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Phytochemical, antimicrobial and mast cell stabilizing activity of ethanolic extract of *Solanum trilobatum* Linn. leaves

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ABSTRACT

Aims: *Solanum trilobatum* Linn., (Solanaceae) is one of the most widely used plants as food supplement in southern part of India and some parts of Southeast Asia. This plant is traditionally used for the treatment of respiratory illness. In animal studies, the extract of *S. trilobatum* showed significant antimicrobial, hepatoprotective and anticancer activities. The complete phytochemical profile, antimicrobial and mast cell stabilizing activities of *S. trilobatum* remains unclear. This study tests the antimicrobial, antihistaminic and mast cell stabilizing activities of ethanolic extract of leaves of *S. trilobatum* (EEST).
Methodology and results: The phytochemical test was carried out using chemical and instrumental [Gas Chromatography Mass Spectrometry (GC-MS)] analytical methods. Antimicrobial effect of EEST was tested against *Streptococcus pneumonia*, *Escherichia coli* and *Staphylococcus aureus*. Intestinal mesentery of Sprague Dawley (SD) rats was used to study the peritoneal mast cell stabilization activity of EEST. The rat intestinal mesentery was exposed to 50, 100, 200, 300, 400 and 600 µg/mL of EEST and the peritoneal mast cell stabilization activity was compared with that of standards (pheniramine 20 µg/mL and ketotifen 20 µg/mL). The phytochemical test showed the presence of carbohydrates, saponins, flavonoids, alkaloids, tannins and phenolic compounds. GC-MS analysis indicated the presence of 45 fragmented compounds which included epoxylinalol, himachalol, illudol, epibuphanamine, baimuxinal and edulan IV. EEST exhibited antimicrobial activity at 10 mg/mL against *S. aureus*, *S. pneumonia*. Significant mast cell stabilizing activity was observed from the dose of 100 µg/mL to 600 µg/mL.
Conclusion: Ethanolic extract of leaves of *S. trilobatum* possess significant antimicrobial and antihistaminic activity.

Keywords: antimicrobial, GC-MS analysis, mast cell stabilizing activity, *Solanum trilobatum*

INTRODUCTION

The incidences of infectious diseases and infections by antibiotic resistant pathogens increased significantly over the last few decades. The increasing antimicrobial resistance is a serious threat to global public health. World Health Organization (WHO) reports suggest that overcoming the antibiotic resistance is the major issue for WHO in the next millennium (Mickymaray *et al.*, 2016). Traditionally, plants are used in the treatment of many infections and systemic disorders. Screening of plants for antimicrobial agents has gained greater attention recently. More than hundreds of chemical compounds are derived from plants and used as therapeutic agents to treat various disorders. The plants which have medicinal values due to their health-enhancing and therapeutic properties are referred as herbs. Various pharmacologically active compounds which are derived from different parts of plants directly or indirectly can act as life-saving drugs (Lahlou, 2013; Parasuraman *et al.*, 2014). Currently, WHO has urged its member countries to provide financial support for traditional practitioners to develop the traditional medical systems. It is imminent to utilize both the traditional and modern medical systems to fulfill the primary healthcare of the world (Oliver, 2013).

Solanum trilobatum Linn., (thuthuvalai in Tamil; climbing brinjal in English) is a rare, perennial, medicinal herb belongs to the family of Solanaceae and its' parts such as berries and flowers are used in the treatment of respiratory illness such as cough and chronic bronchitis. *Solanum trilobatum* is used as herbal remedy for asthma, blood vomiting, reducing blood glucose level and bilious matter phlegmatic rheumatism and different types of leprosy (Doss and Dhanabalan, 2008). This plant also

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showed significant hepatoprotective activity against carbon tetrachloride induced hepatic damage in rats, antimicrobial activity against *Escherichia coli* and, *Staphylococcus aureus* and antifungal activity against *Aspergillus flavus* and *A. niger* (Shahjahan *et al.*, 2005; Nagarajan *et al.*, 2009). The phytochemical and biological importance of the different parts of *S. trilobatum* was not explored completely. Hence, the objective of the present work is to study the phytochemical, antimicrobial and mast cell stabilizing activity of the ethanolic extract of leaves of *S. trilobatum* (EEST).

MATERIALS AND METHODS

Plant profile

Solanum is a large and diverse genus of flowering plants of about 2,000 different species in the family of Solanaceae. *S. trilobatum* Linn., (Solanaceae) is prickly diffused, bright green perennial herb, woody at the base, 2-3 m height and grows in dry places of Indian sub-continent and other parts of Asia. Leaves are deltoid/ triangular, irregularly lobed and flowers are purple in color.

Collection of the plant

Taxonomically identified *S. trilobatum* plant was collected from rural parts of Vellore, Tamil Nadu, India between October and December 2015. Plant was identified and authenticated by Agricultural Research Station, Vellore, Tamil Nadu, India. The leaves of the plant were dried under the shade for a week and ground using a grinder to a coarse powder.

Extraction of leaves

The powdered dry leaves of *S. trilobatum* was packed in a Soxhlet apparatus and extracted with 95% ethanol at 60 °C. The extraction was considered complete when the solvent becomes clear (3-4 cycles). The extract was concentrated to a dry mass by evaporation under reduced pressure. The EEST was stored in a desiccator at room temperature until further studies.The yield of EEST was 6.2 g w/w (dry weight basis).

Phytochemical analysis

One gram of EEST was dissolved in 100 mL of ethanol to obtain a stock concentration of 1% w/v and tested for the presence of carbohydrates, proteins, sterols, alkaloids, tannins, glycosides, flavonoids, phenolic compounds and saponins (Petchi *et al.*, 2014).

Total phenolic content

Hundred mg of EEST was reconstituted with 5 mL of 80% ethanol and centrifuged at 2,000 rpm. The supernatant was taken for the assay. One millilitre of Folin-Ciocalteau reagent was added to 0.5 mL of the alcoholic extract of the sample. Two millilitres of 20% sodium carbonate was added and heated for a minute. After cooling, the solution was made up to 10 mL with distilled water. A blank was prepared by adding all the reagents except the sample. The absorbance was read at 650 nm in spectrophotometer (Sundari *et al.*, 2013).

GC-MS analysis

EEST was reconstituted with a minimum volume of 95% ethanol and analysed using Thermo GC-Trace ultra (VER: 5.0) coupled with thermo MS DSQ II using DB 5-MS capillary standard non-polar column (diameter: 30 Mts, ID: 0.25 mm, FILM: 0.25 µm) (ThermoFisher Scientific, USA). The carrier gas used for the analysis was helium (He) at flow rate of 1.0 mL/min. Initially oven temperature was maintained at 70 °C and the temperature was gradually raised to 260 °C at 6 °C/min. The sample injection volume is 1 µL. The mass spectroscopic analysis was done with 70 eV electron energy level for the duration of 40 min.

Antimicrobial Screening of EEST

Preparation of EEST and ampicillin

The antimicrobial potency of EEST was tested by disk diffusion assay. The EEST was dissolved in a minimum volume of 95% ethanol and final volume (1 mg/mL and 10 mg/mL) made with sterile distilled water. A 1 mg/mL concentration of standard solution was prepared by dissolving 10 mg of ampicillin into 10 mL of sterile distilled water.

Microbial strains

The antimicrobial activity of EEST against three pathogenic microorganisms (namely *S. pneumonia* [ATCC®49619], *E. coli* [ATCC®25922] *and S. aureus* [ATCC®6538]) was carried out. These strains were obtained from Microbiologics KWIK-STIK™ and Culti-Loops™. Using stock, the primary culture was prepared and used for preparation of sub-cultures of microorganism.

Preparation of inoculums

Sub-culture in broth showed turbidity after 24 h incubation. Standardization of inoculums was performed based on the spectrophotometer readings at OD_{600}. Blank was prepared with nutrient broth for *S. pneumoniae*, *S. aureus* and *E. coli.* The amount of overnight culture required to get culture at an OD_{600} of 0.05 was calculated using the equation $S1 \times V1 = S2 \times V2$ to give inoculum concentration of 4.0×10^7 cells/mL. After dilution, the broths were kept on ice to prevent further bacterial growth.

Antimicrobial assay

The screening of antimicrobial activity was performed by disk diffusion method using Nutrient Agar for all the tested organisms. Disks containing known amounts (1 mg/mL

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EEST or 10 mg/mL of EEST or 1 mg/mL of ampicillin) of the extracts were placed on the surface of the agar plate inoculated with a suspension of the strain to give a confluent lawn of growth. The antimicrobial substance diffused into the medium and produced a zone of inhibition around the disk and its diameter was measured in millimetre (mm). The assay was carried out in duplicate and the average was calculated (Meenakshi *et al.*, 2013).

Mast cell stabilization activity

Healthy, adult, male Sprague-Dawley (SD) rats, weighing 180±10 g were obtained from Central Animal house, AIMST University, Malaysia. The animals were housed in large, spacious polyacrylic cages at an ambient room temperature with 12-h-light/12-h-dark cycle. The animals were fed with water, and normal rats pellet diet *ad libitum*. The study was approved by AIMST University Human and Animal Ethics Committee and the study was conducted according to the guidelines by the Animal Research Review Panel.

The rats were fasted overnight and sacrificed by cervical dislocation (physical method). The abdomen was cut open to expose the intestine and mesentery. The mesentery were collected and washed with Ringer Locke solution (composition units in g/L: NaCl, 9; $NaHCO_3$, 0.2; KCl, 0.42; $CaCl_2$, 0.32 and dextrose, 1). A small piece of mesentery layer was cut and placed in a beaker containing Ringer Locke solution with different concentrations of plant extracts for 30 min. The processed tissues were divided into three sets and they were exposed to pheniramine 20 µg/mL, ketotifen 20 µg/mL and EEST (10-600 µg/mL) respectively, and incubated for another 30 min. After incubation, the mesentery was placed on a clean glass slide and fixed with 4% formaldehyde containing O-toluidine blue for ≈20 min. The tissue preparation was washed with acetone and then with xylene (2 times each) for 5 min (three prepared tissues were used for each concentration of plant extract).

The prepared tissue was stained and examined under light microscope at 400× magnification. Randomly, 100 mast cells were counted (left to right, clockwise) and the number of intact and fragmented or disrupted mast cells were noted. Finally, the percentage of mast cells which were intact or fragmented or disrupted was calculated (Gupta *et al.*, 2015).

Statistical analysis

The results were presented as mean ± standard deviation. Antimicrobial activity (zone of inhibition) of EEST was expressed in mm and mast cell stabilization activity was expressed in percentage. Unpaired t-test was used to compare the statistical variations in antimicrobial assay. The statistical test was done using GraphPad Instat 3 (GraphPad Inc., USA). $P < 0.05$ was considered as significant.

RESULTS

Phytochemical test of EEST

Chemical analysis

The chemical analysis of EEST showed the presence of carbohydrates, amino acid, fats and oils, saponins, flavonoids, alkaloids, tannins and phenolic compounds. Total phenolic content of EEST was found to be 1.21 mg/g Gallic acid equivalent.

GC-MS analysis of EEST

GC-MS analysis showed the presence of 45 fragmented compounds in the EEST extract which include epoxylinalol, himachalol, illudol, epibuphanamine, baimuxinal and edulan IV. The compounds identified by mass spectroscopy were presented in Table 1 and the spectrum of GC-MS analysis was depicted in Figure 1.

Antimicrobial activity

The antimicrobial activity of EEST is summarized in Table 2. EEST showed antimicrobial activity at 10 mg/mL against both Gram-positive *S. aureus* and *S. pneumoniae* but not against Gram-negative *E. coli*. The standard ampicillin (1 mg/mL) exhibited antimicrobial activity against *S. aureus* ($p < 0.001$) and *E. coli*.

Mast cell stabilization activity of EEST

EEST showed significant mast cell stabilization from 100 µg/mL onwards (Table 3). The peritoneal mast cell stabilization of EEST was compared with ketotifen. EEST 100 µg/mL showed 48.00±4.00% intact mast cells and 52.00±4.00% degranulated mast cells and the percentage of intact mast cells increased with increase in the concentration of EEST up to 600 µg/mL. It was observed that the mast cell stabilization activity of EEST extracts was low when compared with ketotifen.

DISCUSSION

Solanum trilobatum is traditionally used in the treatment of respiratory illness. In present study, EEST showed mast cell stabilization at as low as 100 µg/mL and antimicrobial activity against *S. aureus* and *S. pneumonia* at 10 mg/mL. GC-MS analysis indicated the presence of 45 fragmented compounds which includes epoxylinalol, himachalol, illudol, epibuphanamine, baimuxinal and edulan IV. The leaves of *S. trilobatum* also contain oladunalinidine, tomatidine, solasodine, betasolamarine, sobatum, solaine and diosogenin (Sahu *et al.*, 2013).The biological activities of the chemical constituents of this plant were predicted using PASS prediction and Lazar online tools. The plant was predicted to have anti-inflammatory, antineoplastic,

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Table 1: Prediction of possible compounds present in the EEST using GC-MS spectra.

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No.	RT	Name of the compound	Probability	Molecular Formula	MW	Area % Peak
1	3.53	tert-Butyl [1-(4-Fluorophenyl)-2-hydroxymethylallyl]carbamate	51.67	$C_{15}H_{20}FNO_3$	281	1.43
2	3.53	Epoxylinalol	0.09	$C_{10}H_{18}O_2$	170	1.43
3	3.53	2-Octenoic acid, methyl ester	0.07	$C_9H_{16}O_2$	156	1.43
4	3.53	3-Azabicyclo[3.2.1]octan-2-one	0.04	$C_7H_{11}NO$	125	1.43
5	3.76	5-Methyl-5H-dibenz[b,f]azepine	81.25	$C_{15}H_{13}N$	207	1.46
6	3.76	Himachalol	0.70	$C_{15}H_{26}O$	222	1.46
7	3.76	Illudol	0.52	$C_{15}H_{26}O$	222	1.46
8	7.02	N-Benzylidene-2-azidobenzylamine	31.87	$C_{14}H_{12}N_4$	236	2.78
9	7.61	2-Methyl-1-thiacyclohept-2-ene 1-oxide	50.47	$C_7H_{12}OS$	144	1.75
10	11.05	Butanoic acid, 2-amino-4,4-dichloro-	1.14	$C_4H_7Cl_2NO_2$	171	1.79
11	11.05	3-Hexenoic acid, methyl ester	0.33	$C_7H_{12}O_2$	128	1.79
12	11.05	2-Chloro-5-(1,5-cyclohexadienyl)pyridine	0.33	$C_{11}H_{10}ClN$	191	1.79
13	25.64	3-isopropyl-4-methyl-1-indanone	14.44	$C_{13}H_{16}O$	188	2.92
14	27.59	1,2-Dihydro-1,4-diphenylphthalazine	62.55	$C_{20}H_{16}N_2$	284	3.13
15	29.00	Methyl 2,3,3-trichloropropanoate	3.92	$C_4H_5Cl_3O_2$	190	1.30
16	29.00	2,4-Dimethoxycinnamic acid	3.04	$C_{11}H_{12}O_4$	208	1.30
17	29.00	á-Asarone	4.87	$C_{12}H_{16}O_3$	208	1.30
18	29.00	chloromethyl 9-chlorododecanoate	2.26	$C_{13}H_{24}Cl_2O_2$	282	1.30
19	30.06	à-D-Glucopyranoside	3.00	$C_{18}H_{32}O_{16}$	504	2.00
20	30.06	Epibuphanamine	2.89	$C_{17}H_{19}NO_4$	301	2.00
21	30.06	Baimuxinal	2.78	$C_{15}H_{24}O_2$	236	2.00
22	31.50	7-Chloro-3-ethyl-4-nitro-2-n-propylindole	27.03	$C_{13}H_{15}ClN_2O_2$	266	2.19
23	31.50	Valerylaldehyde-2,4-Dnp-D	14.35	$C_{11}H_{13}DN_4O_4$	266	2.19
24	31.50	Adamantane-1-carboxamide, N-(6-bromoquinolin-8-yl)-	4.01	$C_{20}H_{21}BrN_2O$	384	2.19
25	31.50	9,10-Anthracenedione, 1,8-diethoxy-	2.99	$C_{18}H_{16}O_4$	296	2.19
26	31.50	9,10-Anthracenedione, 1,8-diethoxy- (CAS)	2.99	$C_{18}H_{16}O_4$	296	2.19
27	31.50	Germacycloundecane-6,7-dione, 1,1-diethyl-	2.31	$C_{14}H_{26}GeO_2$	300	2.19
28	31.81	á-D-Lyxofuranoside	9.51	$C_{20}H_{38}O_9$	422	4.07
29	31.81	4-Amino-1,5-pentandioic acid	1.81	$C_7H_{13}NO_4$	175	4.07
30	31.81	Octadecanoic acid, ethyl ester (CAS)	1.74	$C_{20}H_{40}O_2$	312	4.07
31	32.03	3',4'-Dihydroxy-(mono-14C)-Sudan	1.24	$C_{16}H_{12}N_2O_3$	280	1.66
32	32.36	5-Methylsulfonyl-4-nitroimidazole	10.45	$C_4H_5N_3O_4S$	191	1.91
33	32.71	6-allyloxy-1,4-dimethylcarbazole	2.74	$C_{17}H_{17}NO$	251	5.45
34	33.81	tert-Hexadecanethiol	8.23	$C_{16}H_{34}S$	258	1.97
35	33.81	Palmitic acid, 2-(tetradecyloxy)ethyl ester	3.53	$C_{32}H_{64}O_3$	496	1.97
36	33.81	Distearyl sulfide	2.89	$C_{36}H_{74}S$	538	1.97
37	33.81	1-Octadecanethiol	2.66	$C_{18}H_{38}S$	286	1.97
38	34.13	5,10-dimethyl-6,8-bisdehydropentapentadecafulvalene	4.41	$C_{22}H_{18}$	282	5.21
39	36.25	2-(3',5'-Ditrifluoromethylphenyl)-1,1,3,3-tetramethy lguanidine	85.01	$C_{13}H_{15}F6N_3$	327	2.31
40	36.70	edulan IV	6.48	$C_{13}H_{20}O$	192	1.31
41	36.70	2,3-Dimethoxycinnamic acid	3.26	$C_{11}H_{12}O_4$	208	1.31
42	36.70	3-(Benzylthio)acrylic acid, methyl ester	2.30	$C_{11}H_{12}O_2S$	208	1.31
43	36.94	5-Nitro-croweacic acid	5.77	$C_9H_7NO_7$	241	3.70
44	36.94	cis-1,2-Cyclohexanediamine	3.95	$C_6H_{14}N_2$	114	3.70
45	36.94	Geranylgeraniol, ert-butyldimethylsilyl ether	2.55	$C_{26}H_{48}OSi$	404	3.70

GC-MS, Gas chromatography–mass spectrometry

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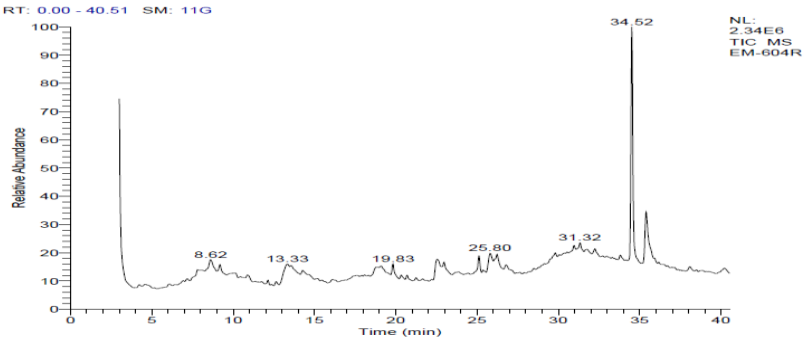

Figure 1: GC-MS analysis of EEST. Analysis was done with Thermo GC-Trace ultra (VER: 5.0) coupled with thermo MS DSQ II using DB 5 MS capillary standard non-polar column (diameter, 30 Mts; ID, 0.25 mm; FILM, 0.25 µm) and helium (He) as carrier gas (flow rate of 1.0 mL/min) at oven temp 70 °C raised to 260 °C at 6 °C/min. The sample injection volume is 1 µL.

Table 2: Antimicrobial activity of EEST.

Drug	*S. aureus*		*S. pneumoniae*		*E. coli*	
	Activity	Zone of inhibition (mm)	Activity	Zone of inhibition (mm)	Activity	Zone of inhibition (mm)
Ampicillin (1 mg/mL)	+	20.67 ± 2.15	-	-	+	14.77 ± 1.37
EEST (1 mg/mL)	-	-	-	-	-	-
EEST (10 mg/mL)	+	5.93 ± 0.50*	+	11.00 ± 1.0	-	-

All the values are mean ± SD (n = 3). *P < 0.0001 compare with EEST (Unpaired t test with Welch's correction).

Table 3: Mast cell stabilization activity of EEST on male SD rat mesentery cells.

Treatment	Intact mast cells (%)	Degranulated mast cells (%)
Sensitized control	23.33 ± 5.03	76.67 ± 5.03
Pheniramine20 µg/mL	34.00 ± 7.21	66.00 ± 7.21
Ketotifen 20 µg/mL	80.67 ± 11.37	19.33 ± 11.37
EEST 10 µg/mL	28.00 ± 10.58	72.00 ± 10.58
EEST 30 µg/mL	24.00 ± 8.00	76.00 ± 8.00
EEST 100 µg/mL	48.00 ± 4.00	52.00 ± 4.00
EEST 300 µg/mL	52.67 ± 7.02	47.33 ± 7.02
EEST 600 µg/mL	56.00 ± 8.00	44.00 ± 8.00

All the values are mean ± SD (n=3).

respiratory analeptic, hepatoprotectant, hypolipidemic, mucomembranous protective and hypercholesterolemic activities. Toxicity predictions of the constituents of *S. trilobatum* did not show any potential major toxicity (Parasuraman *et al.*, 2015). Sub-chronic toxicity studies of EEST showed mild to moderate toxicity signs at 200 and 400 mg/kg administered on SD rats (Data not shown).

EEST showed antimicrobial activity at 10 mg/mL against *S. aureus* and *S. pneumonia*. Latha and Kannabiran (2006) also studied the antimicrobial activity of the aqueous and organic extract of the leaves, stem, flowers and fruits of *S. trilobatum*. Aqueous extract of leaves of *S. trilobatum* inhibited the microbial growth of *S. aureus*, and *Bacillus subtilis* and *Klebsiella pneumoniae*. Whereas n-butanol extract of leaves of *S. trilobatum* inhibited the microbial growth *S. aureus*, *E. coli* and *K. pneumoniae* (Latha and Kannabiran, 2006). The antimicrobial activity of the EEST may be due to the presence of tannins (Doss *et al.*, 2009). In the present study, ampicillin showed antimicrobial activity against Gram-positive *S. aureus* and gram-negative *E. coli.* The activity against *E. coli* may be due to inhibition of microbial growth in lag phase (Lawrence and Anthony, 2013).

Mast cell stabilizing drugs such as ketotifen and sodium cromoglycate inhibit the release of inflammatory mediators from mast cells and are used to prevent allergic reactions (Finn and Walsh, 2013). EEST also exhibited dose dependent mast cell stabilization from 100 µg/mL to 600 µg/mL and the effect was not effective as standard ketotifen 20 µg/mL. Ranjith *et al.* (2010) also reported that the mast cell degranulation inhibition properties of *S. trilobatum* at 15 µg/mL onwards and suggested that the action may be due to the decrease in the release of interleukin 1 alpha (IL-1α). Based on the findings, it may be postulate that the mast cell stabilization activity of EEST may be due to the inhibition of IL-1α.

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CONCLUSION

Ethanolic extract of leaves of *S. trilobatum* showed presence of 45 compounds in GC-MS analysis, mild antimicrobial activity against *S. aureus* and *S. pneumonia* at 10 mg/mL and mast cells stabilization activity from 100 µg/mL to 600 µg/mL.

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REFERENCES

Doss, A. and Dhanabalan, R. (2008). Preliminary phytochemical screening and antibacterial studies of leaf extract of *Solanum trilobatum* Linn. *Ethnobotanical Leaflets* **12, 638-642.**

Doss, A., Mubarack, H. M. and Dhanabalan, R. (2009). Antibacterial activity of tannins from the leaves of *Solanum trilobatum* Linn. *Indian Journal of Science and Technology* **2, 41-43.**

Finn, D. F. and Walsh, J. J. (2013). Twenty-first century mast cell stabilizers. *British Journal of Pharmacology* **170, 23-37.**

Gupta, S., Nataraj, S. K. M., Raju, K. R. S., Mulukutla, S., Ambore, N. and Gupta, R. (2015). Peritoneal mast cell stabilization and free radical scavenging activity of *Yucca gloriosa* L. *Journal of Young Pharmacists* **7, 470-479.**

Lahlou, M. (2013). The success of natural products in drug discovery. *Pharmacology and Pharmacy* **4, 17-31.**

Latha, P. S. and Kannabiran K. (2006). Antimicrobial activity and phytochemicals of *Solanum trilobatum* Linn. *African Journal of Biotechnology* **5, 2402-2404.**

Lawrence, K. and Anthony, M. (2013). The effects of ampicillin on the growth of *Escherichia coli*. Available in http://www.mbio.ncsu.edu/MB360/papers2013/Khadija&Michelle.pdf [Retrieved from 27 May 2016]

Meenakshi, V., Narayanan, K. M, Thakar, B., Subrahmanyam, V. M., Rao, J. V, Dhanaraj, S. A. and Raj, P. V. (2013). Investigation of antibacterial and antifugal potentials of *Macarangapeltata*. *International Journal of Current Research and Review* **5, 26-32.**

Mickymaray, S., Al Aboody, M. S., Rath, P. K., Annamalai, P. and Nooruddin, T. (2016). Screening and antibacterial efficacy of selected Indian medicinal plants. *Asian Pacific Journal of Tropical Biomedicine* **6, 185-191.**

Nagarajan, S. M., Kandasamy, S. and Chinnappa, R. (2009). Comparative antimicrobial activity of callus and natural plant extracts of *Solanum trilobatum* L. *Ancient Science of Life* **28, 3-5.**

Oliver, S. J. (2013). The role of traditional medicine practice in primary health care within Aboriginal Australia: A review of the literature. *Journal of Ethnobiology and Ethnomedicine* **9, 46.**

Parasuraman, S., Thing, G. S. and Dhanaraj, S. A. (2014). Polyherbal formulation: Concept of ayurveda. *Pharmacognosy Review* **8, 73-80.**

Parasuraman, S., Yu Ren, L., Chik Chuon, B. L. and Wong Kah Yee, S. (2015). Computer-aided prediction of biological activities and toxicological properties of the constituents of *Solanum trilobatum*. *Rapports De Pharmacie* **1, 59-63.**

Petchi, R. R., Vijaya, C. and Parasuraman, S. (2014). Antidiabetic activity of polyherbal formulation in streptozotocin - nicotinamide induced diabetic Wistarrats. *Journal of Traditional and Complementary Medicine* **4, 108-117.**

Ranjith, M. S., Ranjitsingh, A. J., Shankar, S. G., Vijayalaksmi, G. S., Deepa, K., Babu, K. and Sidhu, H. S. (2010). *Solanum trilobatum* in the management of atopy: Through inhibition of mast cell degranulation and moderation of release of interleukins. *Pharmacognosy Research* **2, 10-14.**

Sahu, J., Rathi, B., Koul, S. and Khosa, R. L. (2013). *Solanum trilobatum* (Solanaceae) - An overview. *Journal of Natural Remedies* **13, 76-80.**

Shahjahan, M., Vani, G., and Shyamaladevi, C. S. (2005). Effect of Solanum trilobatum on the antioxidant status during diethyl nitrosamine induced and phenobarbital promoted hepatocarcinogenesis in rat. *Chemico-Biological Interactions* **156, 113-123.**

Sundari, S. G., Rekha, S. and Parvathi. A. (2013). Phytochemical evaluation of three species of Solanum L. *International Journal of Research in Ayurveda and Pharmacy* **4, 420-425.**

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