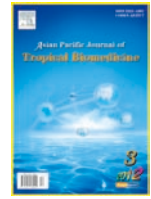




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# Traditional uses, phytochemistry and pharmacology of *Tecomella undulata*— A review

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## ABSTRACT

The aim of the present review is to present comprehensive information of the traditional uses, phytochemistry and pharmacology of *Tecomella undulata* (Family, Bignoniaceae) and to discuss future scope of research. *Tecomella undulata* (TU) is commonly known as desert teak (ver. Rohiro) and is traditionally for treating liver and spleen diseases, tumours, conjunctivitis, hepatosplenomegaly, syphilis, gonorrhoea, hepatitis, as a blood purifier and in wound healing. Compounds such as naphthaquinone derivative, iridoid glucoside, phytosterol, fatty alcohol, flavonols, flavonoid glucoside and triterpenoids have been reported from TU. Anti HIV, anti bacterial, anti microbial, immune modulator, analgesic and hepatoprotective activities have been reported from its various aerial parts. In the present review, attempts have been made to compile research reports on TU, to assess current research trends with possible future avenues of research.

## 1. Introduction

Indigenous herbal medicines have been popular since time immemorial and recently have also commanded major attention worldwide due to their potential nutraceutical values [1]. According to The World Health Organization, more than 80% of the world population in developing countries depends primarily on plant based medicines for basic healthcare needs [2]. *Tecomella undulata* (Family, Bignoniaceae) is commonly known as ammora (in English) or Rohida and is locally known as honey tree, desert teak, marwar teak or white cedar. It is widely distributed in Arabia, southern Pakistan and northwest India up to an elevation of 1200 meters. In Pakistan, it is found in Baluchistan and Sind [3]. *Tecomella undulata* gained prominence due to the presence of secondary metabolites with therapeutic potentials. As a result, a significant number of articles have been published spanning over the second

half of the 20th century. Phytochemical studies of plant parts have lead to identification of pharmacologically relevant compounds such as Iridoid Glucoside [4], naphthoquinone [5,6], phytosterols, flavonoid glycoside, flavonol [7], fatty alcohol [8] fatty acid [9] and triterpenoids [10]. It is reputed to be of considerable medicinal value in Ayurveda [11–12] and traditionally, it is extensively used for treatment of several diseases like liver, spleen, internal tumours, diseases of abdomen, wound healing, conjunctivitis, hepatosplenomegaly, blood purifier, syphilis, gonorrhoea and rewarding in hepatitis [3]. Pharmacological studies have reported its Anti-HIV [13], Antibacterial Activity [14, 15], analgesic and anti inflammatory [16], antioxidants [17], hepatoprotective [3]. Therefore, we aimed to compile an up to date and comprehensive review that covers the current knowledge on morphology, phytochemistry, traditional uses and biological effects possessed by *Tecomella undulata*.

## 2. Taxonomy and cultivation

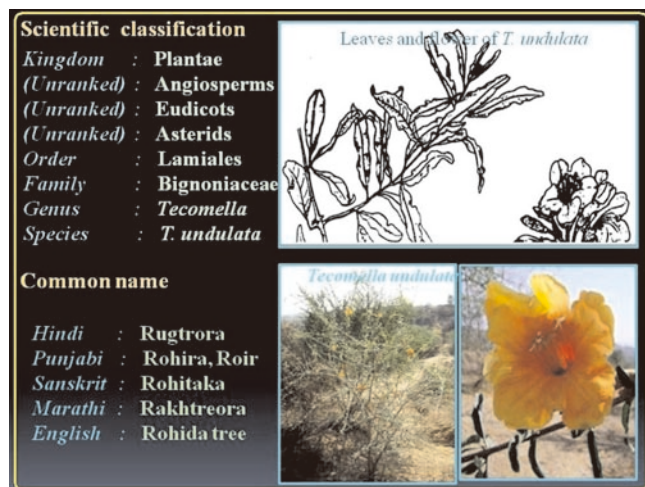
Bignoniaceae is a vast family of flowering trees and

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shrub comprising of 120 genera and nearly 800 species found in tropical and subtropical areas [18]. Taxonomical classification, common names and photographs of leaves, Flower and plant of *Tecomella undulata* are given in Figure 1.



**Figure 1** Taxonomical classification, common names and photographs of leaves, flower and plant of *Tecomella undulata*

In India, it occurs naturally in Rajasthan, Punjab, Haryana, Gujarat and Maharashtra. It is also distributed in sub-Himalyan tract from gonda (Uttar Pradesh), eastward to Bengal, Sikkim and Assam west, in western ghat and Andmans. The species is mainly found to occur in western parts of Rajasthan such as Barmer, Jaisalmer, Jodhpur, Pali, Ajmer, Nagaur, Bikaner, Churu and Sikar districts. It is a deciduous or nearly evergreen tree of arid and semi arid regions [19]. It occurs on flat and undulating areas including gentle hill slopes and sometimes also in ravines. It is well adapted to drain loamy to sandy loam soil having pH 6.5–8.0. The species thrives very well on stabilized sand dunes, which experience extreme low and high temperatures. It grows in areas of scanty rainfall (annual 150–500mm) and high temperature (35 °C to 48 °C). It can withstand extreme low temperature (0 °C to – 2 °C) during winter and high temperature (48 °C to 50 °C) in summers. The tree is a strong light demander. It is drought, frost, fire and wind hardy. At the time of flowering (December–February) it produces beautiful showy flowers in yellow, orange and red colours. Three types of flower bearing trees can be observed near to each other in the same vicinity [20]. It is rarely hardy and resistant to drought and used for forestation and landscaping of dry tracts. The tree is propagated from seeds and cuttings. The leaves are squarish, alternate, rounded at the tips with opposite, entire; lamina elliptic–oblong to elliptic–lanceolate or linear–oblong, 35–95 x (8–) 10–20 mm, margin undulate, petiole 6–18 mm long. The wood is grayish or yellowish brown, close grained and mould with light streaks and is tough, strong and durable. Bark of young plant is soft and greenish brown and it is hard and dark brown in tree. Its bark is up to 8 mm. thick in fully matured tree Flowers

are pale yellow or deep orange–red, showy, large, 6.5 – 7.5 cm. long in corymbose racemes, arrange in few flowered from short lateral branches [3]. Fruit is capsule, slightly curved, 15–20 cm long pods, 8 mm broad, thin, flattened and slightly crooked and seeds are winged, 2cm long and 8 mm broad. Rohitaka blooms in the month of April of May and bears fruits, there after and seeds of *Tecomella undulata* are winged [21].

### 3. Ethno medicinal uses

*Tecomella undulata* occupied a reputed position of having valuable medicinal properties in both folk and classical streams of indigenous medicinal systems. Medicinal usage on various plant parts of *Tecomella undulata* in indigenous system of medicines in India and other countries is outlined below:

It is pungent, astringent and bitter in taste; it has post digestive effect and has cold potency. It alleviates kapha and pitta doshas. It has a special potency (prabhava) as bhedana – accumulation breaking herb, plihāsankocaka – contracts the spleen and as a bhūtapīdanāsaka – averts the evil powers. It possesses light and dry attributes. It is used in the diseases like ascites, liver and spleen disorders, obesity, tumors, blood disorders, flatulence, abdominal pain and cough [21].

#### 3.1. Bark

Bark of TU has great medicinal value and is used for medicinal purpose, externally as well as internally. Externally, the paste of its bark skin is applied on traumatic wounds, associated with haematoma. It also promotes wound healing. In conjunctivitis, the juice is instilled into eyes, with great benefit. Internally, the powder of bark skin is given along with ghee in gaematoma. It is specially recommended in ascites with hepatosplenomegaly. It is an excellent blood purifier and cholegogue, hence, rewarding in hepatitis. It is also used in curing urinary disorder, enlargement of spleen, gonorrhoea, leucoderma, liver diseases and remedy for syphilis [21].

According to ayurvedic classical texts TU is specially used for treating various abdominal ailments including Ascitis. Charaka prescribed powder bark, its decoction and extract in clarified butter in treating jaundice, enlarge spleen, anaemia, intestinal worms, and urinary disorders [9]. Ladies of tribal communities of Samahni valley (Pakistan) take bark powder with hot milk for abortion [22]. Also, in some parts of India, bark and wood of Rohitaka is soaked in water for two days, distillate then obtained is used for treating eczema [23]. It is reported to be a potent blood purifier and is extremely useful in treating syphilis, gonorrhoea and gout. As a keen stimulant for digestive system, it is rewarding in the treatment for piles, anorexia, flatulence, tumors and worm

infestations [24]. It is used for liver ailments and possesses pain relieving properties. Bark is used to treat skin disorder, jaundice, liver disorders, diabetes, cancer and obesity. It is also used as tonic for animals for recumbent animal. The bark of the tree is ground to a powder and 100g of the same is administered daily till the animal recovers [23].

### 3.2. Seeds

Tecomella seeds crushed with pinus leaf extract are taken to cure haemorrhoids. It is also used against abscess [22].

### 3.3. Root

The paste of TU root is given internally in leucorrhoea some time its pulp is given along with rice water [9].

### 3.4. Flower

Traditionally in Musakhel, Pakistan its flowers are used for treating hepatitis [19].

## 4. Ayurvedic formulations

Various formulation of *Tecomella undulata* is available in market some of them are listed here: Rohitakaarishta (based on Bhaishajya Ratnaavali) is the only classical compound available over the counter and is being prescribed in liver and spleen diseases, oedema and anaemia. Other classical, compounds Rohtakaadya Churna, Rohitaka Ghrita, Rohitaka–lauha, are no more available. Ayurvedic brightening and fair complexion mask and lower back massage oil is prepared from this plant in combination with other plants. One patent was found on its medicinal application for immuno–compromised conditions [22]. It

is incorporated into several commercial hepatoprotective formulations as Rohitakghrita, Rohitakarishtha, Herboliv, Livo–plus, Hepato–100, Amlycure, Liv–52 and Himoliv [25].

## 5. Phytochemistry

*Tecomella undulata* has received particular attention by the researchers and, as a result, a significant number of articles have been published. Starting from the second half of the 20th century, several phytochemical studies were performed to investigate the composition of different plant extracts, leading to the isolation and identification of pharmacologically relevant compounds such as iridoid glucoside, naphthoquinone [4–6], phytosterols, fatty alcohol, flavonoid glycoside, flavonol [7], fatty acid [9] and triterpenoids [10]. Some previously isolated chemical constituents are listed in Table 1.

## 6. Pharmacology

In recent years many researchers have examined the effect of *Tecomella undulata* used traditionally by indigenous healers and herbalists to support function of various body parts and treat diseases in human and animals. In most cases, research has confirmed traditional experience and wisdom by discovering the mechanisms and modes of action as well as reaffirming the therapeutic effectiveness of plant or plant extracts in clinical studies.

### 6.1. Anti microbial activity

Both aqueous and alcoholic leaf and stem extracts of *T. undulata* showed growth inhibition of *Salmonella typhi*, a

**Table 1**

Phytochemical constituent isolated from *T. Undulata*.

Plant Part	Constituents isolated	Reference
Heart wood	Radermachol, 2–Isopropenylnaphtho [2,3–b]furan–4,9–quinone, Tecomaquinone–I, Alpha–Lapachone, [4]	
	Dehydro–alpha–Lapachone, Cluetyl ferulate	
	Undulatin, Tectoquinone, Deoxylapachol	[5]
	Lapachole	[32]
Heart wood and Root	Tectol	[6]
	Dehydro– $\alpha$ –lapachone	[5]
Heart wood and Bark	$\beta$ –Sitosterol	[6]
Heart wood, bark and leaf	Stigmasterol	[4]
Bark	Undulatoside B	[6]
	Alphanamixinin	[9]
	$\beta$ –Sitosterol	[4, 7]
Leaves	Deterpene, Aphanamixol	[9]
	Triacontanol, Betulinic acid, Oleanolic acid, Ursolic acid	[10]
Flowers	Rutin, Quercetin, Luteolin–7–glucoside	[7]
Seed	Alimonoid, Rohitukin, Linoleic acid, Oleic acid, Stearic acid, Palmitic acid	[9]
Fruit shell	Aphanamixin lactone, Aphanamixolide	[9]

causal organism of typhoid fever. Chandra et al. reported antibacterial activity with methanolic and aqueous extracts of *Tecomella undulata*. They found that plant extracts were more active against Gram-positive bacteria than against Gram-negative bacteria. The most susceptible bacteria were *B. subtilis*, followed by *S. epidermidis*, while the most resistant bacteria were *P. vulgaris*, followed by *S. typhimurium*. The antibacterial activity of aqueous and methanol extracts was determined by agar disk diffusion and agar well diffusion method. The methanol extracts were more active than the aqueous extract [26–27]. Further, Parekh and Chanda [15], reported anti-microbial potential of aqueous and methanolic extract against *B. cereus*, *S. aureus*, *E. aerogenes*, *E. coli* and *K. pneumonia* species.

### 6.2. Anti HIV potential

Biochemical analysis indicated that TU leaves have oleanolic acid, ursolic acid and betulinic acid, compounds that are strong HIV inhibitors. Octadimethyl succinate derivatives of oleanolic acid and betulinic acid have been reported to be 24 times more active than AZT, a drug that is currently used for checking the spread of AIDS [13]. Other compounds isolated from the leaves of *T. undulata* are sitosterol, triacontanol, cirsimaritin, cirilineol, pentatriacontanol and 4, 5-dihydroxy-3, 6, 8-trimethoxy flavone. However; further studies are required to establish the underlying mechanism of TU in curing AIDS so as to develop a novel therapy of herbal origin.

### 6.3. Anti-inflammatory activity

Ahmad et al., 1994 [16] evaluated anti-inflammatory activity of *Tecomella undulata* whole plant methanolic extract using carrageenan-induced rat paw edema as an experimental model. Authors reported that oral administration of TU extract at doses of 300, 500 or 1000 mg/kg bodyweight significantly reduced paw edema volume in a dose dependent manner. These results were comparable to that of acetylsalicylic acid treated rats. But this study lacks phytochemical characterization of TU extract.

### 6.4. Analgesic activity

Analgesic activity of *Tecomella undulata* whole plant methanolic extract was evaluated using the hot water tail immersion test in mice. Result showed that oral administration of TU extract (300, 500 or 1000 mg/kg) recorded significant decrement in tail flick response. These results were comparable to that of standard drug, acetylsalicylic acid [16]. However, further studies are required on characterization of active principle from TU extract and its subsequent use as an analgesic agent.

### 6.5. Hepatoprotective activity

Hepatoprotective potential of TU has been reported by

various research groups. Rana et al., 2008 [28] and Khatri et al., 2009 [29] reported hepatoprotective potential of TU stem bark methanolic and ethanolic extracts using carbon tetrachloride and thioacetamide induced hepatotoxicity in rats respectively. Both the authors demonstrated that oral administration of TU extracts resulted in significant reduction in serum aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma-glutamyl transpeptidase (GGT), alkaline phosphatase (ALP), bilirubin, total protein, albumin and cholesterol levels. Further, TU supplementation reduced hepatic malonaldehyde levels, significantly improved hepatic glutathione along with significant improvement in the histopathology of liver.

Recently, Patel et al. 2011 [30] evaluated hepatoprotective potentials of chloroform, acetone and methanol soluble fractions and, methanol insoluble fraction of ethanolic extract of TU bark using paracetamol induced hepatotoxicity in rats. Results depicted that, methanol soluble fraction showed significant hepatoprotective activity against paracetamol induced hepatic damage as evidenced by normalization of substantially elevated levels of AST, ALT, ALP and total bilirubin, decreased level of total protein, increased wet liver weight and volume, increased thiopentone sodium induced sleeping time and near normal histopathology.

First report on hepatoprotective potential of TU leaves using a methanolic extract was by Singh and Gupta, 2011 [31] against alcohol and paracetamol induced hepatic damage in rats. They reported that, oral pre-treatment of TU extract (100 or 200 mg/kg) for 15 days was able to prevent elevation in serum AST, ALT, ALP, GGT and total bilirubin and decrement in the activity levels of hepatic antioxidant enzyme along with increment in hepatic lipid peroxidation induced by alcohol and paracetamol treatments. Further, TU extract pre-treatment significantly improved alcohol and paracetamol induced damage to hepatocytes and prevented necrotic cell death.

Recently, Goyal et al., 2012 [25], reported hepatoprotective potential of an ayurvedic formulation, Rohitaka ghrita that contains TU along with four other plants against paracetamol induced toxicity. Oral administration of Rohitaka ghrita (3.6 and 7.2 g/kg, p.o. daily) for 7 days followed by treatment with paracetamol (3 g/kg, p.o.) on 3rd and 5th days significantly minimized elevation in levels of serum AST, ALT, ALP and bilirubin. Further decrement in the hepatic lipid peroxidation along with improvement in glutathione and activity levels of catalase and Na<sup>+</sup>-K<sup>+</sup> ATPase and subsequent improvement in liver histopathology were observed in TU administered rats. These evidences aptly justify hepatoprotective potential of TU and its use in traditional medicines and herbal formulations.

Till date there are no systematic studies carried out to identify the active compound in TU extract that is responsible for imparting hepatoprotection. Considering the dearth in the information, we investigated hepatoprotective

potential of bio assay guided fractions of TU stem bark extract and compounds [32]. Five organic fractions of TU were screened for in vitro hepatoprotective potential in which, methanolic and ethyl acetate fractions were found to be the most potent. Hence, the same were carried forward for in vivo evaluations. Lapachol isolated from TU stem did not show hepatoprotective potential whereas, betulinic was tested positive in this regard. Oral administration of betulinic acid (75 or 100 mg/kg) significantly prevented carbon tetrachloride (CCl<sub>4</sub>) induced elevation in plasma markers of hepatic injury and improved hepatic antioxidant status and histopathological damage [32].

### 6.6. Immunomodulatory activity

Herbal combination of TU with *Moringa oleifera*, *Boerhavia diffusa*, *Onosma bracteatum*, *Bauhinia variegata*, *Spheranthus indicus*, *Chlorophytum borivilianum*, *Ficus racemosa*, and *Cyperus rotundus* is effective for treating a weakened or deteriorating immune system. This herbal preparation has been found to be particularly useful in maintaining the normal physiological functions of the immune system, in regulating the immunological functions and all the aberrations that occur due to the subtle immunological imbalances. It has been reported to be potent in resisting cancers resulting due to a weakened immune system. In case of individuals affected with HIV and AIDS, it has been reported to boost immune system through the following mechanisms: (1) by stimulating the production of growth factors responsible for production of the cells of the immune apparatus, like lymphocytes, macrophages, langerhans cells, histiocytes, etc.; (2) by enhancing the immune response due to the production of new cells and replacing the aging and functionally incompetent cells of the immune system; (3) by mopping up the free radicals generated by the metabolism of cancer cells, the anti-retroviral metabolism in cells of individuals affected with HIV or AIDS, and during the aging process (i.e. antioxidant effect); and (4) by stimulating the immune apparatus to produce antibodies and to form immune complexes (i.e. immunostimulatory effect). Its chemo protective or radio protective properties in patients undergoing cancer therapy are well documented. In this case, it can be used as an adjuvant to conventional treatments to reduce the adverse side effects of these therapies. Also, herbal preparations of TU show radio sensitizing and chemo sensitizing properties in cancer patients wherein, the tumour becomes more sensitive to the conventional anticancer therapy. This also helps in effectively reducing the required dosage of these therapies in order to achieve the prescribed therapeutic effects, thereby reducing and alleviating the powerful and devastating adverse side effects [33].

Recently, Choudhary, 2011 [34], evaluated immunomodulatory activity of TU stem bark ethanolic

extract using experimental models of cellular and humoral immunity. Authors demonstrated that, oral administration TU extract (100 mg/kg) in mice prevented cyclophosphamide induced suppression of humoral response and potentiated the delayed-type hypersensitivity reaction induced by sheep red blood cells (SRBC). These results were comparable with vitamin E treated mice. Based on this study, therapeutic potential of ethanolic extract of TU against various immunological disorders have been indicated.

### 6.7. Anti-cancer potential

Anti-cancer potential of TU stem bark chloroform extract have been reported recently by Ravi *et al.*, 2011 [35]. Anti-tumor potential of TU extract was explored using chronic myeloid leukemia cell line (K562). The study was further extended to standardize the extract using quercetin as biomarker. Results clearly showed significant inhibition of growth by TU in K562, COLO-205, MDA-MB231, HepG2 cells in a dose range of 10–100  $\mu$ g/ml. Further, the effect was found to be dose dependent, having IC<sub>50</sub> of 30  $\mu$ g/ml with activation of FAS, FADD, caspase 8, caspase 3/7 and fragmentation of DNA. Authors successfully demonstrated the potential antitumor effects of TU extract and in the process, also validated the traditional claim.

Recently, Savjiyani *et al.*, 2012 [36] evaluated anti cancer potential of a polyherbal formulation (SJT ONC) prepared from extracts of stem bark of *Tecomella undulata*, *Bauhinia variegata*, *Oroxylum indicum* and leaves of *Indigofera tinctoria* using in vitro and in vivo experimental models. SJT ONC-1 (1000  $\mu$ g/ml) showed significant cytotoxicity against Caco-2 and MCF-7 cell lines. Further, SJT ONC-1 (300 mg/kg, p.o.) fed to Dimethylbenz anthracene treated high fat diet fed rats for 12 weeks resulted in significant reduction in mammary tumor volume. The results were comparable to the standard drug 5-fluorouracil.

## 7. Conclusion and future scope

This review is a meticulous compile of the research data on TU and its various therapeutic potentials. Analysis of literature on TU reveals major lacunae and subsequently opens new avenues for research. They are as follows:

1. Isolation and purification of pure compounds from TU stem, bark or leaves.
2. Therapeutic validation of these pure compounds to validate traditional claims.
3. Translation of these findings into a possible therapeutic alternative for human consumption that is potent with minimal side effects.
4. Preclinical toxicological evaluation of various biologically active TU extracts.

## Conflict of interest statement

Authors declare no conflict of interest.

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