PHYTOCHEMISTRY OF *ANDROGRAPHIS PANICULATA* (Burm. f.) WALL. EX NEES

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Contents

Summary

Andrographis paniculata [Burm. f] Nees is an important medicinal plant widely used in *Ayurveda*, *Siddha* and Homoeopathy in many formulations and is effective in the treatment of various diseases like malaria, diabetes, viral hepatitis, cirrhosis, liver cancer, etc. It is also used to improve sexual dysfunctions and serve as a contraceptive. The plant is native to India, China, and Southeast Asia. All parts of the plant are the rich source of various bioactive phytochemicals, but the compositions of phytoconstituents widely differ from one part to another and with place, season, and time of harvest. Various class of phytoconstituents i.e., more than 55 labdane diterpenoids, 30 flavonoids, 8 quinic acids, xanthone derivatives, different types of glycosides, tannins and rare nor-iridoids are present in *A. paniculata*. Plant extract/fractions as well as the pure phytoconstituents also exert numerous pharmacological properties *in-vitro* as well as *in-vivo*.

This chapter will deal with the detailed phytochemistry and pharmacological aspects of *A. Paniculata* including its safety profile. An extensive literature survey will be performed from various journals, e-books, monographs, books, data base on medicinal plant, etc. till date and Ayurvedic classical text/ earliest literature on Indian Medicine like *Charaka Samhita* (400-500 A.D.), *Sushruta Samhita* (400-500 A.D.), *Nighantus of Dravyaguna* (500-1600 A.D.), etc. for extracting the complete information about the plant. After a brief introduction, detailed botanical information including plant morphology, description, synonyms, habituate and traditional uses will be discussed. Special emphasis will be given to the various types of bioactive phytoconstituents presents in different parts of the plants and their important biological activities as well as safety profile will be discussed. At the end of the chapter a conclusion and perspective section will summarize the subject.

1. Introduction

The dynamic relation of plants, animals, microorganisms, and their interdependent relation serve as a functional unit of ecosystem. The sustenance of the ecosystem is possible as they depend on one another for basic survival needs like food, shelter, protection and propagation. Plants are considered as the backbone of life on earth by maintaining the crucial balance of carbon dioxide in atmosphere. Moreover, the value of plants also lies in the development of different human cultures around the globe. Additionally, some plants are considered as vital source of nourishment and high valued medicinal products. Apart from medicinal purpose, plants are also used as food products, natural dye, perfume, tea, pesticides and so on. In many countries' different kinds of herbs and medicinal plants are used as insect and mosquito repellents. Thus, medicinal plants are important ingredients in household and pharmaceutical products.

It is observed that about 75-80% of the population in developing countries and about 25% of the people of developed countries depend on medicinal herbs to meet their primary healthcare requirements. However, the use of medicinal herbs is as old as human civilization. Plant derived medicines and indigenous medicinal plants are a vital source of alternative medicine and immensely used to combat different health related complications. Therefore, the processing and utilization of various medicinal herbs is on

the rise as a therapeutic measure for different diseases. One such useful medicinal herb of immense therapeutic potential is *Andrographis paniculata*. *Andrographis paniculata* (Burm. F) Nees, is a popular herb which belongs to the family Acanthaceae. It is distributed throughout tropical and subtropical Asia, Southeast Asia, and India. It is also distributed in various parts of Southeast Asia, China, America, West Indies and Christmas Island. It is popular as the "king of bitters". Its uses are mentioned elaborately in ancient oriental and Ayurvedic medicine. The plant is popular by various names in different countries. In India, *A. paniculata* is called as "*Kalmegh*", in China it is known as "*Chuan-Xin-Lian*", in Thailand it is known as "*Fah Tha Lai*", in Malaysia it is known as "*Hempedubumi*", in Japan it is known as "*Senshinren*" and in Scandinavian countries it is known as "green chiretta". It is an annual, branched, erect herb about half to one meter in height. The aerial parts and roots of this plant have been used largely in China, India, Thailand and other Southeast Asian countries as a traditional medicine as a remedy to various ailments. It has a wide spectrum of ethnobotanical uses as a remedy for snake bite, bug bite, diabetes, dysentery, fever, and malaria. It is among the mostly used medicinal herbs in the *Unani* and *Ayurvedic* systems of medicine. Traditionally, it is used as carminative, liver stimulant, laxative, anthelmintic, blood purifier, anti-inflammatory, antileprotic, antipyretic and as preventive measure for malaria. A broad range of study has been done related to the medicinal properties that this plant possesses in accordance with the traditional medical practitioners. Studies have shown that the plant has a wide range of pharmacological spectrum which justifies the medicinal use of *A. paniculata* as anticancer, anti-diarrheal, anti-hepatitis, anti-HIV, anti-hyperglycemic, anti-inflammatory, antimicrobial, antimalarial, antioxidant, cardiovascular, cytotoxic, hepato-protective, immuno-stimulatory and in sexual dysfunctions. Phytochemical research has confirmed that *A. paniculata*has a wide array of phytochemicals including labdane diterpenoid lactones, flavonoids and miscellaneous compounds. The major phytoconstituents present are andrographolide, andrographin, panicolin, diterpene glucoside neoandrographolide, neo-andrographolide, chlorogenic acid, myristic acid, andropanoside, etc. Various toxicity studies have been done to understand the safety profile of this medicinal herb. Various toxicity studies of extracts and metabolites isolated from the plant were found to be free from acute toxicity in experimental animals. The current chapter provides a comprehensive insight into the various aspects of *Andrographis paniculata* with respect to its botanical description, ethnomedicinal uses, phytochemistry, pharmacological activities and safety profile.

2. Botanical Description

2.1. Origin and Distribution

A. paniculata is native to Taiwan, Mainland China and India. It is also commonly found in the tropical and subtropical Asia, Southeast Asia, and some other countries including Cambodia, Caribbean islands, Indonesia, Laos, Malaysia, Myanmar, Sri Lanka, Thailand, and Vietnam. This plant is also found in different phytogeographical and edaphic zones of China, America, West Indies, and Christmas Island. This plant grows abundantly in Southern and Southeastern Asia including India, Java, Sri Lanka, Pakistan, and Indonesia, while it is cultivated in India, China, Thailand, Brunei, Indonesia, the West Indies such as Jamaica, Barbados, and Bahamas, Hong Kong, and the tropical areas in America and also in southwestern Nigeria. *A. paniculata* grows

normally in hedgerows throughout the plane lands, hill slopes, waste ground, farms, moist habitat, seashores, and road sides. It also can be cultured in garden, moist shady places, forests and wastelands.

2.2. Plant Description; Morphology and Physiology

A. paniculata is an imperative remedial plant of Andrographis genus. The total number of species of this genus varied as per different reports, which embraces either 19, 28, 40, or 44 species. The exact numbers of species of Andrographis genus are not ascertained yet. Total number of chromosomes of *A. paniculata* is 25with 50 in gametophytic and sporophytic count, respectively. In addition, genotypic differences are important contemplations to find out high resilient germplasms.

Andrographis paniculata is an annual, branched, herbaceous plant erecting to a height of 30-110 cm. The stem is dark green in color and acutely quadrangular; much branched and can be broken easily due to its fragile texture. The stem is 30-100 cm in length, and 2-6 mm in diameter. Leaves are simple, opposite, glabrous, lanceolate, 2-12 cm long, 1-3 cm wide with acute entire margin. Inflorescence is terminal and axillary in panicle, 10-30 mm long with small bract and short pedicel. The flowers possess calyx with 5 sepals which are small and linear. Corolla tubes are narrow, about 6 mm long, bilabiate, upper lip oblong, white with a yellowish top, whereas the lower tips are broadly cuneate, 3-lobed, white with violet markings. Stamens 2, inserted in the throat, anther basally bearded. Ovary superior 2-celled with exerted style. Capsule of the herb is erect, linear-oblong, 1-2 cm long, compressed, longitudinally furrowed on broad faces with thin glandular hairs. Seeds are very small. The flowering and fruiting of the plant occurs in December to April. The morphological and physiological data of *A. paniculata* are presented in Table 1

Individualities	Values / Features
Plant height	30–110 cm
Stem	Dark green (Color) 30–100 cm (Length) 2–6mm (Diameter) Quadrangular with longitudinal furrows and wings on the angles of the young parts, slightly enlarged at the nodes (Shape)
Leaves	Glabrous 2–12 cm (Length) 1–3 cm (Width) Arrangement Lanceolate, Pinnate, acute apex, entire margin (Shape)
Flowers	Whitewith rose-purple spots on the petals(Colour) Small, in lax spreading axillary and terminal, racemes or panicles (Size)
Seed	Yellowish brown (Color) Capsules linear-oblong, acute at both ends 1.9 cm × 0.3 cm (Size) Subquadrate, numerous (Shape)

Table 1. The morphology and physiological Characteristics of *A. paniculata*

Figure 1. *Andrographis paniculata* (Burm. f.) Wall. ex Nees, plants; a) whole plant b) Full grown plant with flower

2.3. Taxonomy and Phylogeny

Taxonomic hierarchy is illustrated in the Venn Diagram of Figure 2:

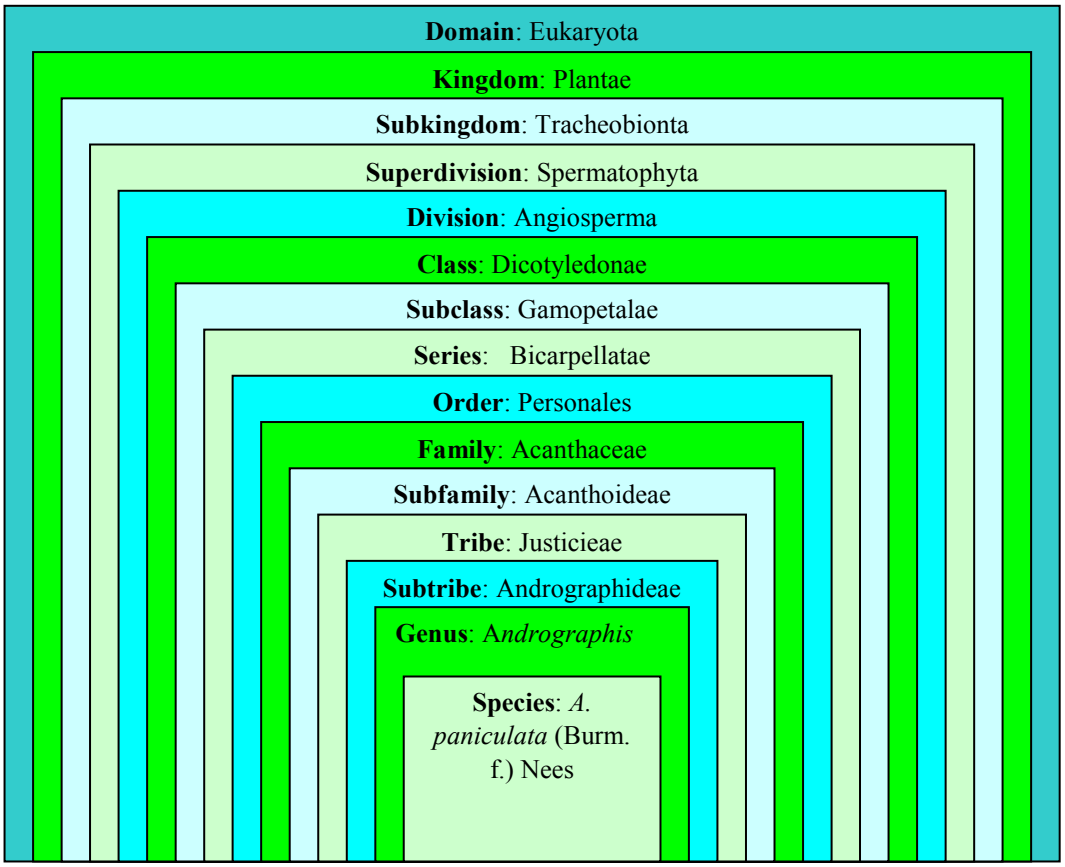

Figure 2. Venn diagram showing the taxonomic hierarchy of *Andrographis paniculata* (Burm. f.) Wall. ex Nees

2.4. Vernacular Names

Generally, the tree is known as "King of Bitters" for its extremely bitter taste. In Malaysia, it is traditionally known as "hempedubumi" (bile of the earth). This plant has different names in different languages. The vernacular names of *Andrographis paniculata* are listed in Table 2:

Language	Name
Arabic	Quasabhuva
Assamese	Chiorta, Kalmegh
Azerbaijani	AcılarS¸ahı, AcılarXanı (khanı)
Bengali	Kalmegh
Burmese	Se-ga-gyi
Chinese	Chuan Xin Lian
English	The Creat, King of Bitters
French	Chiretteverte, Roi des amers
Gujarathi	Kariyatu
Hindi	Kirayat
Indonesian	Sambiroto, Sambiloto
Japanese	Senshinren
Kannada	Nelaberu
Konkani	VhadlemKiratyem
Malay	HempeduBumi, Sambiloto
Manipuri	Vubati
Malayalam	Kiriyattu
Marathi	Oli-kiryata
Oriya	Bhuinimba
Persian	Nain-e Havandi
Sanskrit	Kalmegha, Bhunimba
Spanish	Andrografis
Tamil	Nilavembu
Telugu	Nelavemu
Burmese	Se-ga-gyi
Chinese	Chuan Xin Lian
Indonesian	Sambiroto, Sambiloto
Japanese	Senshinren
Philippines	Aluy, Lekha and Sinta
Russian	Andrografis
Scandinavian	Green Chiratta
Urdu	Kalmegh, Kariyat, Mahatita

Table 2. The vernacular names of *Andrographis paniculata*

3. Ethnomedicinal Uses

The aerial parts, roots and whole plant of *A. paniculata* have been used for centuries in Asia as traditional medicine for the treatment of various ailments. It has been used by traditional medical practitioners for stomachaches, inflammation, pyrexia, and intermittent fevers. The whole plant has been used for several applications such as antidote for snake-bite and poisonous stings of some insects, and to treat dyspepsia, influenza, dysentery, malaria and respiratory infections. The leaf extract is a traditional remedy for the treatment of infectious disease, fever-causing diseases, colic pain, loss of appetite, irregular stools, diarrhea, hepatitis, tuberculosis, fever, mouth ulcers, bronchitis, gastrointestinal disorders and sores. In Malaysia, a decoction of the aerial parts is used to treat common cold, hypertension, diabetes, cancer, malaria, snakebite and urinary tract infections. The roots are used as febrifuge, tonic, stomachic and anthelmintic. It is an important constituent of at least 26 Ayurvedic formulas in Indian pharmacopoeia. The tribal people of Tamil Nadu, India use this herb for a variety of ailments like dysmenorrhoea, leucorrhoea, pre-natal and post-natal care, intestinal worm infestations, complicated diseases such malaria, jaundice, gonorrhea and general ailments like wounds, cuts, eczema, boils and skin diseases.

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Biographical Sketches

N. Sarkar is a Medicinal Chemist with nearly 9 years of experoence in the field of Chemical Biology. At present he is working as an Assistant Professor of Pharmaceutical Chemistry at the Department of Pharmaceutical Technology, School of Medical Sciences Adamas University, Barasat, India. He has a good blending experience of Industry, academia and research. He was awarded Ph.D. from Amity University, Uttar Pradesh Noida in the year of 2020 and recipient of CSIR-RA (Council of Scientific and Industrial Research-Research Associates at Thapar Institute of Engineering and Technology, Patiala, Punjab, India. He has completed M. Pharm in Pharmaceutical Chemistry from Roland Institute of Pharmaceutical Sciences, Berhampur, Orissa in 2011 and B. Pharmacy from Netaji Subhas Chandra Bose Institute of Pharmacy in 2009. Dr. Sarkar is skilled in the field of extraction, isolation, characterization of secondary metabolites from plants, semi-synthesis of bioactive constituents and therapeutic applications in many maladies like antibacterial, antifungal, antioxidant, antimycobacterial, leishmanicidal and cancer studies. He has published several research articles in reputed international and national journals, attended several national and international conferences, supervised graduates and post graduate interns. He is a life-time member of many scientific associations and named among Best Young Researchers 2020 by InSc.

B. Mandal received her Ph.D. degree from Amity University, Noida, India. At present she is an Assistant Professor of pharmacognosy and phytochemistry at the School of Pharmaceutical Technology, Adamas University, Barasat, India. She has previously been a faculty member at the Institute of Biomedical Education and Research, Mangalayatan University, Uttar Pradesh, India. She is a lifetime member of the Indian Pharmacy Graduates' Association. She has published her research work in various journals of repute and has actively participated in paper presentations in various conferences and seminars at national and international levels. She was awarded the second prize for poster presentation on the topic "Antiurolithic efficacy of extract based fractions of *Aerva lanata* (Linn.) Juss. ex Schult." at the international seminar on "Herbal Pharmacovigilance: Current Scenario and Future Strategies" organized by I.T.S College of Pharmacy, Ghaziabad, India. She was also awarded a prize for best poster

presentation in Pharmacognosy on the topic "Physicochemical Analysis and Comparative *In Vitro* antioxidant activity of the aerial parts and roots of *Aerva lanata* (Linn.) Juss. Ex Schult." at the 5th Annual International Conference and Exhibition of Society of Pharmaceutical Education and Research held at Chandigarh College of Pharmacy, Chandigarh, India. Her research interests include quality control and standardization of medicinal herbs, bioassay guided fractionation of herbal extracts, phytochemical analysis using various instrumental techniques and evaluation of anti-urolithic efficacy of herbal extracts and the phytochemical based fractions derived from them.

Yadu Nandan Dey is working as an Associate Professor in the Dr. B.C. Roy College of Pharmacy and Allied Health Sciences, Durgapur-713206, West Bengal, India. He completed his B. Pharm. and M. Pharm. from West Bengal University of Technology. He worked as a Senior Research Fellow at CCRAS-RARIDD, Gwalior where he completed his Ph.D. studies. He has acquired more than 10 years of research experience and 3 year teaching experience. He was awarded ICMR Centenary Post Doctoral Fellowship and carried out his Post Doctoral research work at ICMR-National Institute of Traditional Medicine, Belagavi. He also received "Young Scientist" Award by Madhya Pradesh Council of Science and Technology, Bhopal, India. He also received a prestigious Startup Research Grant from Science and Engineering Research Board, Depratment of Science and Technology, Govt. of India. He has undergone various training programs and workshops in reputed organizations and presented more than 15 research papers in various national and international conferences. He contributed in many book chapters and research papers in various national and international journals which got high citations. His area of research is safety and efficacy of herbal drugs in various animal models of inflammatory and metabolic diseases.