Environment and Ecology 42 (4) : 1599—1605, October—December 2024
Article DOI: https://doi.org/10.60151/envec/NPMA6237
ISSN 0970-0420

A Brief Review on Phytochemical Constituent and Pharmacological Activities of *Andrographis alata* (Vahl) Nees

Ruthrasrilingam Kumar, Kavitha Ramamoorthy

Received 11 May 2023, Accepted 4 September 2024, Published on 18 October 2024

ABSTRACT

Andrographis alata (Vahl) Nees (Acanthaceae) is commonly termed the vernacular name Peria nangai, comes under most undershrub moist deciduous forest with grassland habit and habitat. It is a medicinal plant form the backbone of traditional system of medicine in India. An important unnoticed medicinal plant found in our hedge grows is *Andrographis alata*. *A. alata* is a lesser-known species compared to its widely studied counterpart, *Andrographis paniculata*. The origin of the crop is India and Sri Lanka. A plant is referred to be medicinal plant if any part of the plant or its products is used to treat any ailments or prevent or cure a disease or alter any physiological and pathological processes. The plant *A. alata* parts and the extract from this it is been used by locals for many years. It has garnered attention in traditional medicine systems for its potential therapeutic properties. An important phytocomponent present in the plant are andrographolide and neo andrographolide which have anti-viral, antioxidant, anti-inflammatory, anti-malarial and hepatoprotective properties. The plant is also been used by locals to treat snake bites and jaundice. But these properties are not scientifically proven. The future prospects of *A. alata* depend on continued scientific interest, investment in research and development, conservation efforts, and its acceptance within healthcare systems and markets. The purpose of this review paper is to describe the various aspects of *Andrographis alata* (Vahl) nees botanical description, medicinal values, chemical constituents, phytochemistry, pharmacological properties, biological activities and cultural practices.

Keywords *Andrographis alata*, Jaundice, Andrographolide, Phytocomponent, Antiviral property.

INTRODUCTION

Herbology or Herbal medicine or medicinal plant refers to the use of plants for medicinal purposes and study of such uses (Adhami *et al.* 2018). Since prehistoricera, the ability of plants as medicine in treating human disease has been documented in indigenous traditional knowledge systems around the world. More than 75% of the people around the world depends on the natural sources for their needs. Many medicinal plants have been investigated intensely for

Ruthrasrilingam Kumar[1], Kavitha Ramamoorthy[2]*

[1]PhD Scholar, [2]Professor
[1,2]Department of Biotechnology, Periyar University, Salem 636011, Tamil Nadu, India

Email: drkavitha@periyaruniversity.ac.in
*Corresponding author

their ameliorative properties and have been recognized well for their beneficial effects. However, the vast databases of medicinal plant are still unexplored and needs attention.

Ethnopharmacology refers to the study of plant derived medicines used traditionally by specific group of people. The importance and usefulness of those plants have been validated scientifically and their pharmacological attributes of the plant drugs are now confirmed. But many plants that have a very strong ethnopharmacological values are left unnoticed which in turn results in the avoidance of those plants that can be able to cure specific diseases while exploration (Heinrich 2010). One such plant which have strong ethnopharmacological values is *A. alata*.

The genus Andrographis includes more than 40 temperate and tropical species many of which are used as medicine in different countries. Some medicinally important species of Andrographis are known as Nilavembu, Siriyaanangai and Periyanangai in the Siddha medicine, and Kalmegh in the Ayurvedic medical literature. The Indian traditional medicine honoured the plant for its ability to reduce fever and use as a tonic.

Andrographis is cultivated throughout Southeast Asia, China, Thailand, Bangladesh and the West Indies (Okhuarobo *et al.* 2014). The plant is found growing in the plains of India and Sri Lanka where it is called Kalmegh or Kiiyat. In India, it is spread across the states of Andhra Pradesh, Assam, Bihar, Karnataka, Kerala, Madhya Pradesh, Tamil Nadu and West Bengal. The chemical contents present in plants can be analyzed and chemicals identified can be used in drug design.

An important medicinal plant which was used by our elders but become unnoticed today is *Andrographis alata* (*A. alata*) commonly known as Periyanangai. *A. alata*, a member of the Acanthaceae family, is a medicinal plant that has been traditionally used in various parts of the world for its therapeutic properties. The present review focusses on the description of the phytochemical and pharmacological properties of *A. alata*.

Ethnobotanical claims of *A. alata*

Ethnobotany is considered a branch of ethnobiology. The study of the associations between people and plants is known as ethnobotany (Garnatje *et al.* 2017). The scientific study of a people's traditional knowledge and practices regarding the various traditional uses of plants that exist in their immediate surroundings is known as ethnobotany (Ajao *et al*. 2021). The local people of palayamchettikulam of Tirunelveli district, Tamil Nadu used periyanangai for many medicinal uses (Selvi *et al.* 2019). The inspection of Irular tribes in Pillur valley, Coimbatore revealed that the plant is used by them for diabetes (Jaganathan *et al.* 2016). The chemical Andrographolides present in the plant has antiviral agents which inhibits the replication of virus (Orosco *et al.* 2023). *A. alata* have been used by ethnic people of Sathyamangalam forests of Western Ghats (Silambarasan *et al.* 2017).

Chemical constituents of *Andrographis genus*

Secondary metabolites are produced during the stationary growth phase of a plant. Many pharmaceutical effects of the plants are dependent on these secondary metabolites. Understanding the biosynthetic pathways, regulation, and the genes involved will help improve yield and metabolic engineering. Andrographis contains a number of diterpenoid lactones, collectively known as andrographolide. These comprise both free glycones and glucosides. The main constituent is considered to be the bitter andrographolide, which possesses multiple pharmacological activities and occurs in the leaves at 2% concentration. Andrographis also contains diterpene, xanthones and flavonoids (Okhuarobo *et al*. 2014). Systematic studies have been carried out by various researchers on chemical components of Andrographis species by using the whole plants.

The phytochemical analysis of the different extracts from the leaf and stem sample of *A. alata* revealed the presence of phytochemicals such as saponins, flavonoids, triterpenoids, glycosides, gums and mucilages, tannins, phenolic compounds and steroids. An important compound present in *A. alata* is Andrographolide (Fig. 1). The leaves of *A. alata* are an amazing source of neo andrographolide (Fig. 2) (Dalawai *et al.* 2021, Kadapatti and Murthy 2021). It

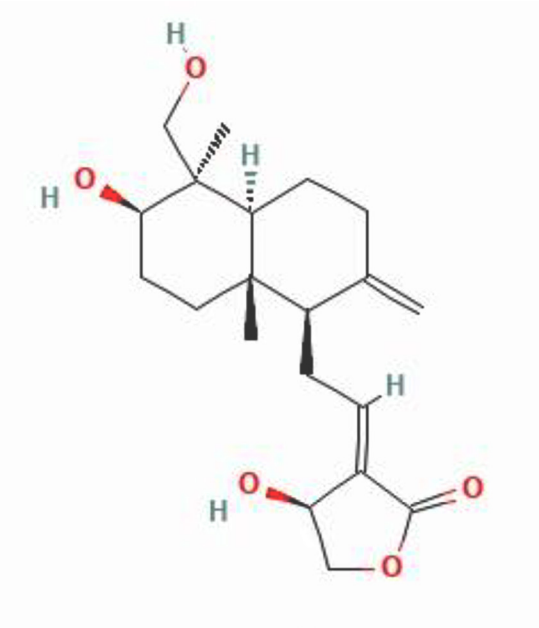

Fig. 1. Structure of Andrographolide isolated from *A. alata.*

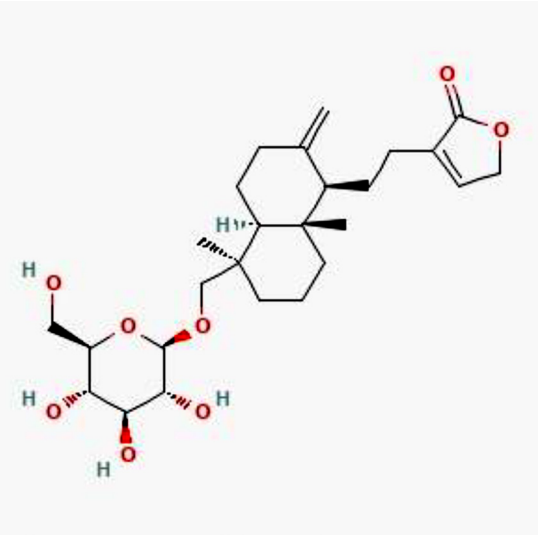

Fig. 2. Structure of Neo andrographolide derived from *A. alata.*

was proved as a potent antioxidant, anti-inflammatory, antimalarial, and hepatoprotective phytochemical *A. alata* (Vahl) Nees contains two important glycosides viz., 5,7,2',6'-oxygenated flavone glycosides and 5,2',6'-trihydroxy-7-methylflavone-2'-O-ß-D-glucopyronoside (Fig. 3) Echioidinin 5-glucoside a new flavone glycoside have been derived from the whole plant of *A. alata*. The structure of the new compound identified by using spectral studies was 5,2′-dihydroxy-7-methoxyflavone 5-O-β-D- glucopyranoside.

The FTIR analysis of *A. alata* showed various stretching frequencies revealed the presence of alkyl halides, alkynes, alkenes ether, ether or aloxy, acyl or nitro compounds, alkene or aromatics, amides, ketones, aldehydes, carboxylic acid, alkanes, alcohol, aromatic ring, amides, amines, alkynes and phenol. By using HPLC analysis 0.01% of andrographolide present in the plant was identified. The above screening led to the identification and isolation of many active compounds from this plant which results in the investigation of new drugs used for the treatment of various ailments Bhavani and Bangajavalli (2020). Five acylated 5,7,2′,6′-oxygenated flavone glycosides along with the known 5,2′,6′-trihydroxy-7-methoxyflavone-2′-O-β-D- glucopyranoside have been isolated from the whole plant of *A. alata.* The structures of the compounds can be studied from spectral and chemical studies (Das *et al.* 2006). The occurrence of such acylated flavone glucosides is rare in nature.

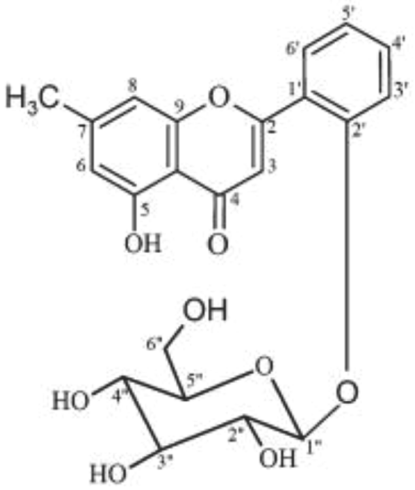

Fig. 3. Structure of 5,7,2′,6′-oxygenated flavone glycosides with 5,2′,6′-trihydroxy-7- methoxyflavone-2′-O-β-D-glucopyranoside isolated from *A. alata*.

Pharmacological properties of *A. alata*

Anti-microbial effect

Anti microbials are substances that kills or prevent the growth of microbes such as bacteria, virus, fungi. Plants offer a wide source of chemicals also called as secondary metabolites which are known to possess the antimicrobial effects. Plants are the sources of new antimicrobial discovery (Ginovyan *et al.* 2017).

A. alata is known to have anti-microbial effect. The various extract of the plant are active against many pathogens viz., chloroform leaf extract against *Alternaria alternata*, ethanol leaf extracts against *Aspergillus niger*, methanol leaf extracts against *A. flavus* : Petroleum ether leaf extracts against *Fusarium solani* and Acetone leaf extracts against *Penicillium pinophiium*. The aqueous extracts from the leaves of *A. paniculata, A. alata, A. elongata, A. macrobotrys* and *A. neesiana* exhibited anti- fungal activity against *Helminthosporium oryzae* which was tested using spore germination and agar cup bioassay methods.

Anti-parasitic effect

Parasites are known to cause diseases of acute, chronic and debilitating nature. In the face of rising resistance and limited options of chemical control for parasites, the alternative ways to prevent them become pivotal (Kandeel *et al.* 2022). Some medicinal plants that contain active principles can be used as anti-parasites (Bauri *et al.* 2015). *A. alata* have anti-parasitic effects. Andrographolide have antiparasitic effect against *Setaria cervi* (Yadav *et al.* 2022).

Anti-inflammatory activity

The anti-inflammatory activities of the alcoholic extracts of three species of Andrographis viz., *A. alata, A. lineate* and *A. paniculata* were assayed at a dose of 500 mg/kg body weight in male albino rats using carrageenin induced rat paw edema. All the extracts were screened for their anti-inflammatory activities in Carrageenin induced inflammation in rats. The maximal anti-inflammatory activity was found with the alcoholic extract of *A. alata* Nees.

Anti-viral activity

Neo andrographolide, a diterpenoid compound, is the major antiviral compound present in *A. alata* responsible for the antiviral property. Recent molecular docking combined molecular dynamics studies have demonstrated that neo andrographolide is a promising candidate for SARS-CoV-2 (Covid-19) treatment (Murugan *et al.* 2020). Andrographolide and related compounds are effective against several viral diseases, including dengue, COVID-19, influenza, and chikungunya (Parani 2023). Andrographolide have antiviral effect and has potential interest in the treatment of SARS-CoV-2 (Adiguna *et al.* 2021).

Hepatoprotective activity

The hepatoprotective activity of aqueous extract and isolated flavone (5-hydroxy, 7, 8, 2'trimethoxy flavone) compound of *A. alata* was tested against CCl4 induced hepatotoxicity and exert significant therapeutic effect in rats (Nagaraja and Krishna 2016). Leaf extract of *A. alata* 25 ml mixed with hot water is given orally twice a day for seven to ten days in jaundice (Alagesaboopathi 2015, Ganesan and Subban 2022). Root is made as a paste with milk and taken orally for seven days to cure jaundice (Karuppusamy 2007).

Anti-cancer activity

Six species, such as *A. alata*, *A. echioides*, *A. glandulosa*, *A. lineata*, *A. nallamalayana* and *A. paniculata* are being extensively used in traditional medicine and are reported to contain several bioactive compounds exhibiting anti-cancer and hepato-protective activities (Arolla *et al.* 2015). TiO_2 nanoparticles prepared via *A. alata* leaf extract shows good anticancerous activity against the MCF-7 cancer cell line (breast cancer).

Anti-diabetic property

Powdered leaves *A. alata* is mixed with cow's milk and drink to treat diabetes (Alagesaboopathi 2014, Jaganathan *et al.* 2016).

Other biological activities

Andrographolide is commonly claimed as cardio-

protective, neo andrographolide is often mentioned as antioxidant, anti-inflammatory, anti-malarial, hepatoprotective, and the 14-deoxy 11,12 di dehydro and rographolide is usually claimed as a hypotensive and antiplatelet agent.

Andrographis has antifertility effects in experimental animals, both in males and in females. The leaf extracts from *A. alata* has antibacterial, antioxidant and antidiabetic, anti-Alzheimer's and wound healing properties which was shown in various *in vitro* biological experiments (Gong and Li 2023).

Treatment of snake bite

Many authors identify the use of *A. alata* in the treatment of snake bite. The tribals of Dharmapuri district, Tamil Nadu used *A. alata* to treat snake bite. Leaf and root paste are applied externally to cure snake bite. A decoction of the leaves of *A. paniculata* with the leaves of *A. alata* is applied externally to treat snakebite (Sughosh *et al.* 2017). A handful of fresh leaves is taken orally for snakebite (Kottaimuthu 2008). To treat snake bite the leaf decoction of the plant was orally administered (Ponnusamy *et al.* 2017). The extract of this plant used against snake bite.

Treatment of Skin disease

A. alata is used to treat skin diseases of humans and leaf paste is used to treat skin diseases in cattle.

Other uses

The juice of the fresh leaves of *A. alata* can be taken twice a day to treat fever and four to six days to treat diarrhoea (Munuswamy *et al.* 2013). *A. alata* is used to treat constipation and lung diseases.

Endangered species

A. alata has been traditionally used in herbal medicine for various purposes, including treating fever, inflammation, infections, and respiratory ailments. However, due to habitat destruction, over-harvesting, and other environmental factors, its population has significantly declined, leading to its classification as an endangered species. Efforts to conserve this medicinal plant involve initiatives such as habitat preservation, cultivation in botanical gardens or protected areas, and regulation of harvesting practices. Additionally, research into sustainable cultivation methods and alternative sources of the plant's active compounds may also aid in its conservation while still allowing for its medicinal use. Conservation efforts are essential to safeguard *A. alata* and its habitat. This involves measures such as habitat restoration, sustainable harvesting practices, imposing strong actions against illegal logging and trading, and raising awareness about the importance of conserving this species for its medicinal value and biodiversity.

Micropropagation offers several advantages for the propagation of *A. alata*, which rapid multiplication of plants, production of disease-free plants, and conservation of genetic diversity. By taking these steps, we can join hands towards ensuring the survival of *A. alata* for future generations.

Future prospects

Plants might be propagated through tissue culture methods to increase its production in order to study about its secondary metabolites through cell line culture and suspension culture. The research on *A. alata* is still in its early stages, there's potential for it to emerge as a valuable medicinal plant with various molecular prospects. Various molecular techniques like genomics and transcriptome analysis could be helpful to find out the various genes responsible for its medicinal properties which in turn could be useful in drug design. These genes function as markers in the plant's genetic analysis. The isolation and study of bioactive compounds from the plant can be done by the new techniques like the use of supercritical fluid extraction, microwave-assisted extraction, and nanotechnology-based approaches. The mode of action of the compounds identified from the plant can be studied by functional genomics and metabolomics. The allelopathic effects of *A. alata* are not studied still. The *in vitro* and *in vivo* models can be used to evaluate the bioactivity and potential toxicity of the plant extracts and isolated compounds. The future of research on *A. alata* is promising, with the application of advanced technologies, multidisciplinary approaches, and sustainable practices that can lead to

the discovery of new therapies and the development of more effective and safe plant-based medicines.

CONCLUSION

The plant demonstrates a range of biological properties, Ethnobotanical claims of *A. alata* Chemical constituents of *Andrographis genus*, Pharmacological properties of *A. alata*, Anti-microbial effect, Anti-parasitic effect, Anti-inflammatory activity, Anti-viral activity, Hepatoprotective activity, Anti-cancer activity, Anti-diabetic property. This herb's recognized component of treatment of snake bite and treat fever and four to six days to treat diarrhoea, treat diabetes, *A. alata* leaf extract shows good anticancerous activity against the MCF-7 cancer cell line (breast cancer).

REFERENCES

Adhami S, Siraj S, Farooqi H (2018) Unexplored medicinal plants of potential therapeutic importance. A review. *Trop J Nat Prod Res* 2 (1) : 3—11.

Adiguna SBP, Panggabean JA, Atikana A, Untari F, Izzati F, Bayu A, Rosyidah AL, Rahmawati SI, Putra MY (2021) Antiviral activities of andrographolide and its derivatives: Mechanism of action and delivery system. *Pharmaceuticals* 14 (11) : 1102.

Ajao AAN, Moteetee AN, Sabiu S (2021) From traditional wine to medicine : Phytochemistry, pharmacological properties and biotechnological applications of Raphia hookeri G. Mann & H. Wendl (Arecaceae). *South African Journal of Botany* 138 : 184—192.

Alagesaboopathi C (2014) Medicinal plants used by tribal and non-tribal people of Dharmapuri district, Tamil Nadu, India. *Int J Curr Res Biosci Plant Biol* 1 (2) : 64—73.

Alagesaboopathi C (2015) Medicinal plants used for the treatment of liver diseases by Malayali tribes in Shevaroy hills, Salem district, Tamil Nadu, India. *World Journal of Pharmaceutical Research* 4 (4) : 816—828.

Arolla RG, Cherukupalli N, Khareedu VR, Vudem DR (2015) DNA barcoding and haplotyping in different species of andrographis. *Biochemical Systematics and Ecology* 62 : 91—97.

Bauri RK, Tigga MN, Kullu SS (2015) A review on use of medicinal plants to control parasites. *Indian Journal of Natural Products and Resources* 6 (4) : 268—277.

Bhavani K, Bangajavalli S (2020) FTIR and HPLC Analysis of *Andrographis alata* (Vahl) Nees of Family Acanthaceae. *Journal of Plant Science Research,* pp 36.

Dalawai D, Aware C, Jadhav JP, Murthy HN (2021) RP-HPLC analysis of diterpene lactones in leaves and stem of different species of Andrographis. *Natural Product Research* 35 (13) : 2239—2242.

Das B, Ramu R, Rao YK, Reddy MR, Harish H, Reddy VS, Ramakrishna KVS (2006) Acylated 5, 7, 2′, 6′-oxygenated flavone glycosides from *Andrographis alata*. *Phytochemistry* 67 (10) : 978—983.

Ganesan T, Subban M (2022) Ethnobotanical survey of medicinal plants used by traditional healers from kiliyur, pattipadi, in Yercaud hills, Salem district. *International Journal of Zoology and Applied Biosciences* 7 (6) : 24—28.

Garnatje T, Penuelas J, Valles J (2017) Ethnobotany, phylogeny, and 'omics' for human health and food security. *Trends in Plant Science* 22 (3) : 187—191.

Ginovyan M, Petrosyan M, Trchounian A (2017) Antimicrobial activity of some plant materials used in Armenian traditional medicine. *BMC Complement Altern Med* 17 (1) : 50.

Gong W, Li X (2023) Biosynthesis and characterization of selenium nanoparticles from *Andrographis alata* : Assessment of their potential antimicrobial, antidiabetic, anti- Alzheimer's and wound healing properties. *Journal of Biochemical and Molecular Toxicology* 37 (12) : e23513.

Heinrich M (2010) Ethnopharmacology and Drug Discovery. *Compr Nat Prod II* 3 : 351—381.

Jaganathan GK, Hoa THT, Liu BL (2016) Ethnobotanical survey of Irular tribes in Pillur valley, Coimbatore, Tamil Nadu (India). *International Journal of Herbal Medicine* 4 (1) : 1—11.

Kadapatti SS, Murthy HN (2021) Rapid plant regeneration, analysis of genetic fidelity, andneo andrographolide content of micro propagated plants of *Andrographis alata* (Vahl) Nees. *J Genet Eng Biotechnol* 19 (1) : 20. doi: 10.1186/s43141-021-00122-5.

Kandeel M, Akhtar T, Zaheer T, Ahmad S, Ashraf U, Omar M (2022) Anti-parasitic Applications of Nanoparticles: A Review. *Pakistan Veterinary Journal* 42 (2) : In press.

Karuppusamy S (2007) Medicinal plants used by Paliyantribes of Sirumalai hills of southern India.

Kottaimuthu R (2008) Ethnobotany of the Valaiyan of Karan damalai, Dindigul District, Tamil Nadu, India. *Ethnobotanical Leaflets* 12:195.

Munuswamy H, Thirunavukkarasu T, Rajamani S, Elumalai EK, Ernest D (2013) A review on antimicrobial efficacy of some traditional medicinal plants in Tamil Nadu. *Journal of Acute Disease* 2 (2) : 99—105.

Murugan NA, Pandian CJ, Jeyakanthan J (2020) Computational investigation on *Andrographis paniculata* phytochemicals to evaluate their potency against SARS-CoV-2 in comparison to known antiviral compounds in drug trials. *Journal of Biomolecular Structure and Dynamics* 39 (12) : 4415—4426.

Nagaraja YP, Krishna V (2016) Hepatoprotective effect of the aqueous extract and 5-hydroxy, 7, 8, 2′ trimethoxy flavone of *Andrographis alata* Nees. in carbon tetrachloride treated rats. *Achievements in the Life Sciences* 10 (1) : 5—10.

Okhuarobo A, Falodun JE, Erharuyi O, Imieje V, Falodun A, Langer P (2014) Harnessing the medicinal properties of *Andrographis paniculata* for diseases and beyond: A review of its phytochemistry and pharmacology. *Asian Pacific Journal of Tropical Disease* 4 (3) : 213—222.

Orosco, Fredmoore Wong, Jonathan (2023) Andrographolides as Antiviral agents : Insights into Mechanisms, Modifications, and Delivery Innovations. *Tropical Journal of Natural Product Research* 7: 5341—5354.

https://doi.org/10.26538/tjnpr/v7i12.1

Parani M (2023) Whole transcriptome analysis identifies full-length genes for neoandrographolide biosynthesis from *Andrographis alata*, an alternate source for antiviral compounds. *Gene* 851: 146981.

Ponnusamy S, Arumugam R, Ariyan S, Chinnaiya R (2017) Ethnobotanical knowledge of threatened plant species Andrographis in Nilgiris biosphere reserve, Tamil Nadu, India. *International Journal of Herbal Medicine* 5(6): 103—107.

Selvi A, Antony Leon T, Stephan Raj (2019) "Ethnobotanical study of palayamchettikulam plains in Tirunelveli district, Tamil Nadu, India."*Acta Biomedica Scientia* 6 (2) : 58—71.

Silambarasan, Rajendran, Jeyalatchagan Sureshkumar, Jayaraj Krupa, Singamoorthy Amalraj, Muniappan Ayyanar (2017) "Traditional herbal medicines practiced by the ethnic people in Sathyamangalam forests of Western Ghats, India." *European Journal of Integrative Medicine* 16 : 61—72.

Sughosh V, Upasani Vishal G, Beldar Anil U, Tatiya MS, Upasani Sanjay J, Surana Divyata S Patil (2017) Ethnomedicinal plants used for snakebite in India: A brief over view. *Integrative Medicine Research* 6 (2) : 114—130.

Yadav S, Ahma F, Rathaur S (2022) Antifilarial efficacy of andrographolide: *Ex vivo* studies on bovine filarial parasite Setariacervi. *Comparative Biochemistry and Physiology Part C* : *Toxicology & Pharmacology* 261 : 109—442.