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CHEMICAL CONSTITUENTS OF *ANDROGRAPHIS PANICULATA* (BURM.F) NEES: A REVIEW

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ABSTRACT: *Andrographis paniculata* Nees is a valuable medicinal herb of Acanthaceae family, is used for centuries to treat several diseases including viral hepatitis, cirrhosis, malaria and diabetes. This medicinal plant has hepato-protective, immunological, anti-bacterial, anti-inflammatory, anti-oxidant and antithrombotic qualities. It has many important bioactive compounds such as diterpenoids, flavonoids and polyphenols. Diterpenoids, including andrographolide, neoandrographolide and dehydroandrographolide are the main determinants of *Andrographis paniculata* quality. The most common and abundant form is andrographolide. Numerous human ailments are treated and prevented by it. Due to its various therapeutic applications, it is widely cultivated in many parts of the world and its relevance as a medicinal plant is constantly increasing. A comprehensive bibliographic search was conducted using offline and Online Databases. The current review aims to offer an updated and thorough analysis of the chemical components, explore their pharmacological potential and lay the basis for further research.

INTRODUCTION: From ancient times, medicinal plants have been used to treat various ailments and disorders. Worldwide, around 80,000 plant species have been recognized and utilized as medicines. In India, 7500 medicinal plants have been recognized for therapeutic use for curing different diseases^{1, 2}. Natural ingredients derived from medicinal plants, used as sources of drug. In spite of tremendous development of synthetic drugs and antibiotics during the 20th century, plant still constitute one of the major sources of drugs in the modern and traditional system of medicine throughout the world.

The largely rural population relies on medicinal plants as a source of treatments or to meet their healthcare needs for several reasons, including accessibility, affordability, and low cost^{3, 4}. It is advantageous to the nature of healthy human life^{5, 6}. *Andrographis paniculata*, often referred to as Kalmegh, is commonly used as traditional medicine in Asian countries to treat various diseases such as upper respiratory infections, fever, herpes, sore throats, and several chronic ailments⁷.

The plant is widely used in Indian traditional medicine, including Ayurveda, Unani, and Siddha, as a home cure for many illnesses. It has many bioactive compounds like diterpenoids, lactones, diterpenes glycosides, flavonoids, and flavonoid glycosides⁸. A significant chemical andrographolide is a diterpenoid lactone having several pharmacological properties⁹⁻¹⁰. The amount of andrographolide is highest in the leaves (2.39 %)

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and lowest in the seeds of *Andrographis*¹¹. It cures and prevents several diseases such as cold, fever and colic pain, and it is active against inflammatory¹², antidiabetic activity¹³, antioxidant¹⁴, antifertility¹⁵, cardiovascular¹⁶, hepatoprotective¹⁷, anti-cancer properties³⁶⁻³⁸ and anti-virus including inhibited HIV³⁹. This study provides the most current information about phytochemical components, pharmacological potentials and research needs relevant to *Andrographis paniculata*.

About the Genus *Andrographis*: Genus *Andrographis* includes 28 species of small herbs basically dispensed in tropical and subtropical Asia as well as some other countries such as Malaysia, Indonesia, Vietnam, Sri Lanka, Laos, Cambodia, Pakistan, Myanmar and the Caribbean islands. Some species, such as *Andrographis paniculata*, are recognized to have healing properties¹⁸. It belongs to the Acanthaceae family, a potent herb utilized for the number of Ayurvedic, Siddha and homoeopathic formulations.



FIG. 1: AERIAL PARTS OF ANDROGRAPHIS PANICULATA PLANT

Bioactive Constituents of *Andrographis paniculata*: All parts of this plant are used to extract the active photochemical. Active components mainly isolated from ethanol or methanol extract of leaves, stems, roots, and whole plant of *Andrographis paniculata*, which include diterpenes, lactones, flavonoids, and xanthenes²¹⁻²³. But the compositions of phytoconstituents widely differ from one part to another. Flavonoids are mostly found in the roots of plants²⁴⁻²⁵. Alkanes, ketones and aldehydes are also present in the aerial components.

Chemistry of Andrographolide: In 1896, Boorsma first isolated Andrographolide from *Andrographis paniculata* and Gorter identified it as

Andrographis paniculata is commonly used in indigenous medicine, especially as a bitter tonic, to treat fevers, diarrhoea and to get rid of intestinal worms. The herb is utilized as a liver tonic, blood purifier, and stomachic¹⁹.

The annual herb *Andrographis paniculata* are found in different habitats including forests, plains, hill area and wetlands. It abundantly grows up to 1 m height with dark green slender stem, glabrous leaves in lanceolate arranged and tiny, hairy, white to pink small flowers. It is very abundant in South East Asia, India and Sri Lanka. Especially, In India, *Andrographis paniculata* are found in southern part such Karnataka, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, and Madhya Pradesh. The plant's leaves and other parts, including the root, have been used medicinally²⁰. It is grown as a kharif (rainy season) crop in India. Heat and humidity with lots of sunshine are the ideal climate conditions for the plant **Fig. 1**.

a lactone in 1911. It has a bitter taste and is a light yellow or colourless crystal compound. The chemical name of andrographolide is 3-[2-[decahydro – 6 – hydroxyl – 5 - (hydroxymethyl) - 5, 8a – dimethyl – 2 - methylene-1-naphthalenyl] ethylidene] dihydro- 4-hydroxy-2(3H)-furanone Fig. 2(1). Its molecular formula is C₂₀H₃₀O₅ and molecular mass 350.4 (C= 68.5%, H= 8.6%, O = 22.8%) is the major phyto-constituent mainly concentrated in leaves of *Andrographis paniculata* plant. It is insoluble in water but soluble in acetone, ether, chloroform and hot ethanol. Crystalline Andrographolide is highly stable even at 70°C for three months, its UV absorption maxima in methanol or ethanol at 222-224 nm.

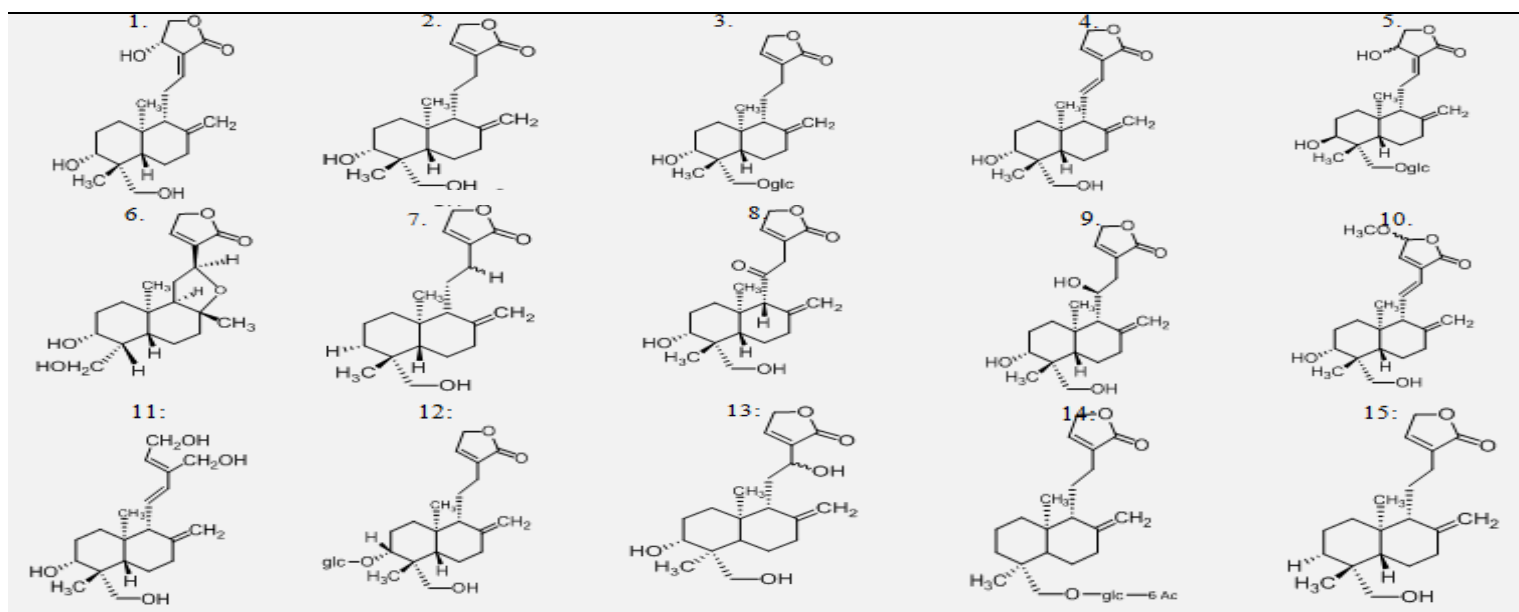
In this review, we described the information of 47 *Andrographis paniculata* and extraction mode with main bioactive constituents isolated from the plant part listed in **Table 1**.

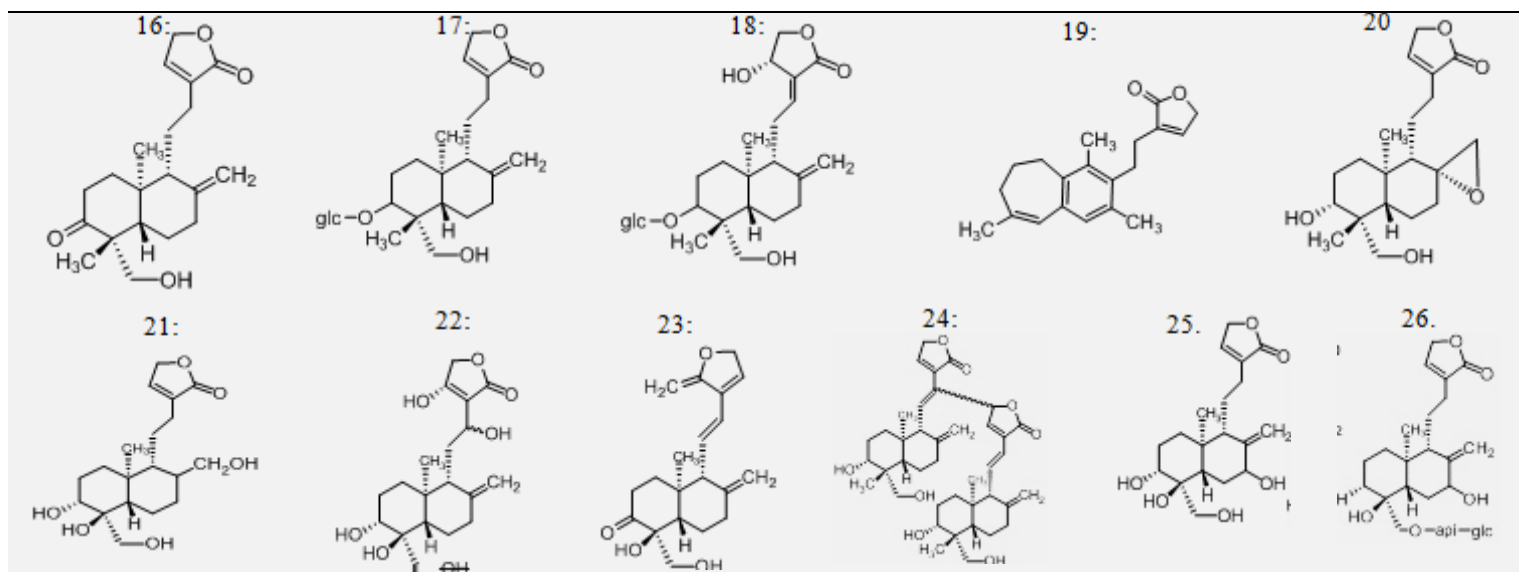
TABLE 1: BIOACTIVE COMPOUNDS OF ANDROGRAPHIS PANICULATA

Chemical constituents (chemical structure No.)	Plant sources/ solvent of extraction	Bio-activity/References
Ent-labdan diterpenoids		
Andrographolides (1)	Whole plant/ Methanol, Ethanol, Hexane, Acetone water,	Anti-inflammatory ²⁶⁻²⁷ , Hepatoprotective ²⁸⁻²⁹ , Anti diabetic ³⁰⁻³² , Anti-influenza ³³ , Anticancer ³⁴⁻³⁷ , Anti retroviral ³⁸⁻³⁹ , Analgesic, antipyretic ⁴⁰ , Anti angiogenic ⁴¹ , Cardio protective ⁴² , Cholestatic ⁴³ , Hepatoprotective ⁴⁴ , Anti fungal ⁴⁵ , Anti bacterial ⁴⁶ , Immunomodulator ⁴⁷ , Antihypertensive ⁴⁸⁻⁴⁹ .
14-Deoxyandrographolide (2)	Leaves, whole plant & Aerial parts / Hexane, Acetone water ethanol	Hepatoprotective ⁴⁴ , Anti fungal ⁴⁵ , Anti bacterial ⁴⁶ , Immunomodulator ⁴⁷ , Antihypertensive ⁴⁸⁻⁴⁹ .
Neoandrographolide:(3)	Leaves , whole plant and Aerial parts / Methanol, Ethanol, Acetone water	Anti-inflammatory ⁵⁰⁻⁵¹ , Antioxidant ⁵² , Antiparasitic ⁵³ , Antiherpes-simplex virus ³⁸ , Hepatoprotective ⁵⁴ , Chemosensitiser ⁵⁵ ,
14-Deoxy 11,12-didehydro andrographolide (4)	Leaves, whole plant, and Aerial parts / Ethanol, Hexane, Dichloromethane	Antiretroviral ³⁹ , Cholestatic ⁴³ , Antioxidant ⁵² , Antifungal ⁴⁵ , Antihypertensive ⁴⁸ , Antidiabetic ⁵⁶ , Hepatoprotective ⁵⁷ , Cytotoxic ⁵⁸ , Antiherpes ³⁸ , Hepatoprotective ⁴⁴ ,
Andrographiside (5)	Whole plant, roots /Methanol, petroleum ether & chloroform	
Isoandrographolide (6)	Leaves, Aerial parts, whole plant & roots /Methanol, Ethanol, Hexane	Anti- cancer and Anti inflammatory ³⁸ , Antiproliferative ⁵⁹ , Anti bacterial ⁶⁰ , Cytotoxic ³⁷ , Cell differentiation inducer ⁶⁰
Andrograpanin (7)	Leaves , and Aerial parts Ethanol and Hexane	Anti-inflammatory ⁶¹
14-Deoxy-11-oxo-andrographolide (8)	Aerial parts /Ethanol and water-Acetone	Anti leishmaniasis ⁶²
14-Deoxy-11-hydroxy-andrographolide(9)	Aerial parts / Ethanol	Cell differentiation inducer ⁶⁰
15-Methoxy-3,19-dihydroxy 8(17)11,13-entlabda-trien-16,15-olide (10)	Aerial parts / Ethanol	Anti proliferative ⁵⁹
8(17),13-Ent-labda-diene-15,16,19-triol (11)	Aerial parts / Ethanol	Anti proliferative ⁵⁹
3-O- β -D-glucosyl-14-deoxyandrographolide (12)	Whole plant/ Methanol and Ethanol	Anti bacterial ⁴⁴ , Antifungal ⁴⁵
14-Deoxy-12-hydroxyandrographolide(13)	Whole plant/ Methanol	Anti microbial ⁴⁶
6'-Acetyl-neo-andrographolide (14)	Aerial parts /Methanol	Cell differentiation inducer ⁶⁰
3,14-Dideoxyandrographolide (15)	Aerial parts /Ethanol	Anti proliferative ⁵⁹ ,
3-Oxo-14-deoxyandrographolide (16)	Aerial parts /Ethanol	Antiproliferative ⁵⁹
3-O- β -D-glucopyranosyl 14,19-dideoxy andrographolide (17)	Aerial parts / water Acetone	Antimicrobial ⁴⁶
3-O- β -D-glucopyranosyl andrographolide (18)		
Andrographolactone (19)	Aerial parts /Ethanol	Cytotoxic ³⁷
8,17-Epoxy-14 deoxyandrographolide(20)	Leaves / Acetone water	Anti microbial ⁴⁶
14-Deoxy-17-betahydroxyandrographolide (21)	Leaves / water, Acetone	Antimicrobial ⁴⁶
12-Hydroxyandrographolide (22)	Aerial parts /Ethanol	Antiproliferative ⁵⁹
3-Oxo-14-deoxy-11,12 didehydroandrographolide (23)	Leaves /Ethanol	Antiproliferative ⁵⁹
Bis-andrographolide A (24)	Aerial parts /Methanol	Cell differentiation inducer ⁶⁰ , analgesic, anti-inflammatory ⁷⁰ ,
7-Hydroxy-14-deoxyandrographolide (25)	Leaves /Ethanol	Antiproliferative ⁵⁹ ,

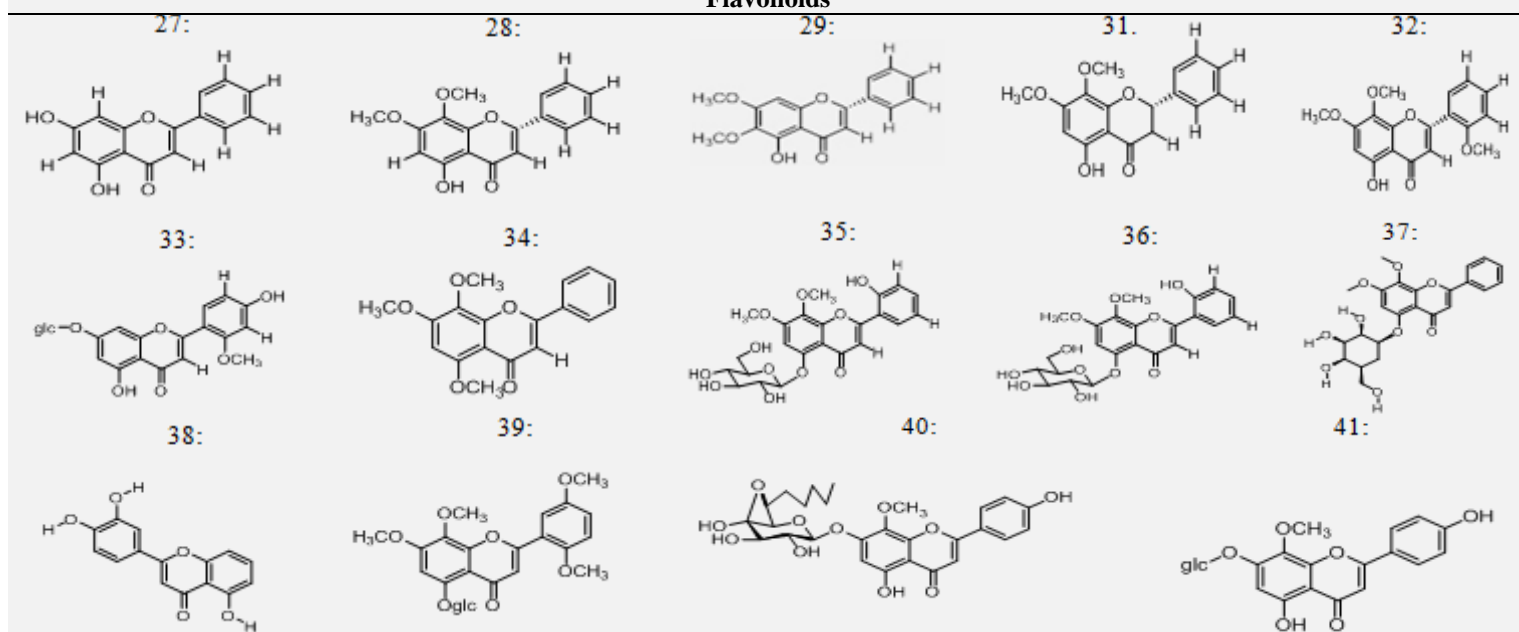
19-O-[beta-D-apiofuranosyl]-beta-D-glucopyranosyl]-3,14-dideoxyandrographolide (26)	Leaves /Acetone, water	Antimicrobial ⁴⁶
Andrographalide-B (47)	Aerial parts/Ethanol	Antiviral ²¹
Flavonoids		
Apigenin (27)	Whole plant parts / Methanol	Antiplatelet aggregator ^{66, 64}
7-O-methylwogonin (28)	Whole plant parts / Methanol , hexane	
Onysilin (29)	Whole plant parts / Methanol	
7,8-Dimethoxy-2-D-glucopyranosyl oxyflavone (30)	Leaves / Ethanol	Anti proliferative ^{63, 59}
7-O-methyl-dihydrowogonin (31)		
Skullcapavone-1,2'-methoxyether (32)		
5,4'-Dihydroxy-7-methoxy-8- O--D-glucopyranosyloxy flavone (33)		
5,7,8-Trimethoxydihydroflavone (34)		
7,8-dimethoxy 2 hydroxy-5-O- β -dglucopyranosyloxyflavone , (35)		
Andrographidine A, (36)		
Andrographidine C, (37)		
Luteolin, (38)		
7,8,2',5'-Tetramethoxy 5-O- β -D-glucopyranosyloxyflavone, (39)		
5,4'-Dihydroxy-7-O- β -D-pyranoglycuronate butyl ester, (40)		
5,4'-Dihydroxy-7-methoxy-8- β -D-glucopyranosyloxyflavone (41)		
Xanthones		
1,2-dihydroxy-6,8-dimethoxy-xanthone (42)	Roots / Petroleum Ether , Methanol, CHCl ₃ and water	Antimalarial ⁶⁵
1,8-dihydroxy-2,6-dimethoxyxanthen-9-one (43)		
8-hydroxy-1,2,6-trimethoxyxanthen-9-one (44)		
4,8-dihydroxy-2,7-di-methoxy-xanthene-9-one (45)		
3,4-Dicaffeoylquinic acid (46)	Whole Plant parts /Methanol	Anti platelet aggregator ⁶⁶

Fig. 2: Chemical Structures of Bioactive Constituents of *Andrographis paniculata*

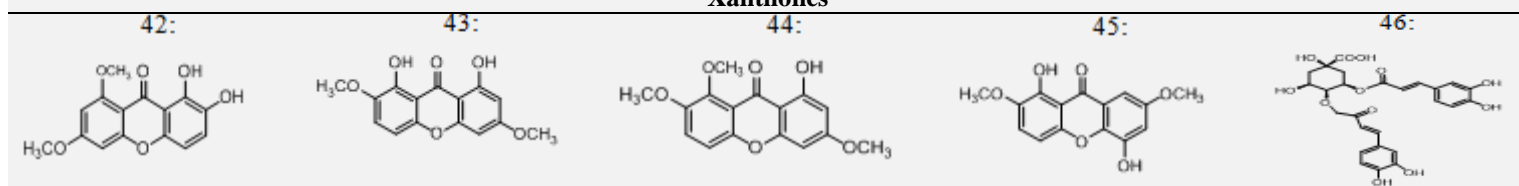




Flavonoids



Xanthenes



Pharmacological Properties: *Andrographis paniculata* crude extracts and its isolated chemical constituents show a numerous medicinal activities 67-68

It includes antioxidant activity ⁶⁹, anti-bacterial ⁴⁶ and anti-microbial activities ⁴⁷, anti-malarial, cold and fever, anti-venom activity, anti-diarrhoeal activity, anticancer activity ⁷⁰, urinary tract infection and antidiabetic activity, cardiovascular activity, immunomodulatory activity *etc.*

CONCLUSION: The primary bioactive constituents in the herb are flavonoids, diterpenoids and polyphenols. Extensive literature review and experimental data analysis suggest that *Andrographis paniculata* are traditionally used for treating fever and several infections. The plant improves the activities of the heart and liver by treating cardiovascular illness and preventing liver damage. According to reports, andrographis reduces fertility in both male and female animals as

well as people. In addition, it has enormous benefits for the functioning of the brain and central nervous system, allergic reactions and respiratory problems. Due to its enormous medicinal potential, *Andrographis paniculata* demand has significantly surged in recent years.

Numerous clinical trials were conducted successfully and without any negative effects, proving that the plant is a valuable and safe medical resource for people. Cultivation could be an excellent solution to make *Andrographis paniculata* available for research in order to satisfy commercial demand. More research is still required to learn more about the novel bioactive compounds and improve the bioactivity of the original chemicals.

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