



AN APPRAISE ON *TECOMA STANS* (L.) EX. JUSS, KUNTH. - PHYTOCHEMICAL POTENTIALS

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ABSTRACT

Tecoma is naturally distributed in the tropical and sub-tropical parts of Central Mexico and South Florida, Central America, Caribbean and South America and Northern Argentina. *Tecoma* is a perennial flowering shrub, 5-8 m in height. *Tecomastans* is drought resistant fast growing ornamental plant which grows throughout India. It is commonly called as yellow trumpet bush, yellow bells, yellow elder, ginger Thomas. In Hindi it is known as Piliya/ Pila kaner. Flowers occur in clusters and are trumpet-shaped with 5 round lobes, pale to bright yellow, with faint orange stripes at the throat of the corolla tube. The flowers of *Tecoma* are the official flowers of the United States Virgin Island and also the floral emblem of the Bahamas. This review intends to infer an insight to the *in vitro* phyto-constituents composition and their respective characteristic pharmacological properties of leaves and flowers of *Tecoma stans*.

Keywords: *Bignoniaceae*, *Tecoma stans*, leaves, flowers, Phytochemistry, *in-vitro* Pharmacological properties.

INTRODUCTION

Bignoniaceae is a small group of small genera including *Schlegelia* often has been placed in Bignoniaceae as a tribe Schlegeliaceae. Phylogenetically evident relationship is with an equivocal with studies showing weakly supported sister group relationship with Bignoniaceae. It belongs to Lamiales whose closest relatives are unclear since, the evidences were not strong enough; Bignoniaceae was placed as a separate group (Olmstead *et al.*, 1993; APG II, 2003; Oxelman *et al.*, 2005; Armstrong, 1985; Gentry, 1980; Bremer *et al.*, 2002; Reveal, 1996; Sprangler and Olmstead, 1999).

Bignoniaceae is a cosmopolitan family with 800 species in 110 genera of flowering plants (trees, lianas, shrubs and rarely herbs) (Gentry, 1980; Watson L and Dallwitz MT, 1992). Later on it was documented that Bignoniaceae belongs to order Lamiales and it included 82 genera and 827 species that are forming the essential part of vegetation (Shashina 1989, Angiosperm Phylogeny II, 2003; Olmstead *et al.*, 1993; Lohmann and Ulloa, 2007 and Usama K Abdel-Hameed, 2014). The greatest diversity occurs in Neotropics, out of 8, nearly five are recognized tribes. The *Tecomae* to which *Tecoma* and all others alongwith an African species, *Kigelia africana* (Lam.) Benth. were assigned have paraphyletic relation having four variant clades: the Neotroic- *Jacaranda* and relatives, The *Tecomae* s.str., the Neotropic-*Tabebuia* and relatives and Paleotropical clade. The Paleotropical clade includes all African and Madagascan members of the family except *Tecoma* (LG Madire *et al.*, 2011). The members can be identified as *Jacaranda* family, Trumpet creeper family, *Bignonia* family and the *Catalpa* family.

Genus-*Tecoma*

The genus *Tecoma* comprises of 14 species with two African and rest Americans. The two distinct pollination guilds occur in the genus, a bee pollinated group and a bird pollinated group with 8 species from South America and 2 African species (Gentry, 1992; Pelton, 1964; Henderson, 2001). *Tecoma* genus was revealed to be monophyletic and it differed from the studies of Olmstead *et al.*, 2009 where it was considered to be paraphyletic group. It can be concluded that Bignoniaceae is a monophyletic family with 8 lineages and 2 genuses.

The plant species are distributed throughout the universe even though it has a small set of species and are known for their vivid pharmacological activity (Anburaj *et al.*, 2016; Raju *et*

al., 2011; Sunitha *et al.*, 2016; K. GopalasatheesKumar and T. Bhoopathi, 2018). Tecomae is a pantropical tribe that includes the great bulk of trees. They are differentiated from Crescentiae based on fruit dehiscence pattern. *Tecoma* is taxonomically different group with poorly demarcated species, segregated through complexly overlapping vegetative characters. There are two basic species onewith narrowly tubular orange or red orange humming bird pollinated flowers and one with campanulated yellow bee pollinated flowers. Yellow flowered group consists of one wide ranging, polymorphic species, i.e., in Western Ecuador, in Northern Peru and in higher altitudes of Andes of Peru and Bolivia (Gentry AH, 1992). The ornamental plant from Bignoniaceae *Tecoma stans* and their respective leaves and flowers were reviewed. A review for a decade of research papers published on these plants and their specific plant parts was done. Tecomae is a pantropical tribe that included the great bulk of trees. They are differentiated from Crescentiae based on fruit dehiscence pattern. *Tecoma* is taxonomically different group with poorly demarcated species, segregated through complexly overlapping vegetative characters. There are two basic species, one with narrowly tubular orange or red orange humming bird-pollinated flowers and one with campanulated yellow bee pollinated flowers. Yellow flowered group consists of one wide ranging polymorphic species, i.e., in Western Ecuador, in Northern Peru and in higher altitudes of Andes of Peru and Bolivia. *Tecoma* is naturally distributed in the tropical and sub-tropical parts of Central Mexico and South Florida, Central America, Carribean and South America and Northern Argentina (Gentry, 1992). “*Tecoma*” name originated from the native name i.e., “Tecomaxochite, where “stans” means “standing” referring to plants habit (Dona Ana County, 2012). *Tecoma stans* origin has been found to be near the United States to Argentina and is grown in North America and East Asia (Mohammed ZM Salem *et al.*, 2013; Nyamai DW *et al.*, 2016). Its flower is the official flower of the United states, Virgin Islands and home flower of Bahamas (K. GopalasatheesKumar and T. Bhoopathi, 2018). *Tecoma* is considered as a destructive weed in Pacific islands, especially French Polynesia and it is called as “Piti” (County DA, 2012).

Tecoma stans

Scientific name: *Tecoma stans* (L.) Juss. ex Kunth.

Synonyms: *Bignonia stans*, *Stenolobium stans*, *Gelsemium stans* Kuntze seem.(K. GopalasatheesKumar and T. Bhoopathi, 2018)

Common name: Yellow bells, yellow trumpet bush, ginger-thomas, yellow elder, Campanilla, Mayan Gold, Roble Amarillo, Saico Amarillo, bios caraibe, trumpet flower, yellow elder, Suvarnaganneru, Pacha ganneru, Pacha gola, Ganer, Piliya/Pila kaner, Koranekelar, Sonnapatti, Pachagotta, Chandaprabha, Ghantiful, Chache, Thangaarali, Timboque and Esperanza (Ariana P. Torres, 2011; Kumanan R *et al.*, 2010; K. Pallavi *et al.*, 2014; Archana Singh *et al.*, 2013; Cates RG 2013; County DA, 2012; Eida Carola Cruz and Adolfo Andrade-Cetto, 2015).



Figure-1: *Tecoma* leaves and inflorescence.

Plant Description:

Tecoma stans is a wide spreading plant of 5-8 meters height pale-brown bark, conflicting compound imparipinnate leaves, 2-5 leaflets in pairs and yellow colored campanulate flowers above a narrowly cylindrical tube base, anthers sparsely pilose or puberulous, held



near middle of corolla tube. The leaves are mostly uniformly pinnate with 5-9 foliate. The leaflets are lanceolate, acuminate and having serrate borders and a light green in color with a smooth upper surface. Inflorescence is raceme having upto 20 flowers each. The flowers occur in clusters throughout the year; trumpet shape, 58mm long, corolla tube was around 3mm long having slightly orange stripes at the throat and calyx with 4-5 fused sepals (Gentry, 1992). The pollen shape, type, class, size from polar axis and size from equatorial axis was found to be elliptic, tricolporate, prolate, 33 ± 3.5 and 23.6 ± 4.4 respectively (GE Ugbabe *et al.*, 2013). The fruits are narrow, slightly flattened and upto 20cm in length with winged seeds. The fruit when young has a green color while on maturity it turns pale brown (Nyamai DW *et al.*, 2016; K. GopalasatheesKumar and T. Bhoopathi, 2018; Thirumal *et al.*, 2012; Parrotta, 2001). It can grow in most of the climates i.e., in tropics as well as arid regions with varying types of soils, with neutral alkaline pH of 6.6 – 7.5, more sunlight and less frost (PIER. 2010). *Tecoma* is oversensitive to lower temperatures and capable to attract insects, sunbirds and humming birds.

It is not susceptible to insect pest and its incorporation can be done based on the unusually pleasing fragrant flowers having nectar that insects feed on (County DA, 2012).

Pharmacological Potentials:

Bianco *et al.*, 1981 found that the leaves of *Tecoma* have iridoid glucoside named 5-deoxystansioside. M. Loyoza Meckes and V. Mellado-Campos, 1985 experimented that the leaves infusion when given intravenously in normal dogs and early hyperglycemic response, reduced blood glucose level and hypertriglyceridemia was noted, apart from keeping the insulin levels stable. Ramesh *et al.*, 1986 found that the fresh leaves of *Tecoma* contain chrysoeriol, luteolin and hyperoside (Quercetin-3-O-beta-D-galactoside). Anonymous, 1995 isolated an antihyperglycemic compound Tecostanine from the leaves of *Tecoma*.

Jennie *et al.*, 2003 experimentally recorded that the leaves extracts inhibit growth of yeast. Marzouk *et al.*, 2006 have reported that the leaves of *Tecoma* can inhibit the growth of yeast and thus prevent infections caused due to it. Aguilar Santamaria *et al.*, 2009 studied the Streptozotocin (STZ) induced diabetic male Sprague-Dawley rats, glucose or corn starch was administered after an oral dose of TAE, acarbose, butamide or vehicle, in order to build starch and glucose tolerance curves (CSTC and GTC). Acute and sub chronic administration of TAE (500mg/kg) in both rat models did not diminish fasting glucose and did not modify the GTC. From the study it is evident that anti-diabetic effects were due to intestinal α -glucosidase inhibition as extracts decreased the postprandial hyperglycemia. The aqueous extracts sub chronic administration reduced triglycerides and cholesterol, without modifying fasting glucose.

A.J. Alonso-Castro *et al.*, 2010 found that *Tecoma stans* leaves consist of water soluble compounds stimulating glucose uptake in murine and human adipocytes and sensitive resistance to insulin without affecting adipogenesis. Gandhi and Ramesh, 2010 found that *Tecoma stans* has properties to resist the fungal growth. Das *et al.*, 2010, experimentally found that the methanolic extracts of leaves possessed wound healing properties. Senthilkumar *et al.*, 2010 and Govindappa M *et al.*, 2011 reported that *Tecoma* are reported to have good antimicrobial effects on some human pathogenic bacteria as well as significant antioxidant activity. R. Kumanan *et al.*, 2010 studied the aqueous leaves extracts for their anti-helminthic activity using adult Indian Earthworms (*Pheretima posthuma*). These aqueous extracts were prepared in the ratio of 1gm plant material: 5ml distilled water. The 24 hour macerated solution was filtered using Whatmann filter paper No. 1 and was used to study its effect on the earthworms at varying concentrations (100, 200 and 500 μ g/ml) using standard Albendazole as reference standard and normal saline as control. At the end of the study it was clearly evident that as the concentration of extracts increased the anti-helminthic activity increased.

Nidhi Mathur *et al.*, 2010 studied the effect of *Tecoma* leaves in the reproductive systems of male albino rats. The hormone phytoestrogens are phytochemicals that act as hormone mimickers in a reaction. On orally administering 50% ethanolic extracts of *T. stans* leaves it was observed that the male rats began to show inhibitory changes on the gonadotropin release and a relative decrease in the sperm count and motility affecting the spermatogenesis within 60 days of extract treatments. M. Indra Gandhi and S. Ramesh, 2010 prepared the extracts by using 5gm plant powder and performed successive extractions using petroleum



ether, chloroform, DMSO and 70% ethanol. Fungi selected for the study were *Candida albicans* (yeast), *Cryptococcus neoformans* and *Microsporium gypseum* (moulds). These fungi were selected because these are opportunistic fungi causing fungal infections in AIDS patients. The *Tecoma* extracts were weak in inhibiting the fungal growth but it was found that it did not lyse the RBC of A, B and O blood groups. This indicated that these extracts can be used as a new antibiotic compound.

Rao, KNV *et al.*, 2010 through in-vitro experiments proved that the leaves of *Tecoma* contained alkaloids tecomine and tecostamine which had hypoglycemic properties when administered intravenously. The screening of the aqueous extraction revealed the presence of alkaloids, carbohydrates, glycosides and proteins while saponins, steroids, tannins and phenolic compounds were absent. Senthilkumar CS *et al.*, 2010 studied the antimicrobial properties of the fresh leaves and roots of *Tecoma* by drying and mixing the plant parts and prepared a decoction by boiling the solution under low flame. The decoction was filtered using muslin cloth and centrifuged at 5000g for 10 minutes and the supernatant was collected after filtration was performed twice. The first and the second filtrates were mixed together and used to study the antibacterial assay. The growth of bacteria *S. aureus* showed inhibition zone of 7mm for nutrient agar media and no inhibition in Muller-Hinton agar. The growth of bacteria *K. pneumonia* showed no inhibition zone for nutrient agar media while 8mm inhibition zone was seen in Muller-Hinton agar.

Ariana P. Torres, 2011 studied the seedlings of *Tecoma* with respect to its day light requirements. *Tecoma* seedlings were grown under wide range of low day light integral during winters and spring seasons. It was observed that with increasing day light integral there was an improved growth and rooting while a decreased incidence of powdery mildew when the day light integral was greater than 4 mol.m⁻²d⁻¹. Farhat *et al.*, 2011 and Singh *et al.*, 2011 both reported that the phytochemical screening of *Tecoma* leaves had the presence of tecomanine, tecostanine, anthranilic acid, alkaloids, flavonoids, saponins, phenols, steroids, anthraquinones and tannins.

S. Vivekanandhan *et al.*, 2011 effectively explored the functionalization of single walled carbon nano-tube with silver nanoparticles as a rapid reduction behavior of the leaves extracts. It was observed that the nanoparticulates from the leaves extracts acted as a possible alternative to other conventional chemical methods for the functionalization of CNT with any metal based nano-structures. Ariana P. Torres and Roberto G. Lopez, 2011 defined *Tecoma* as a tropical plant native to Central and South America; having new green house crop for its physical appearance, drought and heat tolerance capabilities, long blooming and pest/diseases resistance. Seeds were sown and seed propagation was done. The daily light integral increases shoot and root dry weight, stem diameter, leaf area, plug pullability, root number and dry mass in seedlings and cutting transplants as well. Approximate daily light integral for *Tecoma* ranges from 14 – 16 mol.m⁻².d⁻¹. Below 14 value could delay rooting and excessive internode elongation while, above 16 values could lead to an increase in the internode elongation.

Raju S *et al.*, 2011 studied the flowers of *Tecoma stans* ethyl acetate extracts. These extracts were found to be efficient in protecting kidney by their antioxidant effect on gentamicin-induced injury. In-vitro experiments with respect to biochemical and histopathological observations demonstrated that the extracts reduced the damage to the rat's kidney that was induced by gentamicin to initiate injury. The preliminary screening of these extracts revealed the presence of flavonoids, carbohydrates, saponins, tannins and glycosides while, steroids, proteins and alkaloids were found to be absent. Gentamicin activates phospholipases and alters the lysosomal membrane along with creation of oxidative stresses. The antioxidant (natural and/or synthetic) and free radical scavenging agents are known to protect the nephrons in gentamicin induced renal injury. There was a marked difference in the glomerular congestion, peritubular and blood vessel congestion, epithelial desquamation, accumulation of inflammatory cells and necrosis of kidney cells. The extract treatments also reduced serum creatinine, serum uric acid, blood urea nitrogen and serum urea levels. Flavonoids in general are known for their antioxidant properties and also as inhibitors to injury caused by free radicals. Since flavonoids are present in the floral extracts they enhanced the renal mitochondrial antioxidant system and protected against gentamicin induced nephrotoxicity.

Govindappa M *et al.*, 2011 the plant part were air dried at room temperature and ground into powder out of which 100gm of samples were extracted using 200ml of solvent (distil water,

ethanol and methanol). The filtrate obtained was lipophilized under 5µm Hg pressure and stored at -20°C. The microbial assay showed that methanolic and ethanolic extracts showed potent noteworthy microbial growth inhibition for the bacterias (*K.pneumonia*, *E.coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Pseudomonas fluorescens*, *Clavibacter michiganensis sub.sp. michiganensis*, *Xanthomonas oryzae pv. oryzae* and *Xanthomonas axanopodis pv. nivalcarrum*) and fungi (*Aspergillus niger*, *Aspergillus flavus*, *Alternaria carthani*, *Alternaria helianthi*, *Cercospora carthani*, *Fusarium solani*, *Fusarium verticilloides* and *Nigrospora oryzae*). Chloromphenicol was used as control for bacterial assay and carbendazim was used as control for anti fungal assay. Considering the antimicrobial assay for aqueous extracts of *Tecoma* the ethanolic extracts showed the maximum microbial growth inhibitor as compared to other solvents. The phytochemical screening showed the presence of alkaloids, flavonoids, saponins, phenols, steroids, anthraquinones and tannins. The total phenolic content in per gram plant extract equivalent to gallic acid was as follows for methanolic extracts is was 216 ± 16, for ethanolic extracts is was 206 ± 9 and for aqueous extracts it was 177 ± 12. The presence of phenolic components in the plant extracts are considered to be the main compounds to confer the antimicrobial and antioxidant properties. The phenolic compounds and their microbial inhibition as well as their free radical scavenging properties have been explained by various other researcher like Adedapo *et al.*, 2009b; Adesegun *et al.*, 2009; Lai *et al.*, 2010; Lin *et al.*, 2008; Lopez-Lazaro, 2009; Kaur and Arora, 2009; Alcaraz *et al.*, 2000, Amarlal *et al.*, 2009; Erdemoglu *et al.*, 2007 and Maria-Benabdesselam *et al.*, 2007.

According to Al-Azzawi *et al.*, 2012 reported that the whole alcoholic and aqueous extract of *T. stans* exhibited antibacterial activity and isolated Tecomine. The growth of *E.coli* and *B. subtilis* was inhibited at varying concentrations. According to Thinumal *et al.*, 2012 the root stem bark and flowers ethanolic Soxhlet extracts when used for MTT assay against breast cancer MCF- 7 cell lines it was found that anti-proliferative activities were observed. Out of the three plant parts the stem extracts showed extraordinary activity at 64.5µg/ml concentration. Based on the conclusive statement of Zimmermann *et al.*, 2004, Xact Information, 2005 and Pier, 2010 it could be said that there was an inhibition of apoptosis process that could have been initiated by any of the dietary component in the herbal extract that could have helped in the prevention of progressive developmental stages of cancer formation. The phytochemical screening showed the presence of carbohydrates, proteins, saponins, flavonoids, alkaloids, tannins and phenolic compounds.

Cates RG, 2013 studied the acetone and methanol extracts of *Tecoma stans* and found that the extracts could not inhibit the cancer cell lines of breast, HeLa, skin and Tongue as well as the non-cancerous Vero control. The microbial inhibition studies revealed that the methanolic extracts inhibited the growth of *S. mutans*, except the acetone extract. Both the acetone and methanolic extracts of *Tecoma* failed to inhibit growth of *S. aureus*, *E.coli* and *C. albicans*. Torane R.C *et al.*, 2011 prepared the extracts of *Tecoma* leaves using 80% methanol and later used these extract to obtain an aqueous fraction and calculated the total quantity of phenolics, flavonoids and antioxidant activity. The phytochemical screening of the methanolic extract revealed the presence of tannins, flavonoids, alkaloids, phenols and traces of steroids and saponins. The aqueous fraction was found to have 25.33 ± 0.57 mg GAE/ g extract total phenols;

17.66 ± 2.51 mg CE/ g extract and total antioxidant activity as 35.74 ± 0.12%. The aqueous fraction of leaves showed inhibition zones with *E. coli* (12mm), *M. luteus* (6.3±0.9), *S. lutea* (16.6 ± 0.7), while no inhibitory action was noted for other bacteria studied i.e., *B. subtilis*, *S. aureus*, *S. marcescens*, *P. aeruginosa*, *P. vulgaris* and *S. typhi*.

Rajamurugan R *et al.*, 2013 extracted the flowers using ethanol and the phytochemical screening showed the presence of terpenoids, steroids, tannins, alkaloids, cardiac glycosides, steroids, phenols and saponins. IC50 value of ethanolic extracts of flowers was 137µg/ml. The antimicrobial assay showed that at 0.1mg/ml concentration the extracts showed inhibition zone of 14mm for *S. aureus*, 23mm for *E. coli*, 21mm for *K. pneumonia*, 21mm for *B. subtilis* and 25mm for *Penicillium sp.* S. Kameshwaran *et al.*, 2013 used the floral aqueous and methanolic extracts for oral administration to Wistar rats of both sexes by gastric intubation method to understand the anti-urolithiatic activity. The phytochemical screening revealed the presence of tannins, flavonoids, phenolic compounds, alkaloids, steroids, triterpenes and saponins. Ethylene glycol induced urolithiasis rats were studied histopathologically. Kidney sections were taken apart from urine analysis (Magnesium,



Phosphates, Oxalate, Calcium and Citrate); Serum

analysis and Kidney homogenate analysis. There was significant changes in the extract treated rats; but slower rate of recovery was seen in the renal epithelial tissues in comparison to the standard drug treated animals.

V. Lakshmi Prasanna *et al.*, 2013 used the leaves of *Tecoma* were collected to prepare aqueous and methanolic extracts for studying the antinociceptive and anti-inflammatory activities. The phytochemical screening revealed the presence of alkaloids, glycosides, saponins, phenolics, tannins, proteins and carbohydrates in the aqueous extracts, while in the methanolic extracts there was an additional phytochemical phytosterols apart from that are mentioned above. In both the extracts fixed oils and fats were absent. The total phenolic and flavonoid content in aqueous extracts were 64.2 ± 1.02 and 38.5 ± 0.8 respectively. The total phenolic and flavonoid content in methanolic extracts were 72.3 ± 1.23 and 49.5 ± 0.9 respectively. The alcoholic extracts were more active as compared to aqueous extracts when analyzed for the antinociceptive and anti-inflammatory properties. Arunkumar C *et al.*, 2013 studied that the leaf broth reduced aqueous silver nitrate into silver ions and formed silver nanoparticles. The silver nanoparticles were characterized using UV-visible spectroscopy. The leaf broth had pale yellow color before the addition of silver nitrate solution which was colorless. Maria del Carmen Vega Menchaca *et al.*, 2013 experimented the methanolic extracts of leaves and its property to prevent the growth of bacteria. The extracts did not showed any inhibition in the growth of *K. pneumonia*, *E. coli*, *E. aerogenes* and *E. cloacae* while a considerable inhibition of *S. aureus* was seen with the zone of inhibition ranging from 11 - 15mm.

K. Pallavi *et al.*, 2014 found that the methanolic extracts of flowers of *T. stans* showed the presence of flavonoids, alkaloids, mucilage, saponins and phenolics. Based on the antibacterial assay it was found that the aqueous extracts of flowers showed inhibition zone of 17.7mm for *E. coli*, 17.73mm for *B. subtilis* and 18.33 for *S. aureus*. The aqueous extracts of leaves showed the zones for the bacterial strains *E. coli*, *B. subtilis* and *S. aureus* as 15.71, 11.25 and 14.5mm respectively. S. Kameshwaram *et al.*, 2014 used the soxhleted methanolic and aqueous extracts of flowers of *Tecoma stans* and assessed the anti-depressant activity using tail suspension tests and forced swim tests. The Swiss albino rats were divided as control (Carboxy-

methyl-cellulose-CMC), aqueous extracts suspended in 0.1% CMC and Methanol extracts dissolved in water and for all these three sets the tests were performed. For checking the involvement of neurotransmitters in anti-depressant activity the rats were pre-treated with haloperidol, prozosin and p-CPA by intraperitoneal administration in a fixed volume of 1mg/100gm of bodyweight. The flowers methanol and aqueous extracts expressed the anti-depressant activity due to the presence of flavonoids.

Nader A. Ashmawy *et al.*, 2014 performed study on the leaves and branches of *T. stans* for its ability of extracts in preservation of potato from soft rot causing bacteria- *Diskeya chrysanthemi* (DSM4610), *Pectobacterium carotovorum* subsp. *Carotovorum* (ipp038), *Pectobacterium wasabiae* (ipp041), *Pectobacterium atrosepticum* (1007) and *Dickeya dianthicola* (IP02114). The methanolic extracts of the leaves and branches was prepared which was then re-extracted using chloroform, water, ethyl acetate and butanol. Later, the re-extracted fractions were checked for its activity of soft rot, prevention. The chloroform fractions showed prevention as compared to fractions from other solvents.

S. Kameshwaran *et al.*, 2014(a) through in-vitro experiments found that 10% ethanolic extracts of *Tecoma stans* flowers ointment have significant wound healing properties. It efficiently stimulated wound contractions, increased tensile strength of incision and burnt wounds. The 10% ethanolic extracts of flowers showed the presence of flavonoids, phenols, alkaloids, tannins, steroids, triterpenes, anthraquinones and saponins. The wound healing properties were studied by removing the solvent under reduced pressure and controlled temperature and a suspension in 2% (v/v) Tween-80 was made for oral administration through gastric intubation method. 10gm semisolid extract was incorporated into the 100gm of simple ointment base and silver sulfadiazine (0.01%) was used as standard drug. For the control set of Wistar albino rats only the simple ointment base was used. The ethanolic extract ointment was found to stimulate wound contraction, increased tensile strength of incision and burn wound as compared to the control group. S. Kameshwaran *et al.*, 2014 (b) found



that the ethanolic flower extracts of *Tecoma stans* were showing protective effect in animals that were exposed to EMF- induced depression resultantly it proved the potentials to scavenge the free radicals. Sevugaperuma G *et al.*, 2014 grounded *Tecoma stans* flowers in 80% Ethanol and performed the phytochemical screening and antimicrobial assays. The phytochemical screening revealed the presence of tannin, steroids, terpenoids, flavonoids and alkaloids. The antimicrobial assay showed the following zone of inhibition 16 ± 0.2 for *B. subtilis*, 18 ± 0.05 for *K. pneumonia*, 17 ± 0.1 for *P. aeruginosa*, 9 ± 0.15 for *S. aureus*, 17 ± 0.05 for *S. mutans* and 14 ± 0.1 for *C. albicans*. Al-Judaibi A and Al-Yousef F 2014 through his experiment on the antifungal effects of the ethanolic extracts of *Tecoma stans* plant on *Candida sp.* revealed that *Candida albicans* and *Candida tropicalis* showed inhibition zone of 24 ± 0.23154 (MIC-64 $\mu\text{L}/\text{m}$) and 25 ± 0.6009 (MIC-16 $\mu\text{L}/\text{m}$) respectively.

Torres Carola Analia *et al.*, 2015 studied the 80% ethanolic extracts (tincture and infusion) of *Tecoma* leaves for their antimicrobial activities and total phenolic composition. The tinctures and infusions were dried and from these dried extracts the phenols and flavonoids were quantified. The total phenolic and flavonoid content in the tincture was experimentally calculated and found to be $84.61 \pm 4.15 \text{ mg GAE/g}$ dry weight and $10.27 \pm 0.37 \text{ mg QE/g}$ dry weight respectively. The total phenolic and flavonoid content in the infusion was experimentally calculated and found to be $63.85 \pm 4.26 \text{ mg GAE/g}$ dry weight and $1.23 \pm 0.11 \text{ mg QE/g}$ dry weight respectively. Based on the antibacterial results it could be said that the tincture and infusion could only inhibit the growth of *S. aureus* while, *P. aeruginosa* and *K. pneumoniae* were resistant.

Tahir Javid *et al.*, 2015 studied 3 medicinal plants for their antimicrobial properties and extracted fractions using n-hexane, chloroform, ethylacetate, butanol and DMSO. Based on the results obtained for antibacterial it was found that the butanol extracts of leaves of *Tecoma* had a zone of inhibition of 19.66mm for *S. aeruginosa*, nearing the inhibition zone of standard drug Levofloxacin (21mm). Apart from *S. aeruginosa* other bacteria, that were studied were *E. coli*, *Salmonella typhi* and *S. aureus* which also showed significant inhibitory potentials. For the antifungal assay almost all the *Aspergillus species* used in the study namely *A. flavus*, *A. niger*, *A. fumigates* and *Fusarium solani* has positive inhibitory effects on the fungal growth considering the standard as Clotrimazole. According to Brahmam *et al.*, 2015, the phytochemical studies show the presence of carbohydrates, glycosides, alkaloids, steroids, proteins and amino acids, fixed oils, fats, gums and mucilage. Tavs A Abere and Comfort O Enoghama, 2015 found the presence of alkaloids, tannins, flavonoids, saponins and cardiac glycosides in the methanol extracts of *Tecoma* leaves. Tiwari AN *et al.*, 2015 found that in the aqueous extracts terpenoids, saponins, quinines, phenols and tannins were present while, alkaloids and flavonoids were absent.

G. Anburaj *et al.*, 2016 screened the aqueous extracts of *Tecoma* flowers and found the presence of secondary metabolites namely- alkaloids, flavonoids, saponins, tannins, phenols and anthraquinones. Kalyani A. Kedar *et al.*, 2016 with the help of in-vitro experiments using ethyl acetate extracts of leaves of *Tecoma* quantified the ursolic acid with the help of High Performance thin layer chromatography (HPTLC). The HPTLC results revealed that around 1.11% w/w is the quantity of ursolic acid present in *Tecoma* leaves. Ursolic acid is known to possess anti-inflammatory, anti-diabetic and most importantly can stop the formation and development of cancerous and or tumor causing cells. The chemopreventive nature of ursolic acid was also described by Liu J, 1995; Salvador JAR *et al.*, 2010; Novothy L *et al.*, 2001 and Shrikant B and Kirti L, 2014.

Mohamed Abdel-Hamid Taher *et al.*, 2016 prepared 1% methanolic extracts of the leaves and later petroleum ether, methylene chloride, ethylacetate and butanol fractions were obtained. The phytochemical screening of these fractions showed the presence of Terpenes, saponins, alkaloids, flavonoids, glycosides and tannins in 1% methanolic extracts; Terpenes, saponins, alkaloids and flavonoids in methylene chloride fraction; saponins, flavonoids, glycosides and tannins in ethyl acetate fractions; saponins, flavonoids and glycosides in butanol fractions. The total flavonoids content in the methanol extract, methylene chloride, ethyl acetate, butanol and crude fraction was 51.19, 39.21, 59.91, 45.75 and 55.55 respectively. The total phenolic content in the methanol extract, methylene chloride, ethyl acetate, butanol and crude fraction was 230.3, 279.41, 232 and 264.7 respectively. The HPLC analysis of all the fractions was done for the flavonoids and polyphenols present in the leaves which showed the presence of Quercetin (16.6, 14 mg/100gm dry leaves), Gallic acid (0.9 mg/100gm dry

leaves), caffeic acid (1.4 mg/100gm dry leaves), Naringin (21.4 mg/100gm dry leaves), Rutin (112.7 mg/100gm dry leaves), Rosmarinate (27.1 mg/100gm dry leaves), Kaempferol (2.8 mg/100gm dry leaves), Apigenin (3.9 mg/100gm dry leaves), Herperitin (7.97 mg/100gm dry leaves), 7-OH-Flavone (0.9 mg/100gm dry leaves), Catechin (10.74 mg/100gm dry leaves), Pyrogallol (29 mg/100gm dry leaves), Chlorogenic acid (17.04 mg/100gm dry leaves), Vanillic acid (5.84 mg/100gm dry leaves), Ferulic acid (31.38 mg/100gm dry leaves), Isoferulic acid (5.02 mg/100gm dry leaves), 3,4,5-Trimethoxy-cinnamic acid (21.56 mg/100gm dry leaves), p-Coumaric acid (1.49 mg/100gm dry leaves), Cinnamic acid (0.31 mg/100gm dry leaves) and protocatechic acid (11.01 mg/100gm dry leaves). All the compounds that were found to be present had various proven biological activity like anti-hyperglycemic, antioxidant, antimicrobial, anti-inflammatory, antithrombosis, anti-hyperlipidemic, anti-proliferative and anticancerous.

Guillermo R *et al.*, 2016 used the hydroalcoholic extracts of *Tecoma* for its in-vitro pharmacological characterization of anti-lipase activity. HPLC was used to quantify and confirm the identity of bioactive compounds. The phytochemical purification of the extracts showed the presence of chrysoeriol, apigenin, luteolin and verbocside having capability to inhibit the activity of pancreatic lipase. It can be said based on results that flavones produced an increase of the biological activities to inhibit enzyme lipase in a concentration dependent manner. Sundas Iltaf *et al.*, 2016 extracted the leaves of *Tecoma* using n-Hexane and obtained the fraction from it with solvents such as chloroform, ethanol and water. The aqueous fractions showed the maximum inhibition of *P. aeruginosa* as compared to *B. subtilis*, *S. aureus* and *E. coli*. It can be said based on the results that the aqueous fractions could inhibit growth of bacteria in a noteworthy manner. Ratikanti Maiti *et al.*, 2016 studied 18 medicinal plants used traditionally for diabetes in Nuevo Leon, Northeast to Mexico for their macro and micro nutrients. *Tecoma stans* was one among the plants that were studied which showed 48.79% carbon capacity of CO₂ fixation; 216.31 µg/g dry weight zinc content; 444.82 µg/g dry weight iron content; 3.28% nitrogen content and was capable to fix 49% Carbon/Nitrogen. K. Gopalasathees Kumar and T. Bhoopathi, 2017; Govindappa *et al.*, 2011 and Sridharan *et al.*, 2014 described in one of the research reviews that *Tecoma* contains certain pharmacologically active properties like antioxidant, lubricant, hypercholesterolemia, cancer-preventive, cosmetic, anti androgenic, hemolytic, α-reductase inhibitor, vitamin C, Immunomodulator, anti-inflammatory, hepato-protective, nematocidal, insecticidal, insectifuge, anti-histamic, anti-arthritis, anti-coronary, anti-eczemic, anti-cancer, 5-α-reductase inhibitor and suppository. Potentials like wound healing, CNS protectant, cytotoxicity, wound healing, gastric ulcer healing, anti-lipoxygenase, anti-hyperglycemic, acetyl-cholinesterase inhibitory activities and anti-microbial properties.

JP Robinson *et al.*, 2017 prepared fresh and dried methanolic extract using leaves and flowers of *Tecoma stans* to study the cytotoxicity these extracts can cause to the lung cancer cell lines. The results obtained showed nearly 100% of cytotoxicity and DPPH antioxidant activity beginning in the concentrations ranging from 20 to 100 µg/ml. RK Bargah, 2017 screened the aqueous and methanolic extracts of leaves that revealed the occurrence of saponins, flavonoids, alkaloids and phenolic compounds and an additional presence of steroids in the methanolic extracts. The antibacterial assay of the aqueous and methanol extracts for *E. coli*, *Serratia macrescens*, *B. subtilis*, *Micrococcus luteus* and *S. aureus* proved the aqueous extracts to be efficient in curbing the bacterial growth as compared to the methanolic extracts. Bhavan Kumar, 2017 prepared the 50% ethanolic extracts of *Tecoma stans* that showed the presence of alkaloids, carbohydrates, saponins, proteins, amino acids, flavonoids and tannins. In vitro experiments on the Wistar rats demonstrated that these extracts contained insulin resembling compounds that can balance the insulin levels and be effective for diabetic patients.

M. Krishnaveni *et al.*, studied the air pollution tolerance index (APTI) for *Tecoma stans* plant samples obtained from near Karrupur railway junction, Salem, Tamil Nadu. The distilled water extracts of the plant with pH 6 showed the presence of the following phytoconstituents- Ascorbic acid (0.36 mg/g), total chlorophyll content (27.88 ± 4.06 mg/g), RWC (47.45 ± 9.38%), Amino acid (2.5 ± 0.12 mg/g), Total carbohydrate (3.07 ± 0.23 mg/g), APTI = 7.08, total phenolics = 23.5

± 1.16 mg/g; total flavonoids = 26.7 ± 0.58 mg/g; 10.32 ± 0.01 mg/g carotenoid and 5 mg/g protein. These extracts when checked for the antioxidant properties and it was found to have the highest nitric oxide scavenging activity (26.2 ± 1.44 mg/g) as compared to

phosphomolybdenum assay (7.5 ± 3.69 mg/g), reducing power assay (14.5 ± 3.58 mg/g) and metal chelating activity (5.8 ± 0.69 mg/g). From the results it could be concluded that it can effectively reduce the pollutants around its habitat and use it in an efficient way to produce some essential secondary metabolites with pharmacological benefits in an ample quantity. Hence, *Tecoma* can be recommended as one of the best roadside ornamental plant. Aayushi Biswas and Rokhum L, 2018 biosynthesized silver nanoparticles from *Tecoma* aqueous extracts. The nanoparticles obtained were spherical in shape, with a size ranging from 5-20nm. The phytochemicals in these extracts acted as stabilizing and reducing agents and to inhibit the growth of bacterial strains of *K. pneumoniae* (17mm), *S. aureus* (18mm) and *B. subtilis* (16mm). The nanoparticles from *Tecoma* leaves were able to successfully degrade the Eosin yellow dye photocatalytically. Shravan Kumar Dholi *et al.*, 2018 on screening of the ethanolic extracts of leaves and aqueous extracts of flowers found that secondary metabolites like alkaloids, flavonoids, carbohydrates, tannins and phenolic compounds were present. The antibacterial assay for the leaves ethanolic extracts against *E.coli*, *Enterobacter* and *B. cereus* showed the inhibition zone of 1.8mm, 1.55mm and 2.27mm. The antibacterial assay for the flowers aqueous extracts against *E.coli*, *Enterobacter* and *B. cereus* showed the inhibition zone of 1.67mm, 1.8mm and 1.2mm. Mukul Anand and R. Basavaraju, 2018 reported in their review paper that the experiment done by Dewangan N *et al.*, 2017 on the aqueous fraction of *Tecoma* leaves for their anti-bacterial properties concluded that at the concentration of 400 μ g/ml *P. aeruginosa* and *Aspergillus niger* had an inhibitory zone of 13mm and 11mm respectively.

Rujuta Sabne *et al.*, 2018 performed the DPPH assay for the aqueous extracts of *Tecoma stans* flowers which showed that in the concentration range of 10, 50 and 500 μ g/ml the percentage inhibition was 25.6%, 13.41% and 26.82% respectively while for ascorbic acid for the same concentration it was 49.36%, 56.28% and 66.99% respectively. K. Sunitha and M. Nagulu, 2018 through the experiments using the methanolic extracts of leaves found that the percentage inhibition for DPPH assay for concentrations 10, 20 and 40 μ g/ml was 41.38, 43.58 and 45.9% respectively with an IC₅₀ value of 42.6 μ g/ml. The IC₅₀ value of leaves extracts were higher than that of ascorbic acid (38.04%) which was considered as standard. Dabur R *et al.*, 2018 reported Tecomine, a piperidine alkaloid isolated from *T. stans* can increase the glucose uptake rate in rat adipocytes from normoglycemic rats. It has been noted to have a potent stimulating effect on the basal glucose uptakes. The ethanolic extracts can probably cause pancreatotropic action in the β - cells.

Kedar KA *et al.*, 2018 studied the leaf surface and elemental quantification of *Tecoma* by SEM-EDAX and found the following data: Trichome type in the adaxial and abaxial leaf surface were petelliform (46.86 μ m) and multicellular (1-5 cells, 244.27 μ m) respectively and the stomatal type in the abaxial surface was anomocytic (16.3 μ m). The elements present in *Tecoma* leaves were carbon (30.49%), oxygen (65.23%), magnesium (0.27%), Aluminium (0.61%), Silicon (0.4%),

Chloride (0.27%), potassium (0.34%), Calcium (2.22%) and iron (0.17%). El-Amier YA and Alghanem SM, 2018 found the presence of the following micronutrient elements like zinc (23.98

± 10.45 mg/kg leaf), copper (9.97 ± 1.81 mg/kg leaf), cadmium (2.04 ± 0.57 mg/kg leaf) and lead (7.59 ± 1.48 mg/kg leaf). The metal accumulation index was 3.19 and comprehensive bio-concentration index was 1.03. Garg S *et al.*, 2018 investigated the plant sources that could be used as natural indicators for acid-base titrations and thus reduce the use of harmful chemicals. The petals of *Tecoma* were dried and macerated in ethanol for 24 hours and the filtrate was used as natural indicator. In the titration experiments the floral extracts completely neutralized the solution have an acid and the base giving a colorless solution at the end of the titration. Hence, the ethanol flower extracts of *Tecoma* can be used instead of the synthetic indicators.

Aung Mya Thein and Khin Cho Cho Oo, 2019 prepared the aqueous extracts of *Tecoma* leaves that showed the secondary metabolite like glycosides, phenolics, saponins, tannins, while, alkaloids, flavonoids, steroids and terpenoids were found to be absent. The lethality of the aqueous extracts was analyzed through acute toxicity test using brine shrimps. It was found that at a concentration of 3mg/ml the extracts was able to give 96% mortality rate with 25:26 dead: total shrimp ratio. Christopher Larbie *et al.*, 2019 obtained the aqueous fraction of the 50% ethanolic extracts which showed percentage inhibition of 38% in the DPPH assay. And when it was screened for the secondary metabolites it indicated the presence of glycosides,



tannins, flavonoids, alkaloids, saponins and coumarins. The total phenolic content and flavonoids content on quantification had about 4mg GAE and 70mg QE respectively. Swarna SK *et al.*, 2019 considered the various plant parts such as leaves, bark and flowers that were extracted using ethanol as solvent. These extracts were studied for albumin denaturation analysis in order to study their anti-inflammatory potential. Among the three parts of *Tecoma* that were extracted the leaves and flowers showed noteworthy efficiency in preventing denaturation in comparison to the standard drug, Ibuprofen.

CONCLUSION

Based on the reviewed papers it can be noticed that there are lot of missing links i.e., to be precise a lot of scope for advanced research. Researchers can find some latest techniques and technologies those could be employed to get a complete picture of the potentials of *Tecoma stans* flowers. Even though water has been used by the traditional healer's medication the present day researcher are yet to divert their inquisitive minds to come out of toxic solvent selections for extractions. In addition, leaves and flowers of *Tecoma* can be obtained in a decent quantity yet there very few reports on the use of water for extraction to study their various pharmacological efficacies.

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