of sodium, manganese and iron. Lipids and proteins are also quantified in buds and fruits⁹.

***Cyperus rotundus*. L Family (Cyperaceae):**

Is a perennial sedge that is distinguished by its thin long creeping thread-like squamous rhizome, which often produces long lines of small rosettes of leaves along the ground and swollen into white tubers that succulent when young, turning brown or black and fibrous with age. The tuber

size is about the size of a hazelnut. Stems are thin triangular, nodeless and leafy only at the bottom. There is a simple or compound umbel of Spikelets at the ends of stems tops; the spikelets are linear, reddish-brown in colour flowered ¹⁶. Individual seeds are achenes, which are ovate or oblong-ovate, three-angled, dull olive-gray to brown or black in colour. Two or three leaves emerge from the ground simultaneously ¹⁷.

Family Cyperaceae consist of about 70 genera and 600 species. They are spread throughout all continents in both hot and temperate regions. It is an annual or perennial plant. Common names include Papyrus, Flat, Nut, Umbrella sedges and Galingales ¹⁶. Other vernacular names are Arabian, Saadkufi; English, Nut grass; Japanese, Hamasuge; Sanskrit, Mustaka; Hindi, Korehijar; Bengali, Moothoo; Nepalese, Kashur; Sinhalese, Kalanduru; Chinese, Hiang fou; German, Grasmandel; French, Souchet; Unani, Nagarmotha; Persian, Mushk-e-zamin; Tibetan, Gla-gan; Burmese, Rumput halia hitam ¹⁸.

Cyperus species has been described as "the world's worst weed," having a presence in over 90 countries, and infests over 50 crops worldwide. Many members of this family have proved as food and medicine ^{19,20}.

Ethnomedical uses :

Cyperus rotundus has a broad spectrum of applications as herbal remedies in China, Africa, Latin America, India, Saudi Arabia and Sudan ¹⁹.

In Asian countries, *Cyperus rotundus* the rhizomes are used as traditional folk medicines for the treatment of spasms, stomach disorders, bowel disorders and inflammatory diseases ²¹. In Chinese pharmacopoeia, it was described as an agent to regulate circulation, normalize menstruation, and relieve pain ²².

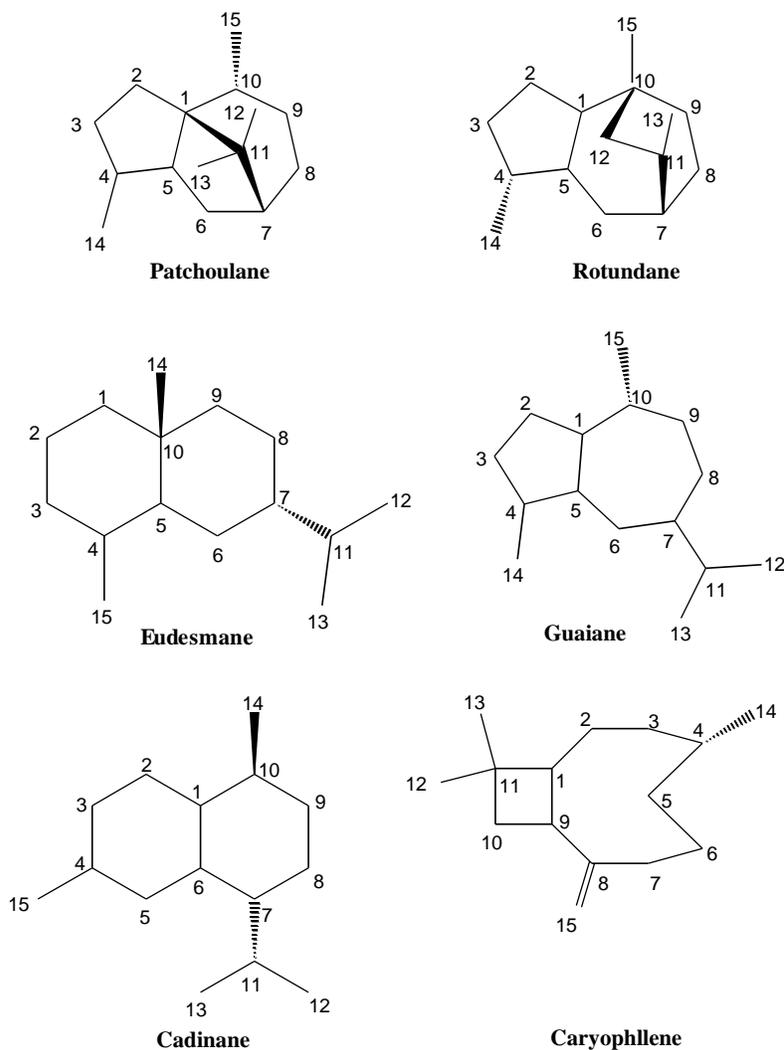
In Sudan the tubers of *Cyperus rotundus* L. are used in stomach disorders and bowels irritation. An infusion of the tubers is used in dyspepsia, diarrhea, dysentery, ascites, vomiting, cholera and fevers. The tubers are given in large doses as an anthelmintic. A poultice of the fresh tubers is used to cure wounds, ulcers and sores; it is also applied to the breast to promote the flow of milk. Paste is used in scorpion stings ¹³.

Phytochemical profile and biological studies:

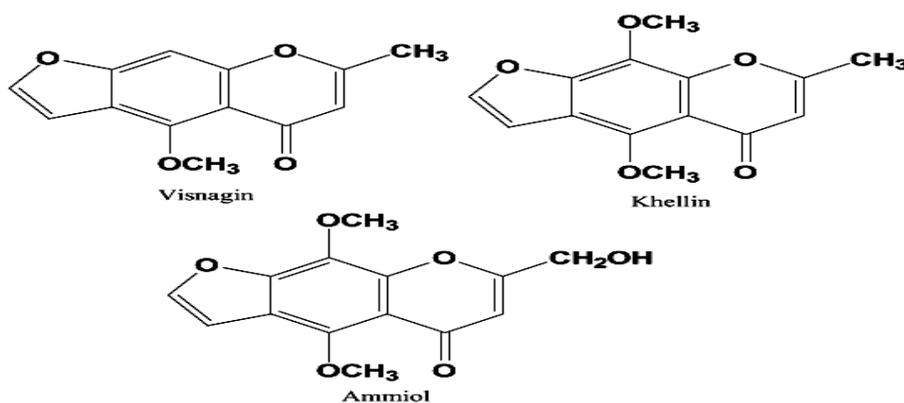
C. rotundus was thoroughly investigated for their secondary metabolites such as sesquiterpenes (with diverse skeletons such as patchoulane, rotundane, eudesmane, guaiane, cadinane and caryophyllene types), quinones, flavonoids (Visnagin, khellin, ammiol, isorhamnetin, and tricin), saponins, alkaloids, phenolic acids (Salicylic acid, protocatechuic acid, caffeic acid and *p*-

coumaric acid), coumarins and steroids (Steroidal glycoside, Sitosteryl-(6'-hentriacontanoyl)- β -D-galactopyranoside)²².

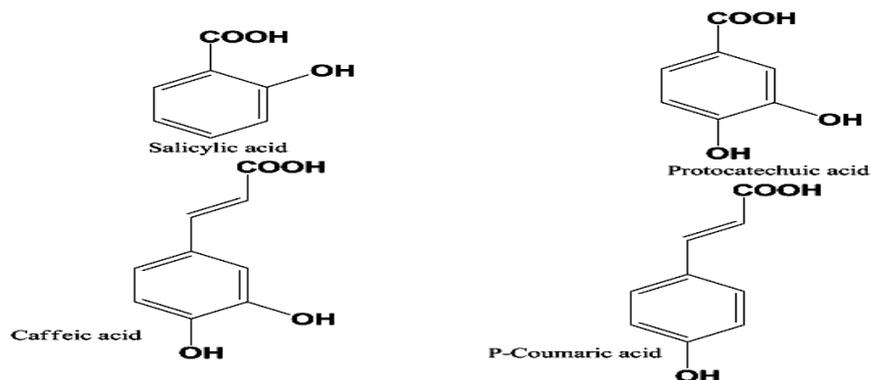
Approximately 1% of the tuber's weight consists of essential oils. The major components of the oil are α - and β -cyperol (40 to 49%), α - and β -cyperene (30 to 40%) and cyperone (0.3%)²².



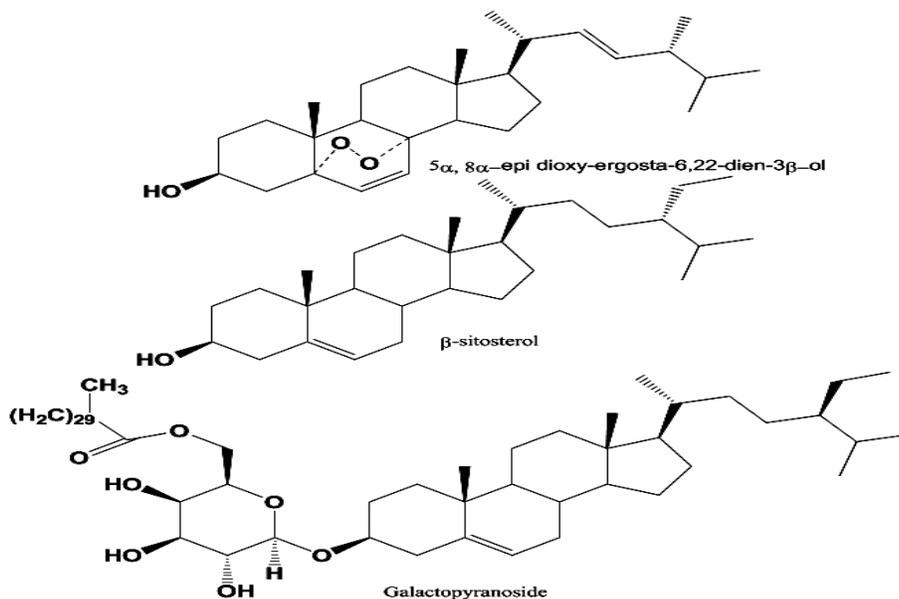
Basic Structures of Various Sesquiterpene Types in the Genus *Cyperus*²³



Structures of Furochromones Isolated from *C. rotundus*



Structures of Phenolic Compounds Isolated from *C. rotundus*



Structures of Steroidal Compounds Isolated from *C. rotundus*

The methanolic extract of the tubers showed an anti-inflammatory effect for the treatment of inflammatory diseases mediated by over production of nitric oxide and superoxide²¹. Moreover, it showed significant antidiarrhoeal activity in castor oil induced diarrhea in mice²⁴. The dried tubers are used to treat dysmenorrhea and other menstrual irregularities. The aqueous extract of the dried tubers has an inhibitory effect on the uterus, (uterine relaxation) in both pregnant and non-pregnant women, and relieving pain. The herb can stimulate gastric and salivary secretion. In addition, the aqueous extract of the dried tubers has antibacterial and anti-malarial effects²².

The growth and acid production of *Streptococcus mutans* were reduced by the tuber extract of *C. rotundus* - *S. mutans* is known as the causative bacteria in the formation of dental plaque and dental caries - Moreover, the same tuber extract inhibited the adherence of *S. mutans* to saliva-coated hydroxyapatite beads. Glucosyltransferase enzyme, which synthesizes water-insoluble glucan from sucrose, was also inhibited by the tuber extract. So, these results suggested that *C.*

rotundus may inhibit cariogenic properties of *S. mutans*²⁵. *n*-Hexane extract of the tubers of *C. rotundus* proved to be a new herbal supplement for controlling body weight because it induced a significant reduction in weight gain without affecting food consumption or inducing toxicity²⁶. Also, *C. rotundus* extract has antihyperglycemic and antioxidant activities^{27,28}.

***Tribulus terrestris* L. Family (Zygophyllaceae):**

Tribulus terrestris is a taprooted herbaceous perennial plant that grows as a summer annual in colder climates. 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 upwards in shade or among taller plants. The leaves are pinnately compound with leaflets less than 6 mm (a quarter-inch) long. The flowers are 4–10 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. The nutlets or "seeds" are hard and bear two to three sharp spines, 10 mm long and 4–6 mm broad point-to-point. These nutlets strikingly resemble goats' or bulls' heads; the "horns" are sharp enough to puncture bicycle tires and lawn mower tires and to cause painful injury to bare feet²⁹.

Family Zygophyllacea includes around 285 species in 22 genera, native to warm temperate and tropical regions of the Old World in southern Europe, southern Asia, throughout Africa, and Australia. It can thrive even in desert climates and poor soil. *Tribulus terrestris* L. is a well known and widely distributed species of the genus *Tribulus*. It is known with several common names including puncture vine, bindii, bullhead, burra gokharu, caltrop, cat's head, devil's eyelashes, devil's thorn, devil's weed, goat head, puncture vine, and tackweed. Arabic names: Al-Gutub, Qutiba, Hasak or Ders El-Agouz³⁰.

Ethnomedical uses :

Tribulus terrestris is known for its use in the traditional medicine of many countries for treatment of cardiac diseases, edema, eye trouble, skin itch and impotence³¹.

The fruits of *Tribulus terrestris* are a famous traditional Chinese medicine. In the Shern- Nong Pharmacopoeia (the oldest known pharmacological work in China) it is described as a highly valuable drug used to restore the depressed liver for the treatment of fullness in the chest and mastitis and also used to dispel the wind and clear the eyes for the treatment of acute conjunctivitis, headache, vertigo³², edema, abdominal distention, emission and morbid leucorrhea as well as vitiligo³³.

It is also used in the folk medicine of India, it known in Ayurveda for its anti-urolithiatic, diuretic and aphrodisiac properties³⁴. In Sudan the Infusion of the aerial parts is used as demulcent and in

renal nephritis.

Preparations containing *T. terrestris* extracts are on sale in USA as food supplements with claim of a general stimulating action on motor activity, muscle tone and restorative tonic for vigor. Indeed, *T. terrestris* preparations are mainly used to improve performance in sports and for the treatment of impotency³⁵.

The saponin fraction of this plant finds application in the contemporary medicine as a component of drugs effective in treating impotence (Tribestan in Bulgaria and Libillov in USA) and cardiovascular diseases (Xin-naoshu- tong in China). It is also included in many dietary supplements claimed to have a biostimulating activity³¹.

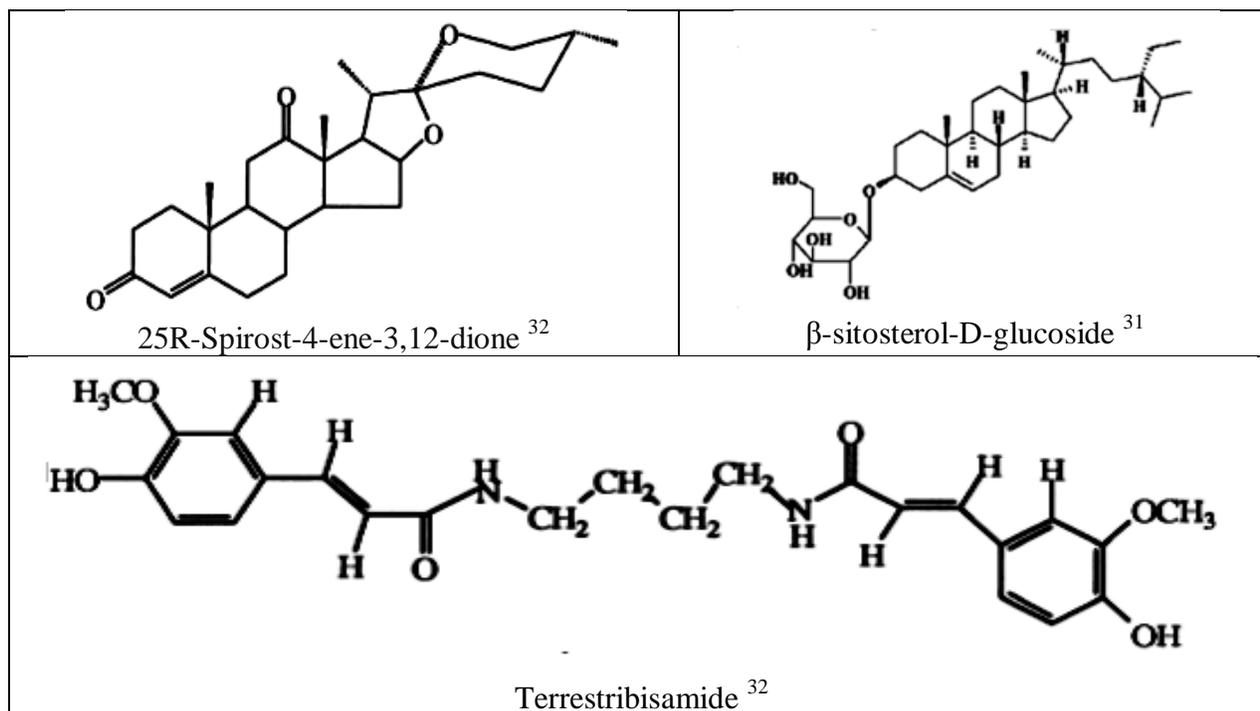
Recently, a new drug named Xinnao Shutong was made of the crude saponin fraction of this plant which showed significant effects for the treatment of various cardiac diseases including coronary heart disease, myocardial infarction, cerebral arteriosclerosis and the sequelae of cerebral thrombosis³⁶.

Phytochemical profile and biological studies:

Tribulus terrestris is reported to contain steroidal saponins, alkaloids, lignanamides, carbohydrates and flavonoids³⁴. Several studies have shown that steroidal saponins are among the compounds responsible for the biological activities of *T. terrestris* extracts³⁵.

The steroidal saponins isolated from the fruits of *T. terrestris* include furostanol saponins and spirostanol saponins³³. Spirostanol saponins bearing a sugar chain linked to C-3 and furostanols carrying a sugar chain at C-3 and a D-glucose residue at C-26. The spirostanols contain mainly diosgenin, tigogenin and gitogenin as aglycones. Moreover, two monosulfated saponins have been recently characterized³⁵.

β -sitosterol-D-glucoside³¹; flavonoid rutin, Saponins with a cis A/B – rings juncture; 4,5-di-p-cis-coumaroylquinic acid; 4,5-di-p-trans-coumaroylquinic acid³⁰; terretribisamide; N-p-coumaroyltyramine; terrestriamide; aurantiamide acetate; tribulusterine ; xanthosine; fatty acid ester; ferulic acid; vanillin, p- hydroxybenzoic acid were isolated and characterized from dried fruits of *Tribulus terrestris*³². Sulphated spirostanol and furostanol saponins are isolated only from *T. terrestris* of Bulgarian origin³⁷.



The crude extract of the dried fruits of *T. terrestris* showed significant anti-inflammatory and immunosuppressive activities³², while the hydroalcoholic extract is active against the nematode *Caenorhabditis elegans* (anthelmintic properties)³⁴ and have long been used for their androgenic activity. New evidence has shown that saponins from the plant have a cytostatic activity against cancer cells³⁸. The total ethanolic extract fractions and isolates of the plant have antioxidant activity;³⁰ it is also included in many dietary supplements³¹. *Tribulus terrestris* is also reported to have antimicrobial, anti hypertension, diuretic, anti acetylcholine and haemolytic activities. It also stimulates spermatogenesis and increase the libido³². *Tribulus terrestris* is reported to have antimicrobial, antihypertension, diuretic, antiacetylcholine, haemolytic & anti oxidant activities³⁰.

CONCLUSION:

In Sudan these plants were used as a natural source for pharmaceutical purpose designed for anti-inflammatory activity and may provide a new lead pharmacophore for more potent analogues; particularly the current review showed that the three plants contains different secondary metabolites and showed different biological activities considered as inflammation or related to inflammation process.

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