World Journal of Pharmaceutical ReseaRch
SJIF Impact Factor 5.045
Volume 3, Issue 6, 1771-1789. Review Article ISSN 2277 – 7105

AN ETHNOMEDICAL, PHARMACOLOGICAL AND PHYTOCHEMICAL REVIEW OF *AMMANNIA BACCIFERA* L.

Vasudevan Poornima[2], Manoharan Sharanya[2] and Muthusamy Jeyam*[1]

[1]Assistant Professor, Biochematics Laboratory, Department of Bioinformatics, Bharathiar University, Coimbatore, TamilNadu, India.

[2]Research Scholars, Biochematics Laboratory, Department of Bioinformatics, Bharathiar University, Coimbatore, TamilNadu, India.

Article Received on
22 June 2014,

Revised on 17 July 2014,
Accepted on 12 August 2014

***Correspondence for Author**
Muthusamy Jeyam
Assistant Professor,
Biochematics Laboratory,
Department of Bioinformatics,
Bharathiar University,
Coimbatore, TamilNadu, India.

ABSTRACT

Ammannia baccifera L. is commonly used in traditional medicine in India and China to raise blisters in rheumatism and in the treatment of scabies, ringworm, parasitic skin infections, common cold, typhoid, strangury, spinal disease, gastroenteropathy and aphrodisiac. The present review covers all the available information on *Ammannia baccifera* from scientific journals, books, thesis, reports and conference proceedings *via* academic libraries and electronic search databases accepted worldwide (Pubmed, Pubmed central, Tropicos, Google scholar, Scopus, Internet archive and Thieme). These sources were scrutinized and evaluated about its botany, traditional uses, biological aspects, chemical constituents and pharmacological relevance. The *in vivo* studies of extracts from *Ammannia baccifera* showed antitumor, antiinflammatory, antiarthritic, antianalgesic, antipyretic, antidiuretic, and wound healing pharmacological activities which can be attributed to the presence of flavonoids, tannins, polyphenols, triterpenes and sterols. The plant was evaluated and validated for the traditional medicinal activity against microorganisms and antimalarial properties using *in vitro* studies. Tetrolane derivatives were found to have antitubercular activity and high toxicity against brine shrimp.

KEY WORDS: *Ammannia baccifera*, Phytocompounds, Pharmacology, Ethnomedical.

INTRODUCTION

The genes *Ammannia* (Fam: Lythraceae) was named by Linnaeus in honour of Paul Ammann (Professor of Botany at Leipzig, Germany) [1]. Ammannia comprises 25 cosmopolitan species and reported as weeds of the rice fields. Some species are well defined and others are highly variable with taxonomic problems[2]. *A.baccifera* was first reported from Guadeloupe in 1930's[3]. *A.baccifera* and some species including *A.coccinea*, *A.auriculata* and *A.multiflora* were well studied when compare to other species like *A.verticillata*, *A.robusta*, *A.prieureana*, *A.lotifolia*, etc. Several studies on *A.baccifera* were available in literature and the plant was proved to have broad spectrum of therapeutic and pharmacological properties. Therefore, this review was carried out to enumerate the benefits of the species *A.baccifera*. The aim of this review is to provide a contemporary overview of botany, traditional uses, biological activities, ethnopharmacological relevances and chemical constituents.

Plant Description

Ammannia baccifera L. commonly known as Red Stems, Acrid Weed and Blistering Ammannia [4,5]. *A.baccifera* is an erect or procumbent herb, grows up to 40 cm high. Branches are usually opposite. It is capable of producing extensive spongy aerenchymatous phellem on submerged stems [6]. Septate fibers in the stem are absent and young stem is quadrangular and green. The leaves are linear oblong, sessile, lower opposite, upper sometimes alternate, 3-4 cm length, 0.6 - 0.8 cm width, with odor specific. Leaf base at lower leaves are attenuate and upper leaves obtuse or cuneate. Type of venation is pinnate and camptodromous. Flowers are reddish in dense axillary clusters, forming whorls, apetalous. Fruits are depressed globose capsules partially covered by calyx. Seeds are superhemisheric, numerous, small, semi-ovoid to obovoid, 0.3-1.0x 0.2mm and dark brown color. Pollen is heterocolpate, sexine thicker than nexine or as thick as nexine. Fruting and flowering during September to March[7,8,9,10,11]. The embryosac is perfectly normal and usual 8-nucleate type with three antipodal cells [12].

Vernacular names

Table 1.Different names of *A.baccifera*[13, 14].

S.No.	Region/ Language/ System of medicine	Name
1.	Ayurveda	Agnidarbha, Kshetravasdhini, Kurandika
2.	Hindi	Aginbuti, Dadmari, Jangli mehendi, Banmirich
3.	Sanskrit	Agni-garbha, Brahmasoma, Kshetrabhusha, Kshetravashini, Mahasyama, Pasanabheda

4.	Tamil	Kaluruvi, Nirumelneruppu
5.	Telugu	Agnivendra, Agnivendramu, Agnivednapaku, Agnijawala
6.	Malayalam	Kallur vanchi
7.	Kannada	Kaadugida
8.	Gujarat	Jalmukhi, Jalaagiyo
9.	Bengali	Banmarich
10.	Oriya	Dadmari, Ramdauni
11.	Marathi	Aginbuti, Bharajambhula
12.	Punjabi	Dadarbottie
13.	Nepali	Ambar
14.	Arabic	Hannta bariya
15.	Benin	Worougboko, Worukoho
16.	English	Blistering Ammannia, Acrid Weed, Monarch Red Stem, Bhatjambol

Natural distribution

The plant is native to tropical and subtropical Asia and Africa [15]but widely distributed throughout India and also found in Greece[16], Australia[17], north to Formosa in the pacific [3], Europe [18, 19], Bhutan, Myanmar, Nepal[20], Ceylon[21], Afghanistan, Pakistan[22]and China. In India, the species spread in Darjeeling, Gujarat, Goa, Uttar Pradesh [23], Karnataka, Andhra Pradesh [24] and Tamil Nadu [20, 25,26].

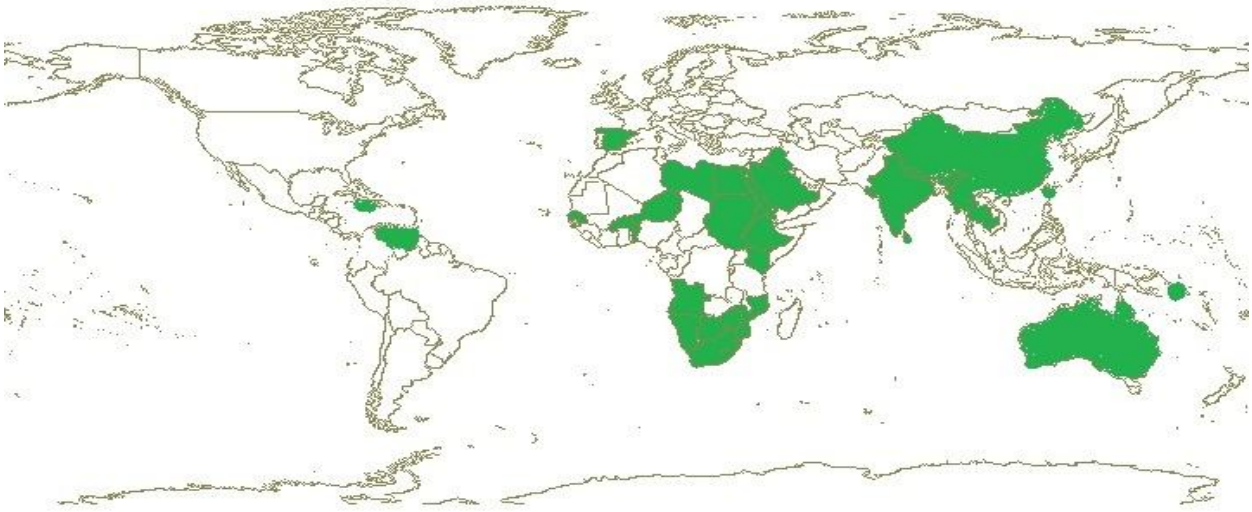


Fig.1.Distribution of *Ammannia baccifera*

Ayurvedic Preperations

In Ayurveda *A.baccifera* was used in PASHANABHEDA as herbal stone crushers by kerala vaidyas[27, 28] in the treatment of vesical calculus, gravels, dysuria, anuria and stone breakup in kidney and bladder and used as substitute for *Aerva lanata* Juss. Ex Schult in Ghrita-Shatavaryadi ghrita[29, 30, 31].

Traditional Uses

In Indian medicinal systems like Ayurveda, Unani, Sidda, the leaves of *A.baccifera* are considered as laxative, stomachic, appetizer, hepatopathy, rubifacient, aphrodisiac, lithontripptic and useful for treating strangury. It is useful in vitiated condition of kapha and pitta. Table 2 list the ethnomedical uses of *A.baccifera*. Leaves are commonly used to raise blisters in rheumatic pain [32, 33] relieve swelling [34], biliousness [35] and to alleviate spleen disorder [36]. Dried leaves are used to treat venereal disease and also employed as an ingredient to betel leaf chewing mixture for human adults [37].The oral infusion acts against syphilis[38]. *A.baccifera* is also extensively used in traditional Chinese herbal formulations for treatment of spinal disease [39], gastroenteropathy [40], hemorrhoids [41], common cold [42], abscess, sore, itching and other skin infections[43].

Biological Aspects of *A.Baccifera*

The plant was reported with activities like hypothermic, hypertensive, antisteriodogenic, antimicrobial, antiurolithic, antiinflammatory, antitumor, antitubercular, antipyretic, antidiuretic, antityphoid and CNS depressant activity[54,55,56]. Das and Maiti, were conducting a field study in Rakha mine, Jharkhand (India) and found that roots of *A.baccifera* having accumulation of more Zn and Ni in their underground tissue when compared to shoots[57]. Higher than toxic levels of metal concentration indicates the presence of internal metal detoxification, tolerance mechanism mainly to copper tailings and Cu accumulator in metal mine waste[58, 59].

Pharmacological relevance / Reported Biological activities of *A.baccifera*

Scientific investigation on the medicinal properties of *A.baccifera* dates back to the 1930s. A summary of the findings of these studies is presented below**.**

Table 2. Traditional uses and extract preparations

S. No.	Geographical region/ state/	Tribes/ village people (group)	Plant parts / preparations	Ethnomedicial uses	References
1.	Orissa	*Jhara, Keuta, Dhivara*	5-6 Shoots are grinded with 7 fruits of *Piper nigrum*, the mixture applied to cure ring worm with in half to one hour.	Ring worm	[44]
	Orissa (Eastern ghat region)	*Kutia Kandha*	Leaf juice with honey in empty stomach. Plant leaves with common salt was also used to cure	Typhoid Skin disease ring worm,	[45]
2.	Western ghats	*Kanikkars*	10gms of *A.baccifera* mixed with *Citrus aurantifolia* (Chrishm.) Swingle juice applied 2 times a day for a week.	Eczema	[46]
3.	Andra pradesh	*Sugali*	Oral administration of 20g whole plant powder for every four hours with hot cow milk works against *Bungarus fasciatus*(banded krait) bite.	Snake bite.	[47]
		Chenchus, Yerukulas and *Yanadis or Irulas.*	*A.baccifera* and *Andrographis paniculata* leaf powder in equal quantities administered orally for every 1 hour up to 10 min works against Scorpion sting.	Scorpion sting	
4.	Kerala	*Muthuvas*	Leaf juice	Poisonous bites	[48]
5.	North- west Himalaya	*Gujjars* and *Bhotiyas*	The decoction prepared from 10g of fresh leaves with 10g of *Cyperus rotundus* roots and 5g of fresh ginger is used.	Intermittent fever	[49]
			Whole plant is burned and ashes are mixed with til oil (*Sesamum indicum*) and the ashes of whole plant mixed with til oil.	Skin eruptions	
			Leaf infusion with warm water	Decrease sexual desire in axon	
6.	Gujarat	*Maher*	Two spoonful decoction of entire plant was taken orally twice a day for a week.	Gonorrhoea	[50]
7.	Rajasthan Shekhawati		Decoction of whole plant is taken twice a day	Fever	[51]
			Leaf paste and inflorescence to skin	itching	
8.	Jaipur	*Santal*- Kantabania	Leaves bruised and applied externally	Ringworm, parasitic skin infection	[52]
9.	Benin	*Bariba and Wama ethnic groups*	Leaves	Jaundice, fever, malaria, eliminate blood clots.	[53]

Antioxidant

The preliminary qualitative chemical assays of ethanol extract indicated the presence of tannins, saponins, steroids, terpenoids, flavonoids [60, 61]and absence of alkaloids [62]and flavonoids are found to be the major constituents of the genus *Ammannia*[63]. The Chinese dietary supplement includes *A.baccifera*, because of the taste of licorice and showing promising activity against lung cancer cells[64, 65]. The quantitative estimation of methanol extract revealed 95.7 ± 1.6, 6.2 ± 4.2 and 43.3 ± 0.1 g/100 g of total phenolics, tannins and flavonoids, respectively. The free radical scavenging assays that include DPPH•, Superoxide, Hydroxyl and Nitric oxide scavenging activities of extract showed the IC50 value of DPPH• as 8.3 g/mL. This value was lower when compared with the positive standards BHA (9.7 g/mL) and rutin (17.4 g/mL). The other assays exhibit higher radical scavenging activity than the positive standards BHA and Rutin[66]. Vijayakumar *et al.*investigated ethanol extract of *A.baccifera* (600 or 800 mg/Kg b.w/day) against CCl_4 induced erythrocyte damage in rats and found that extract protected the loss of functional integrity and lipid alteration in red blood cells. Pretreatment of animals with ethanol extract exhibited inhibition on the accumulation of lipid peroxidation products, decreased the membrane fluidity that was induced by CCl_4 and maintained the activities of superoxide dismutase and catalase, proving the inhibition of free radical attack on bio-membrane. Phenolic compounds had a major contribution to various biological activities which are related to antioxidants[60].

Anticancer

The methanol extract of *A.baccifera* leaves displayed significant anticancer activity than the aqueous extract in the MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide] assay. The methanol extract produced selective cancer cell line cytotoxicity with IC_{50} values of 0.55, 0.59 and 0.91 mg/mL against gastric, colon and breast cancer cells, respectively and also proved no evident cytotoxicity against healthy mouse fibroblast cells [67]. Another *in vitro* study showed methanol extract had potent cytotoxicity against the cancerous cell line HeLa with IC50 value of 0.13 mg/mL. *In vivo* studies were carried out using Dalton's ascites lymphoma (DAL)-bearing Swiss albino mice and compared with the drug 5-Flurouracil. The extract treatment resulted in significant decreases in tumor volume, tumor weight, and viable cell count and enhanced the life span of DAL bearing mice with normal level of RBC, hemoglobin and lymphocyte count [68].

Anti-inflammatory and antiarthritic

The ethanol extract of whole plant exhibited significant dose dependent activity in both acute and chronic inflammatory models. Gopalakrishnan *et al*. evaluated that 100mg/kg bw and 200mg/kg bw of extract produced 38.27% and 43.39% inhibition in anti-inflammatory model (carrageenan induced paw oedema in albino rats) that was comparable with the standard drug indomethacin (48.52%)[69].Loganayaki *et al*. reported that high dose of methanol extract produced significant non-inflammatory activity. In frend's adjuvant induced arthritis model, the dose of 100mg/kg bw and 200mg/kg bw of ethanol extract produced 38.83% and 44.08% inhibition, respectively. Whereas, 55.47% inhibition was reported for the drug[66].

Antianalgesic

The ethanol extract of whole plant was investigated in chemical models of nociception in mice which showed a dose dependent analgesic activity. Abdominal writhes induced by acetic acid in mice was inhibited by 20.7%, 43.4% and 72.9% with the dose of 200, 400 and 600mg/kg i.p, respectively. Whereas in the formalin test those doses did not produce any effect during the first phase (0-5min) of but produce a dose-dependent analgesic effect in second phase (15-20min) with inhibitions of licking time of 27.3%, 47.7% and 57.4%, respectively [70].

Antimicrobial activity

Several studies have found *A.baccifera* to possess antibacterial and antitubercular activity. The methanol extract of the whole plant exhibited potential activity against fungi and bacteria[71, 72,73]. The methanol and choloform extract of leaves showed activity against human pathogenic bacterial strains *Staphylococcus aureus, Bacillus cereus, Enterococcus faecalis, Esherichia coli, Salmonella typhi and Proteus mirabilis*[74]. The root extract showed anti-acne activity against *Propionibacterium acnes*[75]. But Bagchi *et al.* reported that the seeds had low antimicrobial activity[76](**Table 3).**

Table 3. Antimicrobial activity of *A.baccifera*

Tested material	Tested dose and mode of administration	Controls	Method/model used/ MIC/ Other effective results	Experimental evidence assessment	Reference
Ethanol extracts of leaves	6mm diameter Whatmann No. 1 filter paper disks impregnated with 1000µg to 5000 µg	Ampicillin, Tetracycline (30µg/disc) positive control; Ethanol and water negative control.	Disc diffusion method: Diameter of zone of inhibition for 5000 µg: *P. aeruginosa* (12mm); *S. aureus* (14mm); *M. luteus* (10mm); *M. roseus* (11mm); *C.albicans* (12mm); Ampicillin: (24-36 mm) Teracyline: (26mm) on *C.albicans*	Dose dependent study. Positive evidence base	[77]
Ethanol extract of roots	Disc diffusion method: 100mg/ml conc.	Clindamycin standard 10µg/ml	Disc diffusion method:MIC &MBC>5mg/ml against *P. acnes* and *S.epidermidis*	Not dose dependent study; Inconclusive evidence base	[75]
Hexane , methanol and aqueous extract of plant	300µg/disc concentration	Gentamycin (10 µg/disc) Amoxycilin + Clavulonic acid(AC) (20 + 10 µg/disc) Griseofulvine	Disc diffusion method: Diameter zone of inhibition *P.aeuroginosa*: extracts- hexane (26mm), methanol (27mm) and aqueous (26mm); Gentamycin: 26.6mm; AC: 12.0mm. *C.albicans*: extracts- hexane & methanol (21mm); *K.mamlamus*: extract- methanol 20mm; Griseofulvine(14mm)	Dose dependent study	[78]
80% Ethanol whole plant	1000µg/ml	Not reported	Agar dilution-streak method: MIC 1000µg/ml; partial growth inhibition against *S.aureus* smith strain; *S.gallinarum*; *M.smegmatis* ; *C albicans*. No activity against *E.coli*; and *K.pneumoniae*;	Not dose dependent study; Inconclusive evidence base	[79]
95% ethanol extract of Whole plant and other parts leaf, stem and root	Concentration 1000 and 125 µg/disc	Control : Ciprofloxacin 25µg/disc; Fluconazole 10 µg / disc; Amphotericin B 100 units / disc.	Disc diffusion assay: Highest activity - Whole plant : 22.7± 0.47 mm (*E.coli*), 24.6 ±0.63mm (*C.krusei*), 26.0+/-0.54mm (*A.niger*) ; Leaf : 22.0 ±0.8 mm (*S.typhi*), 23.7±0.38mm (*C.albicans*), 27.3± 0.09mm (*A.niger*); Root : 18.5 ± 0.27mm (*S.typhi*); Stem : 20.1±0.31mm (*P. mirabilis*) MIC at 62.5µg/ml of whole plant. Low activity - *P.aeruginosa*, *P.mirabilis, K.pneumoniae*, *S.aureus, N.faecalis*, *V.cholerae, C.tropicalis*.	Positive evidence base	[80]
Aqueous and methanol extract	0.1ml extract.	Negative Control: Distlled water and methanol	Agar disc diffusion and agar well diffusion method. Methanol extract: *E.coli* (15mm), *P.Pseudoalcaligenes* (25mm), *B.cereus* (15mm), *K.pneumoniae* (12mm) No activity in aqueous extract.	Not dose dependent study	[72]

Anti-Tubercular activity

80% ethanolic extract of the whole plant exhibited antimycobacterial activity [81, 82]. Upadhyay *et al*. reported the phytocompound 4-hydroxy-α-tetralone and 4-o-myricitoyl-α-tetralone to have *in vitro* anti-tubercular activity against *Mycobacterium tuberculosis* H37RV by BACTEC-460-radiometric susceptibility assay with MIC as 50µg/ml. The lower concentration of bioactive compound inhibited the growth of the organism and exhibited significant antitubercular activity[83].

Wound healing

Wound healing property of the creams prepared with chloroform, ethyl acetate and ethanol extracts of *A.baccifera* leaf was evaluated by Rajasekaran *et al*. with the standard drug "Framycetin" cream. Rats of both the sex did not produce any signs of toxicity and mortality up to a dose of 2000mg/kg of extracts for 14 days. The cream prepared with 5% chloroform extracts (w/w) showed faster wound contraction and complete healing on 14 day in excision wound model and increased tensile strength in resutured incision wound and the results were comparable to the drug framycetin[62]. According to Udupa *et al*. increase in tensile strength may be attributed to the increase in collagen concentration, stabilization of the fibers and enhanced action of myofibroblasts that are responsible for elasticity of the tissue[84].

Anti-pyretic and Diuretic activity

Brewer's yeast induced pyrexia method is followed by Joanofarc *et al*. to evaluate the antipyretic activity of the extracts of *A.baccifera* against wister albino male rats. Chloroform extract at 200mg/kg dose level exhibited significant activity compared to paracetamol at 100mg/kg after 270 minutes of drug administration. The diuretic activity of ethyl acetate, ethanol and petroleum ether extracts was significant even at 4^{th} hour where as petroleum ether extract showed significant level at 24^{th} hour. Chloroform extract was completely devoid of diuretic activity[85]. They also reported that the diuretic effect of PEE, EAE and EE may be like that of frusemide which brings about local prostaglandin synthesis.

Anti-Steroidogenic activity

Dhanapal *et al*. evaluated the steroidogenic activity in mature female albino mice ovaries. The ethanol extract significantly reduced the weight of ovaries, increased the cholesterol and ascorbic acid content in ovaries and significantly inhibited the key enzyme Δ5-3β hydroxy steroid dehydrogenase (Δ5-3β-HSD) and glucose-6-phosphate dehydrogenase (G-6-PD) which are involved in the ovarian steroidogenisis[86].

Larvicidal action

Methanol extract of aerial part of the plant caused larval mortality of fourth instar larval in *Aedes aegypti and Culex quinquefasciatus.* The probit analysis of methanol extract for 24h and 48h produced LC_{50} value of 164.00 and 107.00 (mg/L) and LC_{90} values of 310.00 and 261.00 (mg/L) on *C. quinquefasciatus*. LC_{50} values for *A. aegypti* were 226.00 and 186.00 (mg/L) and LC_{90}values were 476.00 and 309.00 (mg/L). Methanol extract showed potent lavicidal activity than the ethyl acetate and chloroform[87]. The aqueous extract of aerial parts also showed activity against *Anopheles subpictus* (LC50=257.61) and *Culex quinquefasciatus* (LC50 = 210.88). The green synthesized silver nanoparticles showed significant toxic effects against the larvae of *A. subpictus* (LC50 = 29.54 ppm) and *C. quinquesfasciatus* (LC50 = 22.32ppm) [88].

Antiurolithic

The plant *A.baccifera* showed promising antiurolithiatic activity. Ethanolic extract (2gm/kg/day po.) was found to be effective in reducing the formation of urinary stones (prophylactic) as well as dissolving pre-formed ones (curative) that were induced by implantation of zinc discs in the urinary bladders of rats that resulted in the significant increase of calcium, magnesium and oxalate during urine excretion. The stones formed were mainly of magnesium ammonium phosphate with traces of calcium oxalate. Treatment with *A.baccifera* also significantly reduced calcium and magnesium levels [89].

Toxicological activity

Lavanya Goodla *et al*. screened the ethanolic extract of *A.baccifera* for its acute and sub-acute toxicological effects on rats. Acute oral toxicological studies revealed that all the animals tolerated the test doses up to 2000 mg/kg body weight. Sub-acute toxicity studies indicated that the doses of 50, 100, 250 and 500 mg/kg body weight /day did not produce any significant dose-related changes in haematological, biochemical parameters and histopathology of vital internal organs[90]. Using brine shrimp test (BST) Deeseenthum *et al.* reported that compounds 1,4-napthoquinone and 4-hydroy-1-tetralone from *A.baccifera* showed high toxicity against brine shrimp with LC_{50} of 10.56 and 17.88 ppm, respectively[91].

Phytochemicals in *A.baccifera*

The leaves of *A.baccifera* contain carbohydrates, glycosides, saponins, proteins, steroids, flavanoids, tannins and phenolic constituents. The plant was reported to have chemical components like Vitamin C, Quercetin, Rutin, Kaempferol, Lupeol, Betulinc acid, Ellagic

acid, β-sitosterol and Tetralone derivatives and were listed in Table 4 and 5. [83, 92, 93].

Table 4. Reported compounds of *A.baccifera*

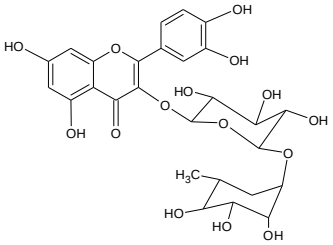
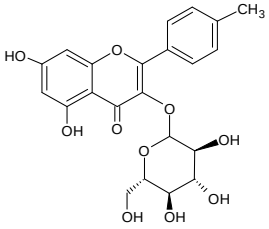
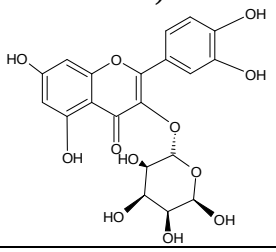
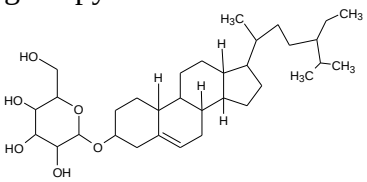
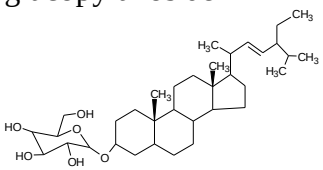
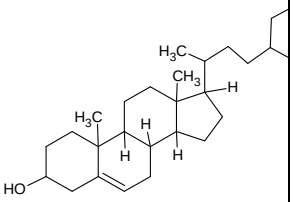
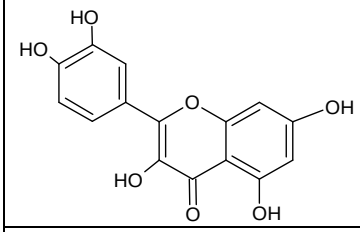
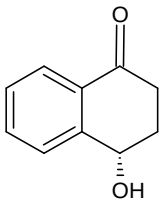
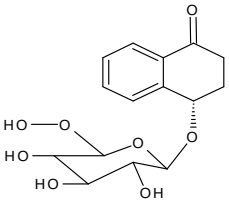
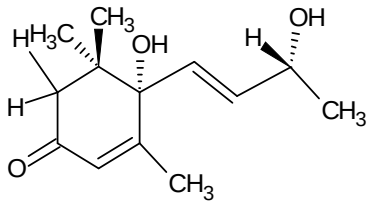
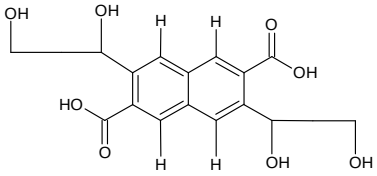
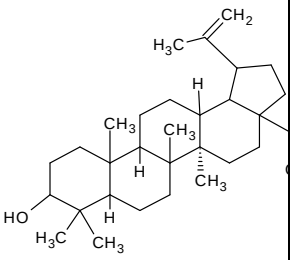
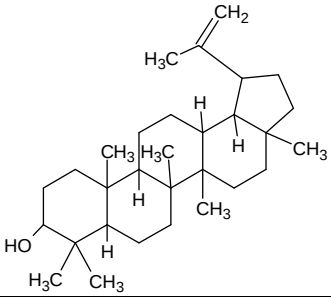
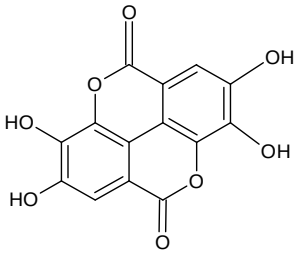
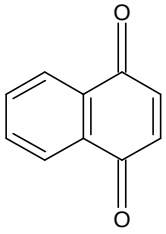
Rutin (Quercetin-3-rutinoside) 	Kaempferol -3- O- β-glucopyranoside 	Quercitrin (Quercetin-3-O-α-L-rhamnoside) 
β sitosterol-3-O-β-glucopyranoside 	Stigmasteryl-3-O-β-D-glucopyranoside 	β – sitosterol 
Quercetin 	4hydroxy –α- tetralone 	Tetralone-4-O-β- D-glucopyranoside 
Ambacinol 	Ambacinin 	Betulinic acid 
Lupeol 	Ellagic acid 	1,4, napthoquinone or lawsone 
Dotricontanol CH3-(CH2)30-CH2OH	Hentiracontane CH3-(CH2)29-CH3	1,30-Tricontanediol HOCH2-(CH2)28-CH2OH

Table 5. Chemical group, part of the plant studied and compounds isolated from *Ammannia baccifera* L.

Phytochemicals	Solvent	Part of the plant	References
Sesquiterpenes			
Ambacinol	Ethyl acetate	Whole plant	[92]
Ambacinin	Ethyl acetate	Whole plant	[92]
Betulinic acid	Petroleum ether	Root	[83]
Lupeol	Petroleum ether	Root	[95]
Flavanoids			
Rutin (quercetin-3-rutinoside)	n- Butanol	Whole plant	[92]
Kaempferol -3- O- β- glucopyranoside	n- Butanol	Whole plant	[92]
Quercitrin (Quercetin-3-O-α-L-rhamnoside)	n- Butanol	Leaves	[92]
β sitosterol-3-O-β-glucopyranoside	n- Butanol	Whole plant	[92]
Stigmasteryl-3-O-β-D-glucopyranoside	n-Hexane	Whole plant	[94]
4hydroxy –α- tetralone	n-Hexane,	Whole plant & Leaf & root	[94][93]
Tetralone-4-O-β- D-glucopyranoside	Methanol	Leaf & root	[93]
Coumarin			
Ellagic acid	Petroleum ether	Leaves	[93]
Alkanes			
Dotricontanol	Petroleum ether	Fruit & leaves	[95]
Hentiracontane	Petroleum ether	Fruit & leaves	[95]
1,30-Tricontanediol	Petroleum ether	Fruit & leaves	[95]
1,4, napthoquinone or lawsone	n-Hexane	Whole plant	[95]
Alkyl trans-4-hydroxycinnamate	n-Hexane	Whole plant	[95]

CONCLUSION

The extensive literature survey revealed *A.baccifera* to be an important medicinal plant documented for diverse applications and used in ethnomedical treatments. Pharmacological studies carried out for the crude extracts and isolated compounds of *A.baccifera* provide a practical support for its numerous traditional uses. Recent studies have been focused on evaluating activity against cancer, inflammatory, arthritic, analgesic, tubercular, larvicidal, microbial activities. The mentioned treatments are conceivable by the presence of phytochemical constituents like alkanes, coumarins, flavonoids and sesquiterpenes. Some of the mentioned pharmacological studies were aimed on validating its traditional uses. It was found that, some of its traditional uses like anti-inflammatory, antimicrobial, etc had been extensively explored by research groups. However, no experimental evidence is available substantiating its traditional use in blood clots, gonorrhea, etc., which can be explored further and there is a need of phytochemical standardization and bioactivity guided identification of bioactive metabolites. Further investigation is necessary to determine the possible benefits on formulation of *A.baccifera* extracts to phytotherapeutic agents against urinary stone, common

cold, skin eruptions, gastroenteropathy and hemorrhoids problems. Studies on the mode of action is anticipated to lead the way for new agents with improved and intriguing pharmacological properties. The outcome of these studies will further expand the existing therapeutic potential of *A.baccifera* and provide a convincing support to its future clinical use in modern medicine.

REFERENCES

1. Stafleu FA, Cowan RS. Taxonomic literature. A selective guide to botanical publications and collections with dates, commentaries and types. 2nd ed, 1(A–G):Regnum Veg,1976.
2. Graham SA. (A revision of Ammannia (Lythraceae) in the western hemisphere). Journal of the Arnold Arboretum, 1985; 66(4): 395-420.
3. Graham SA. (Biogeographic patterns of Antillean Lythraceae). Systematic botany 2003; 28(2): 410-420.
4. Caton, BP, Foin TC, Hill JE. (Mechanism of competition for light between rice (Oryza sativa) and redstem (Ammannia sp.)). Weed Sci, 1997; 45: 269-275.
5. Khare CP, Indian Medicinal Plants. New Delhi, India, Springer Private Limited: 2007: 42–43.
6. Schrenk H. (On the floating tissue of Nesaea verticillata (L.), H.B.K.) Bulletin of the Torrey Botanical Club, 1889; 16: 315–323.
7. Esser PM. Leaf anatomy of the Myrtales. XIV *International Botanical Congress*, Berlin. 1987; Abstract 4-128-3: 245.
8. Turki ZA. (The genes of ammannia L. (Lythraceae) in Egypt). Fl Medit; 2007; 17: 97-114.
9. Jani S, Shukla VJ, Harisha CR. (Phytochemical and pharmacognostical investigation on *Ammanniabaccifera*. Linn (stem and leaf)). International Journal of Pharmaceutical &Biological Archives. 2012; 3(4): 884-887.
10. Deshmukhh PV, Kiran MA, Rakhonde SP. (Experimental taxonomic study of medicinal plant: *Ammanniabaccifera* Linn). An international refreed & indexed quarterly journal, 2012; 2(2): 105-111.
11. Kshirsagar AA. (Anatomical studies of leaves in some species of Ammannia L. (Lythraceae)). Journal of chemical, biological and physical sciences, 2012; 3(1): 228-232.
12. Joshi AC, Venkateswarlu J. (Exceptional behavior of the synergids in the embryosac of angiosperms). *Nature*, 1933; 409.
13. Panda H, Hand book on medicinal herbs with uses. New Delhi; Asian pacific business

press. 2004.

14. Pullaiah T, Medicinal plants in India, 1st ed., Delhi; Regency Pubilcations: 2002.
15. Germishuizen G, Meyer NL. (Plants of South Africa: an annotated check list). Strelitzia. 2003; 14: 616.
16. Greuter W, Raus T. (Med-Checklist Notulae, 21). Willdenowia, 2002; 32: 195-208.
17. Mitchell AS. (A summary of the family lythreceae in the northern territory (with additional comments on Australian materials). J Adelaide Bot Gard, 1976; (1)1: 55-59.
18. Greuter W, Burdet HM, Long G. (Med-Checklist 4. Dicotyledones (Lauraceae-Rhamnaceae)). Geneve, 1989; 228.
19. Raus T. (Ammannia (lythraceae) in Greece and the Balkans). Lagascalia, 1997; 19(1-2): 851-856.
20. Pullaiah T, Muralidhara Rao D, Sri Ramamuthy K. Flora of Eastern Ghats: Hill range of southeast India. Delhi; Daya Publishing House, 2002.
21. Graham A, Nowicke J, Skvarla JJ, Graham SA, Patel V, Lee S. Palynology and systematics of the lythaceae. I. Introduction and genera adenaria through ginoria. Amer J Bot, 1985; 72(2): 1012-1031.
22. Perveen A, Qaisser M. (Pollen flora of Pakistan XLIIL lythraceae). Pak J Bot, 2005; 37(1): 1-6.
23. Kumar S, Narain S. (Herbal remedies of wetlands macrophytes in India), International journal of pharma and bio sciences, 2; 0101(2): 1-12.
24. Rao DM, Bhaskara Rao UVU, Sudharshanam G. (Ethno-Medico-Botanical studies from rayalaseema region of southern eastern ghats, Andhra Pradesh, India). Ethnobotanical Leaflets, 2006; 10: 198-207.
25. Cook CDK. Aquatic and wetland plants of India. New York; Oxford University Press Inc, 1996.
26. Swapna MM, Prakashkumar R, Anoop KP, Manju CN, Rajith NP. (A review on the medicinal and edible aspects of aquatic and wetland plants of India). Journal of medicinal plants research, 2011; 5(33): 7163-7176.
27. Wujastyk, Dagmar, Smith FM. Modern and global Ayurveda: pluralism and paradigms. Albany, NY; State University of New York press, 2008.
28. Venugopal SN. (Herbal stone crusher: The pashhanabheda). ENVIS Newsletter on medicinal plants, 2008; 1(1&2): 7.
29. Ayer NK, Kolammal M. (Pharmacognosy of Ayurvedic Drugs, Kerala), Department of Pharmacognosy, University of Travancore, Trivandrum. 1994; 1(6): 24-26.

30. Anonymous. The Useful Plants of India, New Delhi; National Institute of Science Communication,CSIR, 2000.
31. Chandra K, Chaudhari BG, Dhar BP, Josep GVR, Mnagal AK, Dabur R, Mandal TK, Gurav AM, Yelne MP, Singh SP. (Database on medicinal plants used in Ayurveda), Central Council for Research in Ayurveda & Siddha, 2007; 8: 90.
32. Kritikar KR and Basu KM. Indian medicinal plants 2nd ed vol.3 Basu L.M. (ed) Allahabad, India, 1933.
33. Kaur A, Nain P, Nain J. (Herbal plants used in treatment of rheumatoid arthritis: A review). International journal of pharmacy and pharmaceutical sciences, 2012; 4(4): 44-57.
34. Thirumalai T, Kelumalai E, Senthilkumar B, David E. (Ethnobotanical study of medicinal plants used by the local people in Vellore district, Tamilnadu, India). *Ethnobotanical Leaflets*, 2009; 13: 1302-11.
35. Perry M. Medicinal plants of east and south Asia attributed properties and uses, England; MIT press Cambridge, 1980.
36. Atta-ur-Rahman, HM. Said, VU Ahmad. Pakistan encyclopedia planta medica- chemistry, pharmacology indigenous medicine. *Hamdard foundation press*, Karachi, 1986; 1: 89-90.
37. Sabnis SD, Bedi SJ. (Ethnobotanical India). J For, 1983; 61: 65-69.
38. Prasad KV, Bharathi K, Srinivasan KK. (Evaluation of *Ammannia baccifera* Linn. for antiurolithic activity in albino rats). Indian J Exp Biol, 1994; 32: 311-3.
39. Meng G. Chinese patent, 101417003 A, 2009.
40. Zhang H. Chinese patent, 1398606 A, 2003.
41. Cao Y. Chinese patent, 101549115 A, 2009.
42. Zhu H. Chinese patent, 102078584 A, 2011.
43. Wu H, Wu J. Chinese patent, 101524449 A, 2009.
44. Kumar RK, Mishra SS. (Use of agnikuanri (*Ammannia baccifera* L.) in ringworm of biirmaharajpur block (sonepur district)). Journal of Pharmaceutical and Scientific Innovation, 2012; 1(4): 37-38.
45. Panda A, Misra MK. (Ethnomedicinal survey of some wetland plants of south Orissa and their conservation). Indian Journal of Traditional Knowledge, 2011; 10(2): 296-303.
46. Lalitha rani S, KalpanaDevi V, Tresina Soris P, Maruthupandian A, Mohan VR. (Ethnomedicinal plants used by kanikkars of agasthiarmalai biosphere reserve, western ghats). Journal of Ecobiotechnology, 2011; 3(7):16-25.
47. Basha SK, Sundarshanam. (Evaluation of antibacterial activity of some medicinal plants

by Sugali tribe of Yerramalais forest of Andhra Pradesh). Journal of Pharamacy Research, 2011; 4(7): 2067-2068.

48. Binu Thomas, Rajendran A, Chandrashekara UM, Sivalingam R.(Ethnomedicinal plant knowlwdge of tribe Muthuvas of Mannavan Shola forest of southern western ghats, Kerala, India). Botanical report, 2012; 1-5.
49. Dangwal LR. Sharma A, Kumar N, Rana CS, Sharma U. (Ethno-medio botany of some aquatic angiospermae from north-west Himalaya). Researcher, 2010; 2(4): 1-6.
50. Odedra NK. Ethnobotany of Maher tribe in Porbandar district, Gujarat, India. Sourastra university. 2009; 87.
51. Katewa SS, Galav PK. (Traditional herbal medicines from Shekhawati region Rajasthan). Indian Journal of Traditional Knowledge, 2004; 4(3):237-245.
52. Satapathy KB, Sahu BB, Jena G. (Crop weeds diversity and their ethnomedicinal uses in the treatment of common ailments in jaipur district of Odisha (India)). Int J Med Arom Plants, 2012; 2(1):80-89.
53. Achigan-Dako EG, Ndanikou S. (Traditional vegetable in benin: Diversity, distribution, ecology, agronomy, and utilization). Darwin initiative project and International foundation for science project, 2009: 164.
54. Parrotta JA. Healing plants of peninsular India. 1st ed. Singapore: MRM graphics Ltd; 2001.
55. Immanuel RR, Lyla Elizabeth. (Weeds in agroecosystems: Asource pf medicines for human health care).International Journal of PharmTech Research, 2009; 1(2): 375-385.
56. Dhar ML, Dhar MM, Dhawan BN, Mehrotra BN, Srimal RC, Tandon JS. (Screening of Indian plants for biological activity: part IV). Indian journal of experimental biology, 1973; 2: 43-54.
57. Das M, Maiti SK. (Metal accumulation in 5 native plants growing on abandoned Cu-tailings ponds). Applied ecology and environmental research, 2007a; 5(1): 27-35.
58. Das M. Maiti SK. (Metal accumulation in *A.baccifera* growing naturally on abandoned copper tailings pond). Env Monit and Assess, 2007b; 127: 119-125.
59. Mukhopadhyay S, Maiti SK. (Phytoremediation of metal mine waste). Applied ecology and environmental research, 2010; 8(3): 207-222.
60. Vijayakumar S, Dhanapal R, Sarathchandran I, Kumar AS, Ratna JV. (Evaluation of antioxidant activity of *Ammania baccifera* (L.) whole plant extract in rats). Asian Pacific Journal of Tropical Biomedicine, 2012; S116-S119.
61. Thakkar S, Deshmukh V, Saoji A, Duragkar NJ. (Chemical examination of *Ammannia*

baccifera Linn). Journal of the Indian chemical society, 1986; 63: 619-620.

62. Rajasekaran A, Sivakukmar V, Darlinquine S. 2011. (Evaluation of wound healing activity of *Ammannia baccifera* and *Blepharis maderaspatensis* leaf extracts on rats). Braz J Pharmacogen, 2011; 1-10.
63. Graham SA, Timmermann NN, Mabry TJ. (Flavanoid glycosides in *Ammannia coccinea* (Lythraceae)). Journal of natural products, 1980; 43: 644-645.
64. Lee Glending. 2004. Curry leaves may help control diabetes, scientists say. The Guardian, 2004, 13.
65. Techatanawat I, Houghton PJ, Steventon GB, Hylands PJ.(Investigation of some Thai medicinal plants used to treat cancer). Presented at the British Pharmaceutical Conference, Manchester, 2004.
66. Loganayaki N, Siddhuraju P, Manian S. (Antioxidant, anti-inflammatory and anti-nociceptive effects of Ammannia baccifera L. (Lythrecceae), a folkore medicinal plants). Journal of Ethnopharmacology. 2012; 140(2): 230-233.
67. Uddin SJ, Grice ID, Tiralongo E. (Cytotoxic Effects of Bangladeshi Medicinal Plant Extract). Evidance-Based Complementary and Alternative Medicine, 2009; 1-50.
68. Loganayaki N, Manian S. (Antitumor ctivity of the methanolic extract of *Ammannia baccifera* L.against Dalton's ascited lymphoma induced ascetic and solid tumor in mice). Journal of Ethnopharmacology, 2012; 142: 305-309.
69. Gopalakrishnan S, Kamalutheen M, Ismail ST, Vadivel E. (Pharmacological evaluation of Ammannia baccifera Linn). Journal of Pharmacy Research, 2010; 3(7): 1547-1549.
70. Dhanapal R, Vrushabendraswamy BM, Murugesan T, Chandramohan K, Sridharchandanam K, Kaviimani S. (Evaluation of analgesic activtity of *Ammannia baccifera* Linn. In mice). West Afr J Pharmacol Drug Res, 2004; (20): 31-34.
71. Parekh J, Karathia N, Chanda S. (Screening of Some Traditionally Used Medicinal Plants for Potential Antibacterial Activity). Indian Journal of pharmaceutical sciences, 2006; 832-834.
72. Parekh J, Chanda S. (Antibacterial and phytochemical studies on twelve species of Indian medicinal plants). African Journal of Biomedical Research, 2007; (10): 175-181.
73. Basha S.K and G.Sudarsanam. (Traditional use of plants against snake bite in sugali tribes of yerramalais of Kurnool district, Andra Pradesh, India). Asian pacific journal of tribal biomedicine, 2012; (12): S575-S579.
74. Suresh G, Ramesh B, Kavitha K, Ravichandran N, Suresh A, Gopalakrisnan V, Siva V. (Preliminary screening of antimicrobial compounds from palar river basin flora. Journal

of phytology).2010; 2(2): 24-29.

75. Kumar GS, Jayveera KN, Kumar CK, Swamy VBM, Umachigi SP and Kumar KDV. (Antibacterial screening of selected Indian medicinal plants against acne inducing bacteria). *Pharmacologyonline*, 2007; 2: 34-47.
76. Bagchi GD, Amrita Singh, Khanuja SPS, Bansal RP, Singh SC, Sushil Kumar. (Wide spectrum antibacterial and antifungal activities in the seeds of some coprophilous plants of north Indian plains). Journal of Ethnopharmacology, 1999; 64: 69-77.
77. Jeevan Ram A, Bhakshu LM, Venkata Raju RR. (*Invitro* antimicrobial activity of certain medicinal plants from Eastern Ghats, India, used for skin disease). Journal of Ethnopharmacology, 2004; (90):353-357.
78. Das SK, Dhake AS, Nayak A, Das NB, Pandeya SN. (Antibacterial and antifungal activity of aerial part of plant *Ammannia baccifera* Linn). Research J Pharm and Tech, 2011; 4(3): 430-432.
79. Al-Shamma A, Miyscher LA. (Comprensive survey of indigenous Iraqi plants for potential economic value. 1. Screening results of 327 species for alkaloids and antimicrobial agents). Journal of natural products. 1979; 42(6): 634-642.
80. Sahoo S, Nayak D, Kumar GS, Jayakumari S. (Antimicrobial investigation of *Ammannia baccifera* Linn. Against some urinary and gastro-intestinal tract infection causing pathogens). Indian Drugs, 2012; 49(12): 44-49.
81. Anon. (Antibacterial action of Vakeri root). Indian Journal of Pharmacy, 1967; 29: 103–104.
82. Gautam R, Saklani A, Jachak SM. (Indian medicinal plants as a source of antimycobacterial agents). Journal of ethnopharmacology, 2007; 110: 200-234.
83. Upadhyay HC, Thakur JP, Saikia D, Srivastava SK. (Anti-tubercular agents from Ammannia baccifera (Linn.)). Medicinal Chemistry Research, 2012; 1-6.
84. Udupa A, kulkarni DR, Udupa S. (Effect of Tridax procumbans extracts on wound healing). Int j pharmacog,1995; 33: 37-40.
85. Joanofarc J, Sangeetha J, Jayakumar S, Kumar SS, Gopinadh B, Sam SKG. (Antipyretic and diuretic activity of *Ammannia baccifera*). Natural product sciences. 2003; 9(3): 180-182.
86. Dhanapal R, Kavimani S, Bhyrapur Matha VR, Gupta M, Basu SK. (Antisteroidgenic activity of ethanol extract of *ammannia baccifera* (L.) whole plant in female albino mice ovaries). Iranian journal of pharmacology and therapeutics, 2005; 4(1):43-45.
87. Suman TY, Elumalai D, Vignesh A, Kaleena PK, Murugesan K. (Evaluation of larvicidal

activity of the aerial extracts of a medicinal plant, Ammannia baccifera (Linn) against two important species of mosquitoes, *Aedes aegypti* and *Culex quinquefasciatus*). Asian Pacific Journal of Tropical Disease, 2012; S352-S355.

88. Suman TY, Elumalai D, Kaleena PK, Radhika Rajasree SR. (GC-MS analysis of bioactive components and synthesis of silver nanoparticle using *Ammanniabacciffera* aerial extract and its larvicidal activity against malaria and filariasis vectors). Industrial crops and products, 2013; 47:239-245.
89. Prasad KV, Bharathi K, Srinivasan KK. (Evaluation of Ammannia baccifera Linn. for antiurolithic activity in albino rats). Indian J Exp Biol, 1994; 32:311-3.
90. Lavanya Goodla, Manobolu M, Ravilla S, Poondamalli PR. (Safety evaluation of the ethanol extract of *Ammannia baccifera* (Lythraceae): assessment of acute and subacute toxicity). Journal of pharmacy research. 2010; 3(11): 2634-2637.
91. Deeseenthum S. Tip-pyang S. Wattanasirmkit K, Phuwaprisirisan P. Toxic Metabolites from *Ammannia baccifera*. Asian Coord Group Chem, 2000; (12): 47-50.
92. Mazhar-Ul-Islam. Chemical studies on Ammannia baccifera and bioactivity evaluation of Bergenia ciliate. Ph.D thesis, University of Karachi, Karachi. Pakistan research repository. 2000.
93. Shah. (Chemical constituents of Ammannia baccifera Linn). Pakist J Sci Res, 1962; 14: 4.
94. Tip-pyang S, Deeseenthum S, Wattanasirmkit K, Phuwaprisirisan P. (Bioactive compounds from Ammannia baccifera). *27th congress on science and technology of Thailand*.1. 2001.
95. Thakkar SM, Deshmukh V K, Saoji AN, Duragkar NJ. (Herbal drugs for urinary stones). J Indian Chem Soc, 1986, 64(6): 619-620.