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Review Article

Phytochemical and Pharmacological Studies on *Andrographis paniculata*

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ABSTRACT

Andrographis paniculata (brum.f.) wall. ex nees., of family Acanthacae is a bitter herb commonly used in siddha, Ayurveda and homeopathy medicines as well as tribal medicines in India and some other countries. Its commonly called as king of bitters. In traditional medicine, *A.paniculata* is widely used to get rid of body heat, dispel toxins from body, upper respiratory tract infections, including sinusitis and fever and as antidote against poisons of snakes and insects. The plant has been reported to exhibit various biological activities in vivo as well as in-vitro viz.., anti-viral, anti-bacterial, anti-inflammatory, anti-cancer, anti-HIV and Immunomodulating/immunostimulatory. The various secondary metabolites present in this palnt have considerably enchanced its importance in the arena of medicinal plants. The present studied on phytochemical and pharmacological activities of *Andrographis paniculata.*

Keywords : *Andrographis,* Phytochemical, Pharmacological, Acanthacae.

1. INTRODUCTION

Medicinal plants have been used by human beings since time immemorial for curing health *Andrographis paniculata* belongs to the family *Acanthacae* is an annual herbaceous plant. It is annual herbaceous plant extensively cultivated in southern Asia, China and some parts of Europe [1]. According to Indian ayurveda, *A. paniculata* cools and relives internal heat,inflammation and pain. It is also known as Nelavembu

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meaning "neem of the ground" [2]. It has a strong bitter taste as that of Neem tree. The plant is widely cultivated for its multiple uses. The plant has showed various potential therapeutic actions like liver disorders, cold and cough in humans [3]. It is considered to be highly safe and important.

Botanical description of *Andrographis paniculata* [4, 5]

Growth pattern :

It is a annual, branched, erect, and herbaceous plant which grows in hill slopes, waste grounds, farms, moist habitat, seashores and roadsides.

Habitat

A. paniculata is native to India, Taiwan, Mainland, China, Java, Malaysia, Indonesia, West Indies and America.

Morphology

Its height is 40 to 80 cm, le Its height is 40 to 80 cm, length 2 to 4 cm, apex acuminate, base cuneate, margin shallow unduneate.

Stem : The stem is dark green 2 to 6 mm in diameter, quadrangular with longitudinal furrows and wings at angles of the younger parts, slightly enlarged at the nodes. It can be broken easily due to its fragile nature.

Leaves : Leaves are lanceolate measuring up to 2 to 12 cm long by 1 to 3 cm wide, simple, opposite, acute, glabrous, slightly undulated, pale beneath with tapering base.

Flower : Flowers are small, spreading racemes and solitary. Inflorescence is terminal and axillary in panicle, 10 to 30 mm long with small bract and short pedicle. The flowers posses calyx with 5 sepals which are small and linear. Corolla tubes are narrow, about 6mm long, labiate,upper lip oblong, white with violet markings. Stamens are inserted in the throat and anther basally bearded. Ovary superior 2-celled with exerted style.

Fruit : The fruit is a capsule and contains numerous brown colored seeds. Capsule is erect, linear oblong, compressed, longitudinally furrowed on broad faces with thin glandular hairs. Seeds are very small.

Taxonomical classification

Kingdom : *Plantae*
Subkingdom : *Viridiplantae*
Infrakingdom : *Sterophyta*
Superdivision : *Embryophyta*
Division : *Tracheophyta*
Subdivision : *Spermatophyta*
Class : *Magnoliopsida*
Superorder : *Asteranae*
Order : *Lamiales*
Family : *Acanthaceae*
Genus : *Andrographis*
Species : *paniculata*

Synonyms

Andrographi subspathulata C. B. CI.
Justica laterbrosa Russ. Ex Wall.
Justica paniculata Burm. fil.
Justica stricta Lam. Ex Steud.

Vernacular names

English : Kalamegh,green chiretta, Andrographis
Hindi : Kiryat,kalpanath.
Telugu : Nelavembu
Tamil : Nela vaembu
Kannada : Nelaberu
Malayalam : Nelavepu, kiriyattu.
Marathi : Kalpa

2. MICROSCOPIC CHARACTERS

The T.S of of *A.paniculata* shows short winged projections which consists of single layered epidermal cells compactly arranged. A group of parenchymatous cells, compactly arranged cells with thin cuticle and aligned glandular hairs externally. It consists of 2-5 all layer thick walled hypodermis, cells more or less rounded or polygonal, thin, compactly arranged with the prescence of chlorophyll. The cortical cells are 5 or 6 layer thick rounded, thin walled, compact and parenchymatous. Stele is amphipholic, siphonostele, subjugating supreme part of the stem, spreaded more to the area. Few sclerenchymatous cells are present in the periphery of vascular bundles in a group of 2 to 4 or solitary throughout.

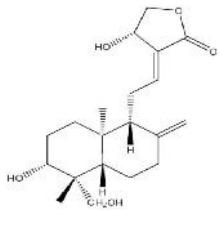
Some other species[6]

Andrographis affinis, Andrographis altata, Andrographis atropurpurea, Andrographis beddomei, Andrographis ceylanica, Andrographis elongate, Andrographis explicate, Andrographis glandulosa, Andrographis gracilis, Andrographis humifusa, Andrographis lawsoni, Andrographis laxiflora, Andrographis lobeliodes, Andrograrphis macrobrotrys, Andrographis neesiana, Andrographis orbiculata, Andrographis ovate, Andrographis paniculata, Andrographis product, Andrographis rothii, Andrographis rotundifollia, Andrographis sinensis, Andrographis stellulata, Andrographis tenera

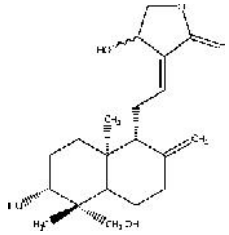
Table 1: Some isolated compounds [17]

S.No	Plant Name	Compounds Isolated
1.	*A.affinis*	5,7,2',3',4'-pentamethoxyflavone, 5hydroxy-7,8,2',5'-tetramethoxyflavone, echioidinin 2'-o-beta-d(6'-o-acetyl)glucopyranoside, 7-0-methyl dihydrowogonin, 7-o-methylwogonin, skulcapflavone, and andrograpanin.[7]
2.	*A.atropurpurea*	7,8,2',3'-tetramethoxyflavone, 5,7,2',3'-tetramethoxyflavone, skullcapflavone 1,2'-methylether, echiodin.[8]
3.	*A.elongata*	2'-oxygenated flavones, 5,2,6'-trihydroxy-7-methoxyflavone, skullcapflavone 1,2'-o-beta-D (4'-E-cinnamyl) glucopyranoside.[9]
4.	*A.glandulosa*	2',5-dihydroxy-7-methoxyflavone, 2',5-dihydroxy-7-methhoxy flavones [10]
5.	*A.lineata*	5,7,2',3',4'-pentamethoxyflavone, 2'-hydroxy-2,4',6'-trimethoxy chaleone, dihydroskullcapflavone.[11]
6.	*A.viscosula*	2'-oxygenated flavones, 5,7,2'-trimethoxyflaone and 5,7,2',4',6'-pentamethoxyflavone,echioidinin,echoidin [12]
7.	*A.altata*	Andrographolide [13]

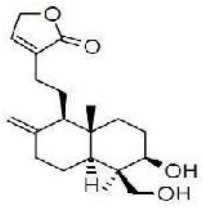
8.	*A.echioides*	Echioidinin, echioidin. [14]
9.	*A.serpyllifolia*	Tectochrysin , apigenin, serpylin [15]
8.	*A.wightiana*	Wightin, echiodinin, wightionolide.[16]



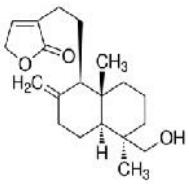
Andrographolide



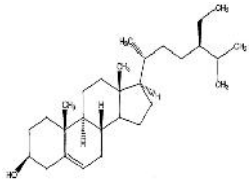
Neoandrographolide



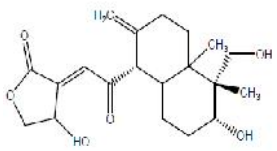
14-deoxyandrographolide



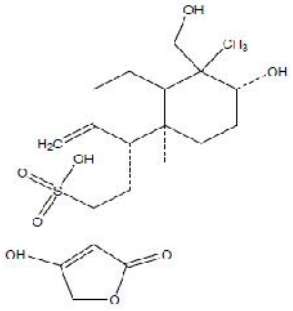
Andrographanin



A-sitosterol



14-deoxy-11-andrograholide



14-deoxy-12(r)-sulfo-andrographolide

3. PHYTOCHEMISTRY [18,19]

The plant contains bitter glucosides such as andrographolide, paniculoside, flavonoids, andrographonin, panicalin, neoandrographolide, apigeninin 7-4-dimethyl ether. The plant contains diterpenoids like 14 deoxy-11-oxoandrographolide, 14- deoxy-11,12-didehydroandrographolide, neoandrographolide and 14 deoxyandrographolide. It consists of flavones like 5-hydroxy-7,8,2`3`-tetra methoxyflavone, andrographonin, flavonesapigenin-7,4`di-o-methyl ether, panicolin and α-sitosterol. The leaves contain andrographosterol, homoandrographolide and andrographone. Whole plant, leaves and root contains a furonoid diterpine Andrographolide; 2',5-dihydroxy-7,8-dimethoxyflavone-2'-o-β-(D)-Glucoside, 3β-hydroxy5-stigmasta-9(11),22(23)-diene, panicolin, diterpene glucoside-neoandrographolide, flavones-5-hydroxy-7,8,2',3'tetramethoxy flavones,andrographin,5-hydroxy-7,8-flavone, apigenin, 7,4-dioxymethyl ester, mono-oxymethylwigthin, deoxyandrographolide-19β-D-glucoside, flavones glucoside A, B, C, D, E and F(root), 5-hydroxy-3,7,8,2'-tetramethoxyflavone, 7-o-methylwogonin, α-sitosterol, apigenin-7,4'-di-omethylether, β-sitosterol glucoside, bitter substances, carcrol, neoandrographolide, eugenol, caffeic, hentriacontane, chlorogenic, pan icolide, eugenol, caffeic, hentriacontane, dicaffeoylquinic acids, tritricontane, 3,14-dideoxyandrographolide, andro-graphoside, en-14 β-hydroxy-8(17),12-laabadein-16,15-olide-3 β199-oxide(aerial part); oroxyliinA, homoandrographolide, wogonin, andropanoside, 14-deoxy-12-methoxyandrographolide, andrograpanin, 14-deoxy-11-oxoandrographolide, 5-hydroxy-2',7,8-trimethoxy flavones, andrographoside, 14-deoxy-11,12-didehydroandrographolide, 2',5-dihydroxy 7,8-dimethoxy flavones, 14 deoxyandrographoside(plant).

Andrographolide is colourless or light yellow crystal compoundwith a very bitter taste [20]. There are four lactones in Andrographais paniculata viz..,(1) 14-deoxyandrographolide, which was also identified[21][22]. Andrographolide, neo andrographolide (a non bitter, C3 O glucoside derivative of the major constituent andrographolide) and 14-deoxy-11,12-di-dehydro-andrographolide which were also identified[23]. The other medicinal chemical principles are diterpenoids viz. 14-deoxyandrographolide, -19β-D-glucoide which has been isolated from leaves. Andrographolide and neoandrographolide were seperated from leaves of Andrographis paniculata [24].

Past work on phyto pharmacology

Anti-microbial activity

The andrographolides and arabinogalactan proteins isolated from the dried herb of *A. paniculata* were screened for anti-microbial activity. The anti-bacterial effect of ehanolic extract of *A. paniculata* against Escherichia coli, klebesiella pneumonia, proteus vulgaris and streptococcus pneumonia by disc diffusion method were identified[25].The aqueous leaf extract of *A. paniculata* was found to have anti-bacterial activity against bacillus subtilis and streptococcus aureus[26]. Petroleum ether, acetone, choloform and methanol extracts of *A.paniculata* leaves and stem exhibit significant anti-microbial activity activity against Enterococcus facialis, streptococcus pyogenses, klebesiella pneumonia, proteus vulgaris [27]. The anti-bacterial activity of hexane, chloroform, methanol extract was determined by using well diffusion method showed the broad spectrum antibacterial activity against tested organisms [29]. The growth of all pathogens was

highly inhibited by methanolic extracts than chloroform and hexane extracts.

Anti-human immunodeficiency virus activity

Aqueous extract of the leaves of *A. paniculata* have shown inhibition abilitytowards HIV-1 infection and replication in the lymphoid cell line MOLT-4. It indicated that extracts of *A. paniculata* may have the potential to infere with viability of HIV virus [29].

Immunostimulatory activity

Intragastric administration of ethanol extract of aerial parts (25mg/kg b.w.) or purified andrographolides (1 mg/kg b.w.) in mice stimulated antibody production and delayed hypersensitivity response to sheep red blood cells. The extract was more effective than either andrographolide or neoandrographolide alone, suggesting that other constituents my involved in immunostimulant response [30].

Andraographolide could interrupt T cell activation both invitro and ivivo. This molecule could interrupt T cell proliferation and cytokine release in response to allergenic stimulation in vitro and in vivo. Andrographolide was reported to have both immunostimulant and immunosuppressant activtity [31]. Moreover andrographolide inhibited the production of TNF-α and IL-12 in macrophages that are stimulated by lipopolysacchride [32].

Anti-inflammmatory activity

Intragastric adminisraion of purified andrographolides to rats inhibited inflammatory responses. In china it is reported that andrographolide have beneficial effects as anti-inflammatory agent. The inflammatory activity of chloroform extract of *A. paniculata* was determined by carragenan induced hind paw odema model for acute inflammation. Ibuprofen was used as a standard drug in this study [33]. Andrographolide is able to downmodulate both humoral and cellular adaptive immune responses. This molecule when used in invitro, was able to interfere with T-cell proliferation and cytokine release in response to allergenic stimulation. This ability of androographolide was applied to interfere with the onset of autoimmune Encphalomyelitis (EAE), an inflammatory demylenating disease [34].

Anti-malarial activity

A 50% ethanol extract of aerial parts inhibited the growth of *plasmodium berghei* both in invitro (100mg/ml) and in mice (1g/kg) [35]. Invitro studies revealed that compound 1,2-dihydroxy-6,8-dimethoxy-xanthone possed substantial anti-microbial activity against Plasmodium falciparum with its IC50 value of 4µg ml-1. Xanthones bearing hydroxyl group at 2 position demonstrated most potent activity while xanthones with hydroxyl group at 1,4 or 8position possessed very low activity [36]. Methanolic extract significantly inhibited *plasmodium flaciparum* at a 50-percent inhibitory concentration (IC50) of 7.2µg/ml.[35]

Anti-hepatotoxic activity

Andrographis paniculata is hepatoprotective in mice treated with carbontetrachloride or tert-butyl hydroperoxide. Significant liver protection occurred when *Andrographis paniculata* compounds were given to animals 3 days prior to the toxic chemicals given to the animal. The methanol extract of aerial parts and their constituents such as andrographolides have shown antihepatotoxic activity both in vitro and in vivo models. Andrographolide was the major active principle of *A.paniculata* against carbontetrachloride.[37] *A. paniculata* was also reported to be better than the silymarin in protecting the liver against paracetmol toxicity.[38]

Anti-cancer activity

Epidermal growth factor receptor (EGFR) and Transferrin receptor (T*f*R) expressed in epidermoid carcinoma (A-431) cells were used to study the effect of andrographolide on receptor trafficking. Receptor distribution, total number of receptors, surface receptors were analysed by immunofluroscence, western blot as well as flow cytometer respectively. Andrographolide treatment inhibited cell growth, down regulated EGFRs and TFR's. [39] . Microculture tetrazolium,3-(4,5-dimethyl thiazole-2-yl)-2,5-diphenyl terazolium bromide (MTT) and sulphorhodamine B (SRB) assays were utilized in assessing the invitro growth inhibition and cytotoxicity of compounds [40].

Antidiabetic activity

Ethanol extract of *Andrographis paniculata* in rats that induced by sterptozcin (STZ) had a significant effect on blood glucose levels and decreased the activity of enzyme glucose-6-phospatase [41]. *Andrographis panicculata* gave an effect on lowering the blood glucose levels in type 2 diabetic rats induced by high fructose fat fed. This study compared the ability of *Andrographis paniculata* extract and andrographolide as active compound for lowering blood glucose levels on various dose [42].

4. CONCLUSION

Literature survey reveals the medicinal importance of *Andrograpphis paniculata*. Phytochemical investigation revealed the prescence of various phytoconstituents like diterpinoids, flavones, plyphenols . Pharmacologcal studies revealed that Andrographis paniculata has antimicrobial, anti-inflammatory, hepatoprotective, immunomodulatory, anti-HIV, anticancer, anti-malarial activity. Taking great concern of the usefull benefits of the plant *Andrographis paniculata*, itcan be advocate as the safe and highly important plant for mankind.

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6. REFERENCES

1. Kabeeruddin M. Kitabul Advia. Vol 2. Delhi, India: Aligarh Barqi Press; 1937:148.
2. Dymock W. Pharmacographia Indica. Karachi, Pakistan: "e Institute of Health and Tibbi research, Hamdard National Foundation; 1972:45.
3. Gabrielian ES, Shukarian AK, Goukasova GI, Chandanian GL, Panossian AG. A double blind, placebo-controlled study of Andrographis paniculatafixed combination Kan Jang in the treatment of acute upper respiratory tractinfections including sinusitis. Phytomed 2002; 9: 589-597
4. Niranjan A, Tewari SK, Lehri A. Biological activities of Kalmegh(Andrographis paniculata Nees) and its active principles-A review. Ind J NatProd Resour 2010; 1: 125-135
5. Zhang X (2004) WHO monograph on selected medicinal plants. World HealthOrganization, Geneva.
6. Parixit.B.,*et.al*. The genus andrographis . A review journal of pharmaceutical sciences 2012; 4(2) 1835-56.
7. Bhaskar reddy MV *et.al* .J Nat prod.2003. New two oxygenated flavones from Andrographis affinis.
8. O.Sareer 2014.prophylactic and innovative effects of Andrographis atropurpurea
9. Galla jayakrishna, Pennaka harikishore, Chunduri venkata rao, Duvvuru gunaseka, Alan blond, and Bernard bodob. Two New 29-Oxygenated Flavones from Andrographis elongata Natural Products Division,a Department of Chemistry, Sri Venkateswara University, Tirupati-517 502, India and Laboratoire de Chimie des Substances Naturelles,b ESA 8041 CNRS-GDR 790 CNRS, Museum National d'Histoire Naturelle, 63 rue Buffon, 75005 Paris, France.
10. Neeraja Cherukupalli, Sudarshana Reddy Bhumiredd, Subrahmanya Sarma V Akella, Aaysha Sataniya, Prabhakar Sripadi, Venkateswara Rao Khareedu1, Dashavantha Reddy Vudem. Phytochemical Profiling and In Vitro Anticancer Activity of Purified Flavonoids of Andrographis glandulosa.
11. P Hari kishore, M.Vijay bhaskar reddy, M.Kesava reddy, Bernad bodo. Article in phytochemistry 2003;63(4); 457.
12. Y Koteswara Rao, B.Bodo. Phytocemistry.2004. flavones from Andrographis viscosula.
13. Algesaboopathi C and S.Ethnobotany of Indian Andrographis Wallich ex Nees.J.Econ.Tax.Bot. 1999; 23:29-32.
14. Chopra R.N.,Nayer S.L.,Chopra I.C. Glossary of Indian medicinal plants. Counsil of scientific and industrial research; New delhi ,India:1980.p.18.
15. T.R.Govindachri 1968. Chemical investigation of andographis serpyllifolia.
16. T.R.Govindachari, P.C.Parthasarathy, B.R.Pai , P.S Subramaniam . Chemical investigation of Andrographis wightiana.
17. Andrographis paniculata: A Review of its Traditional Uses, Phytochemistry and Pharmacology Joseph Joselin and Solomon Jeeva. Department of Botany and Research Centre, Scott Christian College (Autonomous) Nagercoil, Tamilnadu, 629 003, India
18. Chaiwongkeart D. Medicinal plant used in shrimp: Luk-Tai-Bai, Pha-Ya-Yoe andFha-Talai-Jone. Microbiology, Faculty of Science, Kasetsart University.
19. SCHRI Sichuan Chinese Herb Research Institute. Review of chemicalstudies on A. paniculata. Journal of New Medicinal and New Drugs 1973; 23-30.
20. Tang, W, Eisenbrand G (1992) Chinese drugs of plant origin: chemistry,pharmacology and use in traditional and modern medicine. Springer-Verlag,Germany.
21. Sangalungkarn V, Thummauppakorn P, Kittiyanee U, Chaichantipyuth C. The effect of andrographolide, neoandrographolide and 14-deoxy-11,12- dedehydro-andrographolide on the intestinal motility of white rat. Journal ofPharmaceutical Sciences 1990; 15: 5-7.
22. Garcia LL, Kintanar QL, Fojus FR, Sison FM, Chua NG, et.al. Pharmacologic studies on the leaves of Andrographis paniculata Nees plantgrown in the Philippines. Acta Medica Philippina 1980; 16: 59-68.
23. Dhamma-Upakorn P, Chaichantipyuth C, Pongjunyakul P, Sangalungkarn V,Chaimongkol S (1992) Pharmacological active substances from natural source:spasmolytic activity of some active substances from Andrographis paniculata.Faculty of Pharmacy, Chulalongkorn University, Bangkok, 21.
24. Chem WM, Liang XT. Deoxyandrographolide 19 ß-D-glucoside from theleaves of A. paniculata. Planta Medica 1982; 15: 245-246.
25. Abubacker MN, Vasantha S (2010) Antibacterial activity of ethanolic leafextracts of Andrographis paniculata Nees (Acanthaceae) and its bioactivecompound Andrographolide. Drug invention today 2
26. Manjusha G, Rajathi K, Mini Alphonse JK, Meera K Antioxidant potentialand antimicrobial activity of Andrographis paniculata and Tinospora cordifoliaagainst pathogenic organisms. Journal of Pharmacy Research 2011; 4: 452.
27. Radha R, Sermakkani M, Thangapandian V. Evaluation of phytochemicaland antimicrobial activity of Andrographis paniculata nees (Acanthaceae) aerialparts. IJPLS 2011; 2: 562-567.
28. Bobbarala V, Koteswara Rao P, Srinivasa Rao G, Aryamithra D. Bioactivity of Andrographis paniculata against selected phytopathogens.Journal of Pharmacy Research.2009
29. Stephen H, Comac L. How herbs combine with modern medicine to treatcancer, heart disease, AIDS, and more. Miracle herbs; Kensington PublishingCorporation, New York. 2000.

30. Puri A, Saxena R, Saxena RP, Saxena KC, Srivastava V, et al. Immunostimulant agents from Andrographis paniculata. J Nat Prod 1993; 56: 995-999.
31. Iruretagoyena MI, Sepulveda SE, Lezana JP, Hermoso M, Bronfman M, et.al. Inhibition of NF- {kappa} B enhances the capacity of immaturedendritic cells toinduce antigenspecific tolerance in Experimental AutoimmuneEncephalomyelitis. J Pharmacol Exp Ther 2006; 318: 59-67.
32. Qin LH, Kong L, Shi GJ, Wang ZT, Ge BX . Andrographolide inhibits theproduction of TNF-alpha and interleukin-12 in lipopolysaccharide-stimulatedmacrophages: role of mitogen-activated protein kinases. Biol Pharm Bull 2006; 29:220-224.
33. Radhika P, Prasad Rajendra Y, Sastry BS, Rajya Lakshmi K. AntiinflammatoryActivity of Chloroform Extract of Andrographis Paniculata NeesStem. Res J Biotech 209; 4.
34. Iruretagoyena MI, Tobar JA, González PA, Sepúlveda SE, Figueroa CA,et al. Andrographolide interferes with T cell activation and reducesexperimental autoimmune encephalomyelitis in the mouse. J Pharmacol ExpTher 2005; 312: 366-372.
35. Mishra K, Dash AP, Swain BK, Dey N. Anti-malarial activities ofAndrographis paniculata and Hedyotis corymbosa extracts and theircombination with curcumin. Malar J 2009; 8: 26.
36. Dua VK, Ojha VP, Roy R, Joshi BC, Valecha N, et al. Anti-malarialactivity of some xanthones isolated from the roots of Andrographis paniculata.J Ethnopharmacol 2004; 95: 247-251.
37. Handa SS, Sharma A. Hepatoprotective activity of andrographolide fromAndrographis paniculata against carbontetrachloride. Indian J Med Res 1990; 92:276-283.
38. Visen PK, Shukla B, Patnaik GK, Dhawan BN Andrographolide protectsrat hepatocytes against paracetamol-induced damage. J Ethnopharmacol 1993; 40:131-136.
39. Tan Y, Chiow KH, Huang D, Wong SH Andrographolide regulatesepidermal growth factor receptor and transferrin receptor trafficking inepidermoid carcinoma (A-431) cells. Br J Pharmacol 2010; 159: 1497-1510.
40. Jada SR, Matthews C, Saad MS, Hamzah AS, Lajis NH, et al. Benzylidene derivatives of andrographolide inhibit growth of breast and coloncancer cells in vitro by inducing G(1) arrest and apoptosis. Br J Pharmacol.2008
41. Zhang, XF., Tan, BK., "Anti-diabetic property of ethanolic extract of *Andrographis paniculata* in streptozotosindiabetic rats", *Acta Pharmacol Sin*, vol/issue: 2000; 21(12): 1157-64.
42. Nugroho, AE., Andrie, M., Warditiani, NK., Siswanto, E., Pramono, S., Lukitaningsih, E., "Antidiabetic andantihiperlipidemic effect of *Andrographis paniculata* (Burm. f.) Nees and andrographolide in high-fructose-fat-fedrats", Indian J Pharmacol, 2012; 44(3); 377-381.

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