

Andrographis Paniculata: A Inclusive assessment on phytochemistry, pharmacological activities and therapeutic potential.

Asawari Kolekar ¹, Shradha Lokare ², Dr. Dhanraj Judge ³

Womens college of pharmacy, peth vadgaon, Kolhapur, Maharashtra ^{1,2,3}

Abstract:

Medicinal plants have been essential for enhancing human health and preventing a variety of illnesses since ancient times. Over the past century, the medicinal potential of over 80,000 plant species has been recognized and explored. However, the rise of multidrug-resistant strains and the rising prevalence of infectious diseases like tuberculosis which slew 1.4 million people in 2019 highlight the critical need for new treatments. With an emphasis on natural substances with several therapeutic effects, the traditional "one drug, one target" strategy has given way to "one drug, multitarget." Among these, It has drawn a lot of consideration because of its main bioactive component, andrographolide, which has been revealed to have cardioprotective, hepatoprotective, neuroprotective, antiviral, anti-inflammatory, antioxidant, antibacterial, and anticancer properties. Other phytochemicals with strong antiviral properties and promise for treating illnesses like COVID-19 include glycyrrhizinic acid, curcumin, and extracts of *Azadirachta indica*. Because they are widely accessible, safe, and natural, medicinal botanicals have a lot of potential for creating efficient treatments for chronic illnesses and newly emerging viral infections. Additionally, plant-based treatments may be beneficial for neurological illnesses, which increase morbidity and cognitive impairment in the aged. *A. paniculata*, recognized as Kalmegh or King of Bitters, has been rummage-sale conventionally in China, India, Thailand, and other parts of Southeast Asia. It is a valuable natural resource for drug discovery because it contains a variety of phytochemicals with broad pharmacological activities, such as flavonoids and diterpenoid lactones.

Keywords

Andrographis paniculata, Kalmegh, Andrographolide, Medicinal Plant, Phytochemistry, Pharmacological Activities, Antioxidant Activity, Anti-inflammatory Activity, Antiviral Activity, Hepatoprotective Activity, Anticancer Activity, Ethnobotany, Herbal Medicine, Therapeutic Potential, Phytoconstituents

INTRODUCTION:

Subsequently beginning of development, therapeutic plants have been an essential aspect of human life to fight against misery ^[1]. Over 80,000 different plant species are said to have been recognized and utilized as medicines worldwide ^[2]. The body count is increasing rapidly. About 206,000 fresh cases of multidrug-resistant tuberculosis were reported in 2019, a 10% increase from 187,000 cases in 2018. The number of tuberculosis-related deaths in 2019 was

1.4 million. Additionally, the use of antibiotics frequently results in adverse effects such as hypersensitivity and the loss of important gut microbes ^[3]. These days, the "one drug, one target" approach to drug development has given way to "one drug, multitarget"^[4].

Andrographolide is bioactive substances existing in *A. paniculata* that has been explored the most aimed at its potential medical uses ^[5]. Andrographolide, curcumin, glycyrrhizinic acid, and other *Azadirachta indica* plant extracts are pure compounds that show promise as antiviral agents against a range of viruses. Their potential as a treatment should be further explored. Natural phytochemicals found in medicinal plants are valuable and potent resources with a variety of antiviral qualities. Indian plants are expected to produce newer chemical entities and have produced a number of novel leads. A promising approach for investigating potential treatments for COVID-19 is the use of medicinal botanicals. Natural plant-based substances that have been

thoroughly tested for safety and effectiveness and are widely available, especially given the high prevalence of respiratory diseases, may be crucial in combating the COVID-19 pandemic [6]. Different laboratory and neuroimaging tests are used to detect neurodegenerative diseases (ND), which have distinct epidemiological and symptomatologic features. Additionally, the neuropathological causes and therapies for these diseases are distinct. Nevertheless, decreased cognitive capacity and morbidity might be caused by any neurodegenerative illness in the aged [7]. In Southeast Asian countries, plant's aerial parts and clandestine bases are being used as usual.

Medications for a variety of medical issues. It goes by several names in different Indian languages[8]. The medicinal potential of the herb has been reported after a series of experiments. Flavonoids, diterpenoid lactones, and other compounds were identified in phytochemical investigations of *A. paniculata*. They exist and exhibit a extensive assortment of pharmacological properties.[9]

Ethnobotanical:

For their qualities, they are also suggested for management of gonorrhoea, leprosy, boils, scabies, skin eruptions, and fever, whether it's seasonal or chronic [10]. In Asia, people have used this herb for a long time to remedy a range of illnesses, like respiratory infections, gastrointestinal issues, fever, herpes, and sore throats (Wangboonskul et al.) [11]. According to Unani medicine, the herb has many uses, including soothing the stomach and liver, reducing inflammation, astringent, carminative, diuretic, and anthelmintic. For a variety of ailments, including leucorrhoea, dysmenorrhoea, prenatal and postnatal care, severe illnesses like malaria, jaundice, and gonorrhoea, and general ailments like cuts, wounds, boils, and skin conditions, this plant is used in Ayurvedic medicine by the tribal people of Tamilnadu, India [12]. The following table details all of the conventional uses of AP in different countries' traditional medical systems. It is commonly employed as a folk remedy in several states by old practitioners, tribes, or societies for medical devotions [13]. Eight kinds of *Andrographis* plant leaf decoction combined with curd, goat, or buffalo milk is being employed in the ethnobotanic knowledge of the Malayali tribes of the Shevaroy Hills to cure liver swelling and jaundice, according to a recent report[14]. The potential bitter chemicals, such as andrographolide, from *Andrographis* species have been shown to have antibacterial, antioxidant, diabetic, and cancer-curing biological effects in animal models and for ethnomedical purposes [15].

Ethnobotanical Use of *A. Paniculata* [16].







Country/TMS	Traditional Use
Traditional Indian Medicine	Diabetes, snake bites, herpes, dysentery, peptic ulcer.
Unani Medicine	Fever, Inflammation, Skin eruptions, liver tonic, leprosy.
Malaysia	Diabetes, Hypertension
Traditional Chinese Medicine	Fever, Inflammation, Respiratory Infections, Skin disorders, Diarrhoea.
Japan	Fever , Common cold
Ayurvedic	Fever ,liver disorders, Vitiligo
Traditional Thai Medicine	Fever, Common cold.

Table no. 1: Traditional Uses of the Plant in Various Traditional Medicine System.

Morphology of plants:

The paniculata variety of *Andrographis* is one of the most valuable medicinal herbs in the world. This upright, branching herb blooms once a year. This herb grows abundantly in hedgerows all over the world, including on flatlands, hills, waste ground, farms, in damp environments, along beaches, and on roadsides^[17]. This plant has a potential to reach a height of 30–110 cm when allowed to mature. Its dark-green, quadrangular stem is significantly expanded at the nodes and features longitudinal troughs and wings at angles of the juvenile sections. Its diameter is 2–6 mm and its length is 30–110 cm. A very small petiole accompanies this dark-green, opposing, decussate, lanceolate, whole-bordered, pinnately vascular plant that is 2–12 cm long and 1–3 cm broad. Upright capsule of plant is linear- oblong in shape. Approximately 2–5 mm widespread and 1–2 cm lengthy. Its big faces are longitudinally grooved, and it is compressed, pointed at both ends. Little, subquadrate seeds ^[18]. Indian, Sri Lankan, Pakistani, Javanese, Malaysian, and Indonesian countries are rich with it. This plant, often recognized as Kalmegh in India, is a common element in Ayurvedic and Unani

medicine. It grows mostly in the plains of the nation .^[19]

Sr. no.	Traits	Characteristics
1.	Plant height 	30–110 cm.
2.	Stem 	<ul style="list-style-type: none"> • Colour: Dark green • Length: 30–100 cm • Diameter: 2–6 mm • Shape: Quadrangular, longitudinal furrow; wings at the angles; slightly swollen nodes
3.	Leaves 	<ul style="list-style-type: none"> • Surface: Glabrous • Length: 2–12 cm • Width: 1–3 cm • Shape: Pinnate, acute apex, entire margin
4.	Flower size 	<ul style="list-style-type: none"> • Size: 1.2–2.0 cm in diameter • Petals: White with purple spots • Inflorescence: Axillary and terminal racemes, small, laxly spreading racemes or panicles
5.	Seed 	<ul style="list-style-type: none"> • Type: Linear oblong capsules with acute ends • Size: 1.9 cm (length), 0.3 cm (width) • Colour: Yellowish brown • Shape: Sub-quadrangle
6.	Flowering and fruiting 	<ul style="list-style-type: none"> • Period: December to April

Taxonomy

It is a sizable medicinal herb from *Andrographis* genus. The total species count within this group ranges from ^[20].

S. No.	Scientific Classification	Name
1.	Domain	Eukaryote
2.	Kingdom	Plantae
3.	Sub-kingdom	Tracheophyta
4.	Division	Angiosperms
5.	Superdivision	Spermatophyta
6.	Class	Dicotyledonae
7.	Sub-class	Gamopetalae
8.	Series	Bicarpellatae
9.	Order	Lamiales
10.	Family	Acanthaceae
11.	Sub-family	Acanthoideae
12.	Tribe	Justicieae
13.	Sub-tribe	Andrographideae
14.	Genus	<i>Andrographis</i>
15.	Species	<i>paniculata</i>

Table no. 2 : Scientific Classification of *Andrographis Paniculata*

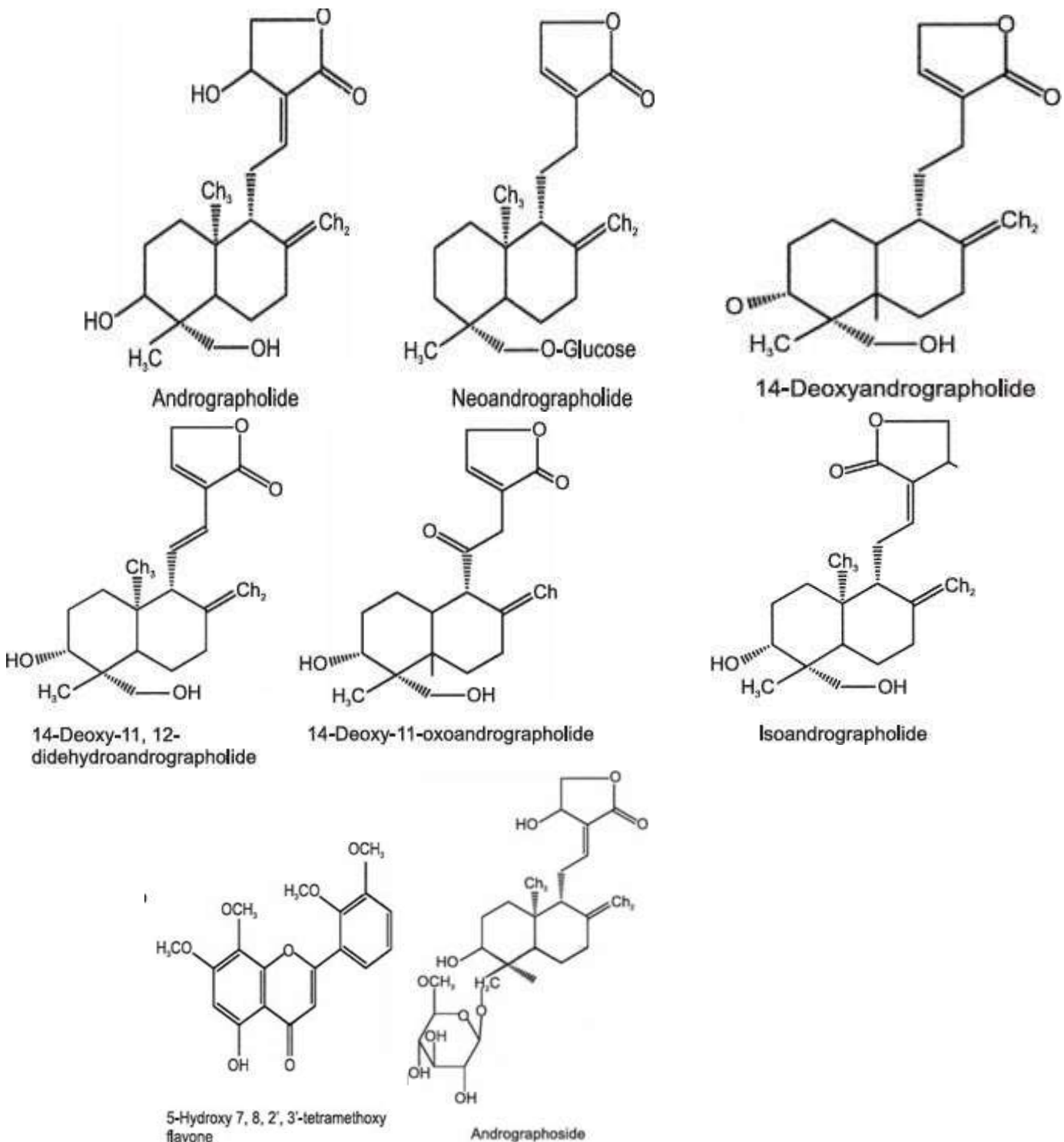
Language Names:

Tree is stated to as “King of Bitters” as of its very bitter flavor. In Malaysia, traditional name is “hempedu bumi” (bile of earth). English: The Creat, King of Bitters, French: Chirette verte, Hindi: Kirayat, Kalpanath, Japanese: Senshinren.^[21]

Phytoconstituents:

According to research, aerial parts contain many chemical components, one of which is andrographolide, a bitter, colorless, crystalline diterpene lactone. ^[22] is a Kalmegin, a lactone andrographolide, is responsible for bitter values in leaves, whereas ketones, alkanes, and aldehydes are present in the aerial portions. From the aerial portions, four lactones were extracted: Chuaxinlian A, which is deoxyandrographolide; andrographolide; neoandrographolide; and D, which is 14-deoxy-11, 12-didehydroandrographolide. Steroids, phenolic chemicals, glycosides, tannins, saponins, terpenoids, gums, and flavonoids were all examined in the stem and leaf extracts. Kalmegh was tested for secondary metabolites in a variety of solvents, including chloroform, methanol, ethanol, petroleum ether, and acetone ^[23]. Andrographolide (C₂₀H₃₀O₅), the main diterpenoid in *A. paniculata*, amounts to around 4% in dried whole plant extracts, 0.8% to 1.2% in stem

extracts, and 0.5% to 6% in leaf extracts [24]. Andrographolide, apigenin-7,4'-di-O-methyl ether, and 5-hydroxy-7,8,2',3'-tetramethoxy flavone were all extracted from the roots. Among the other components of *Andrographis* sp. are stigmasterol, andrographosterin, andrographan, and 14-deoxy-11,12-didehydroandrographolide (andrographide D) [25].



Cultivation:

It can be grown up in a range of soil kinds, like laterite soils by ideal pH and fertility and sandy loam soils. Although it may be cultivated in wastelands, it likes partial shade. In the field, transplanting techniques or

direct seeding are two methods of propagation. Pure, healthy, and disease-free seed is the ideal quality^[26]. Intercultural tasks such as irrigation, weeding, and thinning should be completed on time and as needed. In general, the start of the monsoon is a suitable time for seed germination. By keeping the seeds at the ideal distance of 60 x 30 cm, 2,22,000 plants were produced per hectare, with an average biomass of almost 3 t/ha^[27]. The plant grows lushly and blooms in September when the weather is reasonable. However, the Northern Plains has a dramatic drop in temperature during the full flowering stage and fruiting, which occurs in late November and early December. Harvested herb yield is partially shade-dried for two to three days after harvest. Supa assists in gathering and winnowing seeds. The crop's output has been significantly impacted by the planting and harvesting dates^[28]. It is a crop grown during the rainy season (kharif) in India. Natural seeds that have been broken are used for propagation. In some unique situations, stacking can also be used for vegetative propagation because each node can produce enough roots. Small seeds need five to six months to dormant^[29]. The harvest stops maturing in the dead of winter. A well-kept crop sown in the monsoon season can yield dry herb at a rate of 3.5 to 4 tonnes/ha. Due to its status as a sciophytic, it can be grown in proximity to crops with relatively large gaps between rows. According to recent research, intercropping pigeon pea and kalmegh produced a herbage yield of 4412 kg/ha when the kalmegh population was full (55,555 plants/ha) and the pigeon pea population was 27,777 plants/ha^[30].

Nursey Management and transplanting:

To develop a crop in one hectare, three 10-by-2-meter beds should be tilled, ground, and leveled in May. A nursery on one hectare of land requires about 650-750 grams of seeds. It is possible to physically prepare the nursery beds by digging them out with a shovel and then grinding them down with a hoe. The next step is to remove any stones or pebbles from the soil. Organic manures, including vermicompost and farm yard manures, should be used extensively in the nursery for the purpose of growing strong, healthy seedlings. Once the bed surface has been ground up and leveled, seeds can be planted in shallow furrows that have been prepared five to six centimeters apart. At a depth of 1.5 cm to prevent crust formation, promote rapid seed germination, and allow for the emergence of seedlings through appropriate aeration.^[31]



Fig no.1 : Nursery Cultivation and Harvested Leaves of *Andrographis Paniculata*.

Plant spacing and geometry:

Furthermore, researchers in middle Gujarat looked at how different plant spacing affected kalmegh-panchang yield. They found that plants had significantly improved growth characteristics at harvest, including a plant width of 23.89 cm and a plant height of 71.36 cm, when planted with a spacing of less than 30 cm × 45 cm between rows and plants. A plant geometry of 30 cm × 45 cm was also observed in the kalmegh plant that

produced the most fresh herbage (10335 kg/ha) and dried herbage (4375 kg/ha) according to previous research [32]. Examined the formation of diterpenoid lactones, growth, behavior, and biomass in Kalmegh strains at varying population densities. Based on their research, the optimal spacing for plants in the subtropical temperature of North India is 30 × 15 cm, which allows for 222222 plants per hectare. This spacing led to the maximum dry biomass and yields of andrographolide and neoandrographolide [33].



Fig. no.2 : Field Plantation and Spacing Pattern of Andrographis Paniculata.

Weed management:

Weed infestation is a major issue that lowers the quality and quantity of kalmegh herbs because it is a short-duration crop that is planted during the kharif season. Therefore, Using effective weed control methods can enhance the characteristics of growth and raise the plant's herbage production, crop growth rate, relative growth rate, and leaf area index.[34]

Predominant weeds associated with kalmegh

Type	Botanical Name	Common Name	Family
Sedge	<i>Cyperus rotundus</i>	Motha / Nutsedge	Cyperaceae
	<i>Cyperus iria</i>	Motha / Nutsedge	Cyperaceae
	<i>Cyperus difformis</i>	Motha / Nutsedge	Cyperaceae
Grasses	<i>Echinochloa crusgalli</i>	Sewai	Poaceae
	<i>Echinochloa colona</i>	Dawra	Poaceae
	<i>Cynodon dactylon</i>	Doob grass	Poaceae
Broad leaf	<i>Eleusine indica</i>	Goose grass	Poaceae
	<i>Panicum spp.</i>	Witch grass	Lythraceae
	<i>Acalypha indica</i>	Indian copper leaf	Euphorbiaceae

Harvesting :

When *A. paniculata* leaves are three to five months old, or halfway through their blossoming period, they contain the most active lactone chemical and are thus the best time to harvest them. Following another 2-3 months of harvesting, the leaves can be collected again, producing 0.5-1 tons per hectare of dry weight or 2-3 tons per hectare of fresh weight [35]. The timing of this crop's planting and harvesting is thought to be crucial for both crop quality and output. A plant's active principle changes over time and in response to various environmental factors. The harvesting season significantly impacted Kalmegh's yield and quality [36].

Post-harvest and storage:

A hot air oven was used to dry the plants for eight hours at a temperature of 46-50°C, or until they were completely dry, after harvesting. The plants were rinsed afterward. The amount of total diterpene lactone can be reduced by 25% after one year of storage in clean, cold settings in airless plastic bags [37]. At 25°C, the rate constant of breakdown was found to be $6.58 \times 10^{-6} \text{ d}^{-1}$, and the stability of andrographolide was examined using a heat-accelerated experiment to show a second-order kinetics of degradation [38].

Pharmacological activities:

Anti-inflammatory activity:

At the right dosages, *A. paniculata* can also reduce acute risks and prevent the synthesis of inflammatory mediators [39]. Shen et al. found that rat neutrophils' inflammatory responses are inhibited by andrographolide, an active ingredient in *A. paniculata*. *in vitro* & *in vivo* studies initiate that it prevented tumor-specific angiogenesis through modulating production of several pro & antiangiogenic factors [40]. Atherosclerosis, artery stenosis due to deendothelialization, and a high-cholesterol diet are all conditions in which *A. paniculata* has been shown to lower the rate of restenosis subsequently experimental angioplasty [41].

Antioxidant activity:

By studying the liver defense mechanisms of lymphoma-bearing mice, Verma and Vinayak were able to determine the antioxidant properties of the water extract [42]. Catalase, glutathione-transferase, and superoxide dismutase activities were enhanced, whereas lactate dehydrogenase activity was lowered, in hydro alcoholic and aqueous extracts of medicinal herb *A. paniculata* [43]. In every model system that was examined, the results showed that the ethanol extract of *A. paniculata* had lesser antioxidant activity than the aqueous extract [44]. In order to maintain normal cardiac function and induce oxidative changes in the myocardium, the hydroalcoholic extract of *A. paniculata* has substantial cardioprotective effect [45].

Antidiabetic action:

The ethanolic extract has antihyperglycemic and, according to Zhang et al.'s research, antioxidative stress-reducing capabilities in diabetic rats [46]. Furthermore, Yu BC et al. came to the conclusion that the antihyperglycemic action was due to andrographolide. Finally, it was discovered that *A. paniculata*'s antidiabetic properties might improve the estrous cycle in rats with diabetes induced by alloxan [47].

Antibacterial action:

An ethanol extract of leaves inhibited *in vitro* growth of *Staphylococcus aureus* and *Escherichia coli* [48]. A 50% reduction in *Proteus vulgaris* development was seen *in vitro* when the leaves were extracted with methanol. But there was no *in vitro* antibacterial action shown when the dried powder from the aerial parts was tested against *Shigella* species, *Salmonella typhi*, *Staphylococcus aureus*, and *E. coli* [49].

Antihyperlipidemic activity:

High cholesterol is a major contributor to atherosclerosis, which in turn causes cardiovascular disease and

stroke. Established on their results for atherosclerosis, experts proposed andrographolide as a likely medical specialty^[50]. Andrographolide and neoandrographolide were recently discovered to have anti-hyperlipidemic properties in another study^[51]. Using a high-fat emulsion and a 75% yolk emulsion as a framework, properties of andro-grapholide and neo-andrographolide on hyperlipidemic rats and mice are investigated^[52]. There was a section-dependent reduction in greasy fat with androgen-grapholide and neo-andro-grapholide^[53]. In comparison to the positive control group (Simvastatin), the negative control group had somewhat lower plasma levels of aspartate transaminase and alanine transaminase ($p < 0.01$)^[54]. Lower levels of cholesterol lipoprotein were associated with decreased activity in the aorta of hyperlipidemic rats, elevated expression of eNOS clarification, and elevated expression of iNOS verbalization. Additional research into subnuclear mechanism and related hailing pathway is necessary due to delayed effects of hypolipidemic thesis^[55].

Anticancer activity:

Andrographolide acts as a beneficial agent in a variety of prostate cancer cell lines. When taken orally, andrographolide is rapidly digested, in contrast to other cytotoxic anticancer drugs^[56]. Additionally, anticancer efficacy was demonstrated by a 2-cell line panel composed of breast and colon cancer cell lines. It may be chemoprotective against chemotoxicity, including carcinogenicity, according to a study by Singh that used a variability of cancer cell lines^[57]. This combination is utilized in advanced stages of cancer, when cytotoxic activity of NK and TNF-alpha is maximized. There are stigmasterols, flavonoids, and diterpenes in the *Andrographis paniculata* plant extract^[58].

In contradiction of human epidermal cancer and P388 mouse leukemic cell line, andrographolide the principal active diterpenoid displays remarkable cytotoxic activity^[59].

Anti-HIV activity:

The most significant pharmacologically active andrographolide, an active metabolite, is generated in Kalmegh and has considerable potential for treating HIV-related viral infections^[60]. By altering the cellular signal transduction process, andrographolide stops the virus from spreading to other cells and slows the progression of the illness^[61].

Antifertility activity:

There is a lot of curiosity in any potential side effects because its use as a natural cure is on the rise. There are indications of *Andrographis paniculata* in this respect. Research has focused on the possible effects on sperm and egg production. Afterward 60 days of daily administration of 20 mg of leaf powder of *Andrographis paniculata*, researchers Akbarsha et al. discovered that the herb had antiandrogenic and antispermatogenic effects on male albino rats^[62]. Outcomes included spermatogenesis loss, seminiferous tubule regression, sperm vesicle alterations, ventral prostate gland dysfunction, and coagulating gland dysfunction. While 95.2% of control female mice became pregnant after not receiving *Andrographis paniculata*, Zoha et al. found that female mice prevented pregnancy by eating 2 gm/kg weight per day of plant powder for six weeks^[63]. Because of its potent anti-fertility effects, this herb is not safe to consume while pregnant. After 48 days of taking andrographolide orally, researchers saw the same effects in male Wistar albino rats. The dried *Andrographis paniculata* extract, according to Burgos et al., relaxes the uterine muscles by obstructing voltage-sensitive calcium channels^[64].

Immunomodulatory activity:

Andrographolide is believed to possess properties that both stimulate and inhibit the immune system. Diterpene lactone and rographolide have immunomodulatory effects such as increasing the synthesis of important cytokines, increasing the number of human peripheral blood lymphocytes, and the number of total blood cells expressing immunological activation markers. Andrographolide stimulated the immune system by activating HPBLs, or human peripheral blood lymphocytes, according to the in vitro PHA findings. HPBLs are defined as white blood cells that are able to produce and multiply more IL-2^[65]. Furthermore,

andrographolide prevented lipopolysaccharide-stimulated macrophages from secreting TNF and IL-12. Furthermore, andrographolide prevented lipopolysaccharide-stimulated macrophages from secreting TNF and IL-12. Studies have shown that andrographolide successfully decreases T-cell activation in both vitro and vivo, suggesting that it may be useful for lowering potentially harmful T-cell reactions. In addition, the plant has a wonderful effect on the immunological system^[66].

Hepato-protective activity:

Andrographis paniculata has several applications in Indian medicine due to its hepatostimulant and hepatoprotective properties. One study found that andrographolide, a well-known hepatoprotective medicine, was more effective than silymarin (0.75-12 mg/kg). Andrographolide reportedly improves digestion in animals by increasing bile flow. Andrographolides accumulate in various organs following intake, including the brain, spleen, heart, lungs, kidneys, liver, and intestines, as shown in a study. Researchers found that 90% of the material was removed through the gastrointestinal and renal systems in less than 48 hours, indicating that both assimilation and elimination were rapid. They found that hepatitis might be successfully cured by a plant^[67].

Antipyretic activity:

An ethanol extract of the aerial portions was given to rats intragastrically at a dose of 500 mg/kg body weight to reduce pyrexia caused by yeast. Mice with Brewer's yeast-induced pyrexia were relieved by andrographolide (100 mg/kg body weight) when administered intragastrically. Deoxyandrographolide, andrographolide, neoandrographolide, or 11, 12- didehydro-14-deoxyandrographolide, when administered intragastrically to rats, rabbits, or mice, reduced pyrexia produced by endotoxins or 2, 4-dinitrophenol^[68].

Antidiarrheal activity:

It has been demonstrated that *A. paniculata* extracts exhibit antidiarrheal activity in cases of

E. coli-infected diarrhea (Gupta et al., 1990). The most widely used antidiarrheal medication, loperamide, exhibited comparable activity to andrographolide. Other clinical trials have demonstrated that andrographolide significantly reduces bacterial diarrhea and dysentery in patients (Deng, 1978).

Adverse effects:

Research on animals has consistently demonstrated that *A. paniculata* is not extremely poisonous. Large oral dosages of *A. paniculata*, however, may result in nausea, vomiting, and stomach distress. The bitter taste of andrographolide seems to be the cause of these side effects. Injecting the crude drug extract can result in anaphylactic responses^[69].

Toxicity studies:

Numerous studies on animals have demonstrated that *A. paniculata* is a low-toxic species. However, taking Kalmegh orally may result in anorexia, nausea, and vomiting. This response appears to be brought on by the bitter taste of andrographolide. In order to establish Kalmegh as a viable alternative resource in medical care, more active research is required, including longer clinical studies and the isolation of its phytoconstituents. Participants with HIV were administered 1,500–2,000 mg of andrographolides for approximately 42 days. The trial was terminated because of adverse effects, even though CD4+ increased somewhat^[70].

Conclusion:

Traditional medicine often makes use of *Andrographis paniculata*, also known as Kalmegh, also known as the "King of Bitters," to alleviate fever, liver issues, and infections. Andrographolide is one of many bioactive compounds found in this plant, which also contains anti-inflammatory, antiviral, anticancer, hepatoprotective, and antioxidant properties. Its potential to combat diseases like COVID-19, TB, and neurological disorders has been highlighted by recent investigations. It is a viable candidate for therapeutic research due to its broad pharmacological profile and ease of cultivation. To guarantee safety and effectiveness, however, the right dosage and clinical validation are crucial. As a result, *A.*

paniculata is a powerful natural source for upcoming medical developments.

Reference:

1. Chaudhary G., Goyal S., and Poonia P., *Lawsonia inermis* Linnaeus: a phytopharmacological review, *International Journal of Pharmaceutical Sciences and Drug Research*. (2010) **2**, no.2, 91–98.
2. Joy PP, Thomas J, Mathew S, Skaria BP. Medicinal plants. *Tropical horticulture*. 1998 Feb 3;2:449-632.
3. Namita P, Mukesh R. Medicinal plants used as antimicrobial agents: a review. *Int Res J Pharm*. 2012;3(1):31-40.
4. Fang J, Cai C, Wang Q, Lin P, Zhao Z, Cheng F. Systems pharmacology-based discovery of natural products for precision oncology through targeting cancer mutated genes. *CPT: pharmacometrics & systems pharmacology*. 2017 Mar;6(3):177-87.
5. Hamid MA, Adam RA, Ramli F, Wahab R. Antioxidant activity of andrographolide from *Andrographis paniculata* leaf and its extraction optimization by using accelerated solvent extraction: Antioxidant activity of andrographolide from *Andrographis paniculata* leaf. *Journal of Tropical Life Science*. 2023 Jan 31;13(1):157-70.
6. Ali SI, Sheikh WM, Rather MA, Venkatesalu V, Muzamil Bashir S, Nabi SU. Medicinal plants: Treasure for antiviral drug discovery. *Phytotherapy Research*. 2021 Jul;35(7):3447-83.
7. Erkkinen MG, Kim MO, Geschwind MD. Clinical neurology and epidemiology of the major neurodegenerative diseases. *Cold Spring Harbor perspectives in biology*. 2018 Apr 1;10(4):a033118.
8. Li J, Huang W, Zhang H, Wang X, Zhou H. Synthesis of andrographolide derivatives and their TNF- α and IL-6 expression inhibitory activities. *Bioorganic & medicinal chemistry letters*. 2007 Dec 15;17(24):6891-4.
9. Mishra SK, Sangwan NS, Sangwan RS. Phcog rev.: Plant review *Andrographis paniculata* (Kalmegh): A review. *Pharmacognosy Reviews*. 2007 Jul;1(2):283-98.
10. L D. Outline of current clinical and pharmacological research on *Andrographis paniculata* in China. *Newsl Chin Herb Med*. 1978;10:27-31.
11. Gabrielian ES, Shukarian AK, Goukasova GI, Chandanian GL, Panossian AG, Wikman G, Wagner H. A double blind, placebo-controlled study of *Andrographis paniculata* fixed combination Kan Jang in the treatment of acute upper respiratory tract infections including sinusitis. *Phytomedicine*. 2002 Jan 1;9(7):589-97.
12. Okhwarobo A, Falodun JE, Erharuyi O, Imieje V, Falodun A, Langer P. Harnessing the medicinal properties of *Andrographis paniculata* for diseases and beyond: a review of its phytochemistry and pharmacology. *Asian Pacific journal of tropical disease*. 2014 Jun 1;4(3):213-22.
13. Kabir MH, Hasan N, Rahman MM, Rahman MA, Khan JA, Hoque NT, Bhuiyan MR, Mou SM, Jahan R, Rahmatullah M. A survey of medicinal plants used by the Deb barma clan of the Tripura tribe of Moulvibazar district, Bangladesh. *Journal of Ethnobiology and Ethnomedicine*. 2014 Feb 6;10(1):19.
14. Alagesaboopathi C. 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*. 2015 Jan 19;4(4):816-28
15. Thakur AK, Chatterjee SS, Kumar V. Adaptogenic potential of andrographolide: An active principle of the king of bitters (*Andrographis paniculata*). *Journal of Traditional and Complementary Medicine*. 2015 Jan

1;5(1):42-50.

16. Borhanuddin M, Shamsuzzoha M, Hussain AH. Hypoglycaemic effects of *Andrographis paniculata* Nees on non-diabetic rabbits. *Bangladesh Medical Research Council Bulletin*. 1994 Apr 1;20(1):24-6.
17. Hossain MS, Urbi Z. Effect of naphthalene acetic acid on the adventitious rooting in shoot cuttings of *Andrographis paniculata* (Burm. f.) Wall. ex Nees: an important therapeutical herb. *International Journal of Agronomy*. 2016;2016(1):1617543.
18. Subramanian R, Asmawi MZ, Sadikun A. In vitro α -glucosidase and α -amylase enzyme inhibitory effects of *Andrographis paniculata* extract and andrographolide. *Acta biochimica polonica*. 2008 May 29;55(2):391-8.
19. SAGGOO MS, Bir SS. Meiotic studies in certain members of family Acanthaceae from South India. *Journal of the indian Botanical Society*. 1986;65(3):310-5.
20. Jarukamjorn K, Nemoto N. Pharmacological aspects of *Andrographis paniculata* on health and its major diterpenoid constituent andrographolide. *Journal of health science*. 2008;54(4):370-81.
21. Sajeeb BK, Kumar U, Halder S, Bachar SC. Identification and quantification of andrographolide from *Andrographis paniculata* (Burm. f.) Wall. ex Nees by RP-HPLC method and standardization of its market preparations. *Dhaka University Journal of Pharmaceutical Sciences*. 2015 Jun 18;14(1):71-8.
22. Niranjana A, Tewari SK, Lehri A. Biological activities of Kalmegh (*Andrographis paniculata* Nees) and its active principles-A review. *Indian Journal of Natural Products and Resources*. 2010 Jun;1(2):125-35.
23. Das P. Phytochemical extraction and characterization of the leaves of *Andrographis paniculata* for its anti-bacterial, anti-oxidant, anti-pyretic and anti-diabetic activity. *International Journal of Innovative Research in Science, Engineering and Technology*. 2024 Jun 11.
24. Pholphana N, Rangkadilok N, Thongnest S, Ruchirawat S, Ruchirawat M, Satayavivad J. Determination and variation of three active diterpenoids in *Andrographis paniculata* (Burm. f.) Nees. *Phytochemical Analysis: An International Journal of Plant Chemical and Biochemical Techniques*. 2004 Nov;15(6):365-71.
25. Dua VK, Ojha VP, Roy R, Joshi BC, Valecha N, Devi CU, Bhatnagar MC, Sharma VP, Subbarao SK. Anti-malarial activity of some xanthenes isolated from the roots of *Andrographis paniculata*. *Journal of Ethnopharmacology*. 2004 Dec 1;95(2-3):247- 51.
26. Weiming C, Xiaotian L. Deoxyandrographolide-19 β -D-glucoside from the leaves of *Andrographis paniculata*. *Planta medica*. 1982 Aug;45(08):245-6.
27. Renu Parashar RP, Anubha Upadhyay AU, Jasmeet Singh JS, Diwedi SK, Khan NA. Morpho-physiological evaluation of *Andrographis paniculata* at different growth stages.
28. Kumar S, Kumar A. Spatial and harvesting influence on growth, yield, quality and economic potential of Kalmegh (*Andrographis paniculata* Wall Ex. Nees). *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*. 2013 Aug 9;114(1):69-76.
29. Maheshwari SK, Sharma RK, Mishra PK, Gangrade SK. Response of kalmegh (*Andrographis paniculata*) to dates of planting and harvesting in a shallow black soil.
30. Verma K, Singh KP, Singh A, Lothe NB, Kumar D, Singh AK, Kumar R, Khare P, Singh S. Co-cultivation of a medicinal plant kalmegh [*Andrographis paniculata* (Burm. F.) Wall ex. Nees] with food crops for enhancing field productivity and resource use efficiency. *Industrial Crops and Products*. 2021 Jan 1;159:113076.
31. Sanjutha S, Subramanian S, Rani CI, Maheswari J. Integrated nutrient management in *Andrographis*

paniculata. Res J Agric Biol Sci. 2008 Aug 13;4(2):141-5.

32. Makwana PD, Patel DH, Patel JJ, Patel HK. Effect of different organic manures and spacing on yield and yield attributes of Kalmegh-Panchang (*Andrographis paniculata* Wall. Ex. Nees.) under middle Gujarat conditions.

33. Ramesh G, Shivanna MB, Ram AS. Interactive influence of organic manures and inorganic fertilizers on growth and yield of kalmegh (*Andrographis paniculata* Nees.). Int. Res. J. Plant Sci. 2011;2:16-21.

34. Meena BR, Meena D, Kapoor A, Kumar A. Dynamics of growth parameter and yield of kalmegh (*Andrographis paniculata*) under different weed control technique. International Journal of Chemical Studies. 2017;5(6):773-6.

35. Ghosh KB, Datta KA, Mandal A, Dubey KP, Halder S. AN OVERVIEW ON ANDROGRAPHIS PANICULATA (BURM. F.) NEES. International Journal of Research in Ayurveda & Pharmacy. 2012 Nov 1;3(5).

36. Maiti S, Geetha KA. Country status report on Medicinal and Aromatic Plants in India. Expert consultation on promotion of medicinal and aromatic plants in the Asia- Pacific region: proceedings. 2013 Dec:101-23.

37. Rafi M, Devi AF, Syafitri UD, Heryanto R, Suparto IH, Amran MB, Rohman A, Prajogo B, Lim LW. Classification of *Andrographis paniculata* extracts by solvent extraction using HPLC fingerprint and chemometric analysis. BMC Research Notes. 2020 Feb 4;13(1):56.

38. Shah RK, Yadav RN. Qualitative phytochemical analysis and estimation of total phenols and flavonoids in leaf extract of *sarcochlamys pulcherrima* wedd. Glob J Biosci Biotechnol. 2015;4(1):81-4.

39. Hassan A, Achakzai P, Nangyal H. Detection and estimation of alkaloids, saponins and tannins in herbs of quetta baluchistan. American-Eurasian Journal of Agricultural & Environmental Sciences. 2015;15(6):985-90.

40. Braun L. *Andrographis paniculata*. Journal of Complementary Medicine: CM, The. 2004 Nov;3(6).

41. Tipakorn N. Effects of *Andrographis paniculata* (Burm.F.) Nees on performance, mortality and coccidiosis in broiler chickens. Ph.D. thesis. Institute of Animal Physiology and Animal Nutrition, Georg August-Universität, Göttingen; 2002.

42. Brinda P, Sasikala P, Purushothaman KK. Pharmacognostic studies on Merugan kizhangu. Bull. Med. Eth. Bot. Res. 1981;3(1):84-96.

43. Yadav R, Yadav N, Kharya MD. Immunomodulation potential of *Andrographis Paniculata* and *Tinospora Cordifolia* methanolic extracts in combination forms. International Journal of Pharmacological Research. 2016;6(1):29-40.

44. Rafi M, Devi AF, Syafitri UD, Heryanto R, Suparto IH, Amran MB, Rohman A, Prajogo B, Lim LW. Classification of *Andrographis paniculata* extracts by solvent extraction using HPLC fingerprint and chemometric analysis. BMC Research Notes. 2020 Feb 4;13(1):56.

45. Verma N, Vinayak M: Antioxidant action of *andrographis paniculata* on lymphoma . Mol Biol Rep. 2008, 35:535-540.

46. Renu Parashar RP, Anubha Upadhyay AU, Jasmeet Singh JS, Diwedi SK, Khan NA. Morpho-physiological evaluation of *Andrographis paniculata* at different growth stages.

47. Reyes BA, Bautista ND, Tanquilut NC, Anunciado RV, Leung AB, Sanchez GC, Magtoto RL, Castronuevo P, Tsukamura H, Maeda KI. Anti-diabetic potentials of *Momordica charantia* and *Andrographis paniculata* and their effects on estrous cyclicity of alloxan-induced diabetic rats. Journal of ethnopharmacology. 2006 Apr 21;105(1-2):196-200.

48. Hassan A, Achakzai P, Nangyal H. Detection and estimation of alkaloids, saponins and tannins in herbs of quetta baluchistan. *American-Eurasian Journal of Agricultural & Environmental Sciences*. 2015;15(6):985-90.
49. Leelarasamee A, Trakulsomboon S, Sittisomwong N. Undetectable anti-bacterial activity of *Andrographis paniculata* (Burma) wall. ex. n. *Journal of the Medical Association of Thailand= Chotmaiher Thangphaet*. 1990 Jun 1;73(6):299-304
50. Kumar S, Kumar A. Spatial and harvesting influence on growth, yield, quality and economic potential of Kalmegh (*Andrographis paniculata* Wall Ex. Nees). *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*. 2013 Aug 9;114(1):69-76.
51. Verma N, Vinayak M. Antioxidant action of *Andrographis paniculata* on lymphoma. *Molecular biology reports*. 2008 Dec;35(4):535-40.
52. Chang CC, Yang MH, Wen HM, Chern JC. Estimation of total flavonoid content in propolis by two complementary colorimetric methods. *Journal of food and drug analysis*. 2002 Jul 1;10(3).
53. SAGGOO MS, Bir SS. Meiotic studies in certain members of family Acanthaceae from South India. *Journal of the Indian Botanical Society*. 1986;65(3):310-5.
54. Pandey J, Saini VK, Raja W. Evaluation of phytochemical analysis of *Andrographis paniculata* leaf and stem extract. *World Journal of Pharmaceutical and Life Sciences*. 2019;5(2):188-90.
55. Obadoni BO, Ochuko PO. Phytochemical studies and comparative efficacy of the crude extracts of some haemostatic plants in Edo and Delta States of Nigeria. *Global Journal of pure and applied sciences*. 2002;8(2):203-8.
56. Dhananjayan R, Gopalakrishnan C, Kameswaran L. Studies on the Pharmacological Effects of Extracts and Total Alkaloids of *Tylophora Indica*. *Indian Journal of Pharmacology*. 1975 Oct 1;7(4):13-20.
57. Rajesh KD, Vasantha S, Rajesh NV, Panneerselvam A. Qualitative and quantitative phytochemical analysis in four pteridophytes. *International Journal of Pharmaceutical Sciences Review and Research*. 2014;27(2):408-12.
58. Harborne AJ. *Phytochemical methods a guide to modern techniques of plant analysis*. Springer science & business media; 1998 Apr 30.
59. Tan ML, Kuroyanagi M, Sulaiman SF, Najimudin N, Muhammad TT. Cytotoxic activities of major diterpenoid constituents of *Andrographis paniculata*. In a panel of human tumor cell lines. *Pharmaceutical biology*. 2005 Jan 1;43(6):501-8.
60. Poolsup N, Suthisisang C, Prathanturarug S, Asawamekin A, Chanchareon U. *Andrographis paniculata* in the symptomatic treatment of uncomplicated upper respiratory tract infection: systematic review of randomized controlled trials. *Journal of clinical pharmacy and therapeutics*. 2004 Feb;29(1):37-45.
61. Antony A, Nagella P. Heavy metal stress influence the andrographolide content, phytochemicals and antioxidant activity of *Andrographis paniculata*.
62. Braca A, Sortino C, Politi M, Morelli I, Mendez J. Antioxidant activity of flavonoids from *Licania licaniaeflora*. *Journal of ethnopharmacology*. 2002 Mar 1;79(3):379-81.
63. Liu J, Wang ZT, Ji LL. In vivo and in vitro anti-inflammatory activities of neoandrographolide. *The American Journal of Chinese Medicine*. 2007;35(02):317- 28.
64. Akbarsha MA, Murugaian P. Aspects of the male reproductive toxicity/male antifertility property of andrographolide in albino rats: effect on the testis and the cauda epididymidal spermatozoa. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural*

Product Derivatives. 2000 Sep;14(6):432-5.

65. Das P. Phytochemical extraction and characterization of the leaves of *Andrographis paniculata* for its anti-bacterial, anti-oxidant, anti-pyretic and anti-diabetic activity. *International Journal of Innovative Research in Science, Engineering and Technology*. 2024 Jun 11.
66. Ma X, Rininger J, Chigurupati P, Dong H, Babish JG. Biochemical pathways of inhibiting human immunodeficiency virus-1 replication and cytopathicity by andrographolide (abstract no. T12). *Gen. Meet. Am. Soc. Microbiol.* 1997;97:538.
67. Choudhury BR, Poddar MK. Andrographolide and kalmegh (*Andrographis paniculata*) extract: in vivo and in vitro effect on hepatic lipid peroxidation. *Methods and Findings in Experimental and Clinical Pharmacology*. 1984 Sep 1;6(9):481-5.
68. Gupta S, Yadava JN, Tandon JS. Antisecretory (antidiarrhoeal) activity of Indian medicinal plants against *Escherichia coli* enterotoxin-induced secretion in rabbit and guinea pig ileal loop models. *International Journal of Pharmacognosy*. 1993 Jan 1;31(3):198-204.
69. Thamlikitkul V, Dechatiwongse T, Theerapong S, Chantrakul C, Boonroj P, Punkrut W, Ekpalakorn W, Boontaeng N, Taechaiya S, Petcharoen S. Efficacy of *Andrographis paniculata*, Nees for pharyngotonsillitis in adults. *Journal of the Medical Association of Thailand= Chotmai het Thangphaet*. 1991 Oct 1;74(10):437-42.
70. Calabrese C, Berman SH, Babish JG, Ma X, Shinto L, Dorr M, Wells K, Wenner CA, Standish LJ. A phase I trial of andrographolide in HIV positive patients and normal volunteers. *Phytotherapy Research*. 2000 Aug;14(5):333-8.



Copyright & License:

© Authors retain the copyright of this article. This work is published under the Creative Commons Attribution 4.0 International License (CC BY 4.0), permitting unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.