

# A Comprehensive Review on *Andrographis paniculata* for Its Antiviral, Anti-inflammatory, and Immunomodulatory Activities.

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## ABSTRACT:

*Andrographis paniculata*, commonly known as 'Kalmegh' or 'King of Bitter,' is part of the Acanthaceae family. It typically thrives in countries like India, Thailand, Sri Lanka, Indonesia, Malaysia, and China. The leaf serves as the primary healing component, whereas the entire plant, as well as the root, is utilized for different diseases. It contains numerous significant bioactive molecules like flavonoids, diterpenoids, and polyphenols. Andrographolide is the most prevalent and abundant diterpenoid. This review examines in detail the immunomodulatory, antiviral, and anti-inflammatory effects of andrographolide, the main active compound responsible for these activities. The antiviral effects of *Andrographis paniculata* have been proven against various viruses like influenza, dengue, zika, hepatitis, and even coronaviruses, by disrupting viral replication and boosting immune reactions. Its ability to reduce chronic inflammation lies in its anti-inflammatory effects, which work by modulating important pathways like NF- $\kappa$ B, that controls the release of pro-inflammatory cytokines. Moreover, *Andrographis paniculata* also shows immunomodulatory effects by increasing the activity of lymphocytes, macrophages, and cytokine release in both natural and acquired immune responses. The combination of these activities positions *Andrographis paniculata* as a potential treatment for viral infections and related inflammatory conditions, while also boosting the immune system. This review emphasizes the healing potential of *Andrographis paniculata* for viral diseases and immune-related disorders, advocating for its integration into contemporary medical practice.

**KEYWORDS:** Andrographolide, cytokine, NF- $\kappa$ B (nuclear factor-kappa B), macrophages, lymphocytes, diterpenoids, flavonoids, polyphenols.

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## 1. INTRODUCTION:

*Andrographis paniculata*, a popular plant in the Acanthaceae family, is referred to as 'Maha-tita' in north-eastern India, meaning 'king of bitters'. It is also called 'Bhui-neem' due to its resemblance in appearance and bitter taste to Neem. It is known by different common names such as "green chiretta", "Kalmegh" or "Creat"<sup>1</sup>. It typically thrives in regions of Southern and Southeastern Asia such as India, Sri Lanka, Pakistan, and Indonesia. In India, it flourishes during the rainy season, benefiting from the hot and humid weather with plenty of sunlight. Kalmegh holds the 17<sup>th</sup> position among the list of 32 prioritized medicinal herbs by the INMPB (Indian National Medicinal Plants Board). Extract from the *Andrographis paniculata* plant is recognized for its diverse pharmacological effects<sup>2</sup>. The bitter active ingredient andrographolide extracted from the plant's leaves gives it medicinal value. It is used to address various health issues like the fever, common cold, liver disease, diabetes, insect poisons and snake bites, jaundice, malaria, typhoid, dysentery, and sore throats<sup>21</sup>. *A. paniculata* is mentioned in many government-approved materia medica and pharmacopeias from various countries, such as the Indian, British, PPRC (Chinese), and Thai herbal pharmacopeias, and is listed in the US pharmacopeia as a nutritional supplement. Additionally, the WHO designated *A. paniculata* as a medicinal herb in a WHO publication about frequently utilized medicinal plants for monitoring quality assurance and herbal medicine use. Public health services and hospitals in Thailand use *A. paniculata*, which has been chosen by the Thailand ministry of public health to be listed on the Thailand national list of essential medicines<sup>3</sup>.



**Figure 1.** *Andrographis paniculata*.

### 1.1 PLANT DISCRIPTION:

Kalmegh is an annual herbaceous plant that thrives in shaded areas, moist and usually reaches a height of 31-111 cm. Its stem is thin, highly branched, dark green and measures 0.3 to 1.0 meters in height, with a diameter of 2 to 6 mm, and having wings and longitudinal furrows on the angles of the younger sections, which are somewhat larger near the nodes; leaves glabrous, lanceolate, pinnate that are up to 8.1 cm long and 2.6 cm wide; flowers white blossoms with pink-purple spots on their petals. tiny, loosely spreading panicles or axillary and terminal racemes; capsules measuring 1.9 cm by 0.3 cm, linear-oblong, and acute at both ends; many, subquadratic, yellowish brown seeds<sup>4</sup>. The plants bloom and bear fruit in the months of April–May (Grishma Ritu) and September–October (Sharad Ritu)<sup>2</sup>.

**Table 1: Botanical description of *Andrographis paniculata*<sup>5</sup>.**

Characteristic	Values/traits
<b>I. Stem</b>	dark green
i. Length	0.3 - 1.0 m
ii. Shape	thin, highly branched, dark green, sharply four-sided, and brittle
<b>II. Flowers</b>	white blossoms with pink-purple spots on their petals
i. Structure	The flowers consist of five petals that create a tubular shape with a slender throat. The usual length of the corolla is approximately 2-3 cm.
ii. Blooming Season	April–May and September–October / Grishma Ritu and Sharad Ritu
<b>III. Leaves</b>	glabrous
i. Length	3-11 cm
ii. Width	2.5 cm
iii. Arrangement	lanceolate
<b>IV. Seed</b>	numerous very small
i. Shape	square-shaped
ii. Colour	golden-brown / yellowish brown

#### 1.1.1. TAXONOMY:

There are 40 species in the genus *Andrographis*, with about 26 of them species known to exist in India. Some of these include *Andrographis paniculata*, *A. elongata*, *A. alata*, *A. echioides*, *A. lineata*, *A. nallamalayana*, *A. ovata*, and *A. serphyllifolia*<sup>6</sup>.

**TAXONOMIC HIERARCHY:**

Taxonomic hierarchy of *Andrographis paniculata* is classified as below:

**Table 2: Taxonomic classification<sup>7</sup>**

1.	Kingdom	Plante
2.	<b>Division</b>	Angiosperma
3.	<b>Class</b>	Dicotyledonae
4.	<b>Order</b>	Personales
5.	<b>Family</b>	Acanthaceae
6.	<b>Genus</b>	Andrographis
7.	<b>Species</b>	Andrographis paniculata

**1.1.2. REGIONAL NAMES:****Table 3: Regional names<sup>5</sup>**

S.No	Place	Name
1	Oriya	Bhuinimba
2	Arab	Quasabhuva
3	Sanskrit	Kalmegha, Bhunimba
4	Tamil	Nilavembu
5	Kannada	Nelaberu
6	Bengali	Kalmegh
7	Telugu	Nilavembu
8	Hindi	Kirayat
9	Marathi	Oli-kiryata
10	English	The Creat
11	Gujarathi	Kariyatu
12	Indonesian	Sambiloto
13	Malayalam	Nelavepu, Kiriayattu

**1.1.3. BIOGEOGRAPHY:**

*Andrographis paniculata* is a indigenous plant of India, Taiwan, and mainland China, thrives in warm-climate and near-tropical regions of Asia, including Southeast Asia and countries like Laos, Cambodia, Indonesia, and Sri Lanka. It also inhabits diverse ecological zones across the Americas, Christmas Island, and the West Indies<sup>5</sup>.

**Table 4: Geographical distribution<sup>5</sup>**

Region	Countries/States	Habitat
Asia	India (Uttarakhand, Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Kerala, West Bengal, etc.), Sri Lanka, Myanmar, Thailand, Malaysia, Indonesia, China, Vietnam	Plains, tropical forests, cultivated lands
Africa	Kenya, Nigeria, and other tropical regions	Dry and tropical zones
Australia	Northern parts, particularly in Queensland	Tropical and subtropical regions
America	Mexico, Caribbean regions	Cultivated and semi-natural habitats
Other Regions	Cultivated worldwide due to its medicinal value	Tropical and subtropical climates

## 1.2. PHYTOCONSTITUENTS OF KALMEGH:

The plant is believed to contain a variety of flavonoids, lactones, and diterpenoids. However, the concentration and composition of these phytochemicals change based on factors such as geographical location, plant parts, season, and the stage of phenological growth. Andrographolide, the primary active ingredient in *A. paniculata*, is present in the entire plant, encompassing the leaves, stem, and roots. In fact, Boorsma was the first to isolate this chemical. Then, in 1911, J. Gorter discovered andrographolide as a diterpenoid compound with lactone structure and isolated it from the herb *A. paniculata*. Based on the chemical makeup of the substance and the genus name andrographis, he also came up with the name andrographolide. Although andrographolide may be isolated from any part of the plant, the leaves have the highest concentration of this compound. Numerous studies demonstrate that the vegetative stage, which occurs around 131 days after beginning cultivation, contains the maximum concentration of andrographolide. Pharmacological actions are also exhibit by the other ent-labdane-type diterpenes from this plant, including neo-andrographolide, iso-andrographolide, 12-didehydroandrographolide, and 14-deoxy-11. Furthermore, the results of this investigation show that many flavonoids have been identified throughout the last 31 years. Although flavonoids were discovered in the plant's aerial parts, the root was mostly used for their separation and elucidation. According to earlier research, the flavonoids exhibit biological action, such as growth-inhibiting qualities and anti-clotting. In addition xanthone, d-quinic acid, and sitosterol, Polysaccharide, and its compound were identified as minor chemicals present in *A. paniculata*<sup>3</sup>. The chemical compounds present in *A. paniculata* are shown in Figure 2<sup>8</sup>.

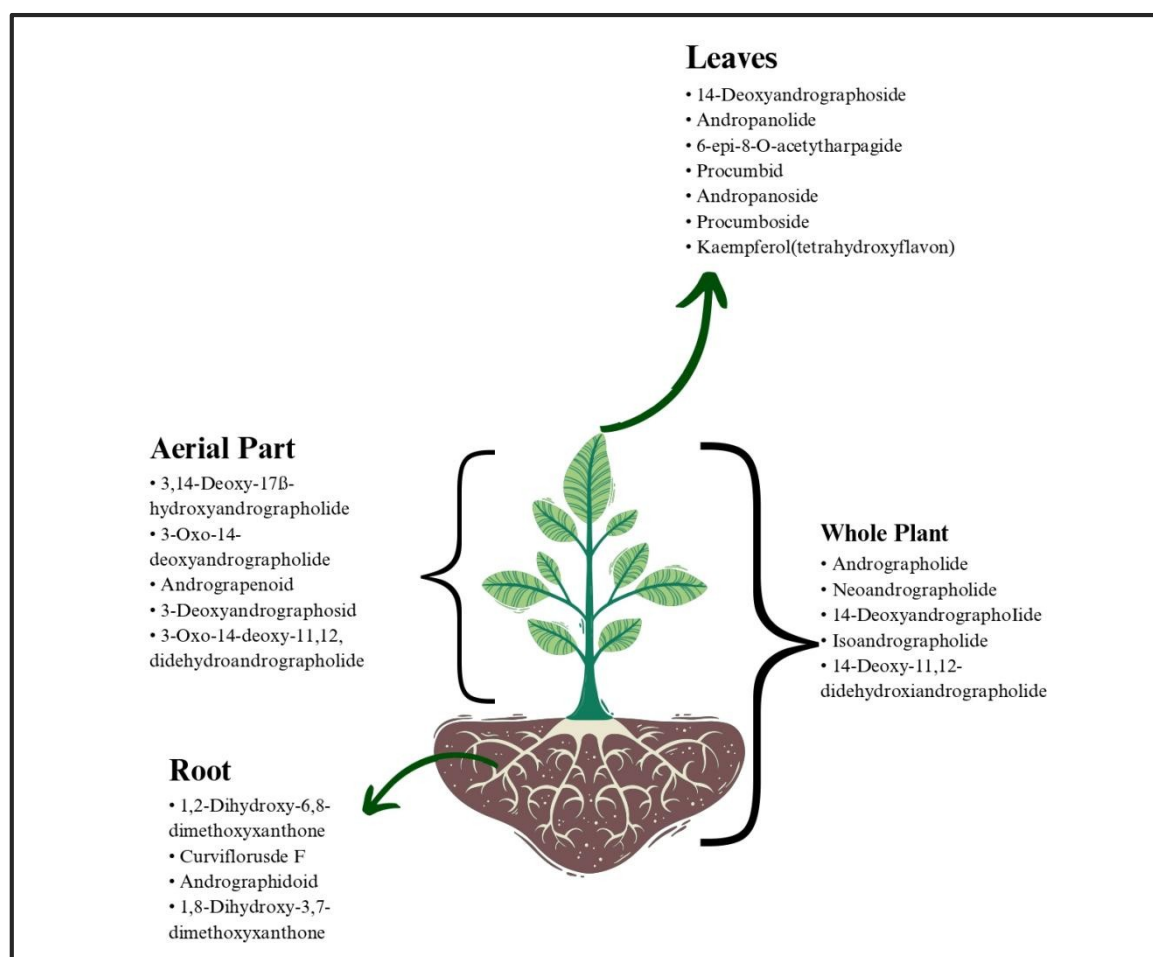
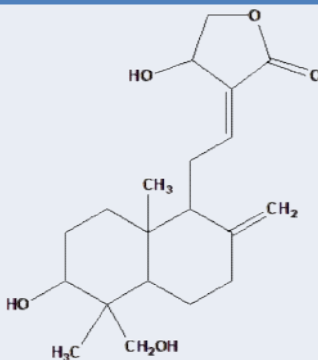


Figure 2. shows the components present in *A. paniculata*, separated into four categories: entire plant, above-ground plant parts, leaves, and underground roots. The entire plant includes every part of the plant. The part above ground is the one that is in direct contact with the air, consisting of branches, sticks, leaves, and blooms<sup>8</sup>.

## 1.2.1. CHEMISTRY OF PRIMARY BIOACTIVE COMPOUND ANDROGRAPHOLIDE:

Table 5: Chemistry of andrographolide<sup>9</sup>

Aspect	Details
Structure	
Chemical Name	3 $\alpha$ , 14, 15, 18-tetrahydroxy-5 $\beta$ , 9 $\beta$ H, 10 $\alpha$ -labda-8, 12-dien-16-oic acid $\gamma$ -lactone
MF	C <sub>20</sub> H <sub>30</sub> O <sub>5</sub>
MW	374.45 g/mol
Functional Groups	<ul style="list-style-type: none"> <li>- Lactone group (-C=O)</li> <li>- Hydroxyl groups (-OH)</li> <li>- Double bonds (unsaturation)</li> </ul>
Source	Extracted from the leaves and stems of <i>A. paniculata</i>
Properties	<ul style="list-style-type: none"> <li>- colorless crystalline solid</li> <li>- Not very soluble in water, soluble in organic solvents like methanol and ethanol</li> </ul>
Melting Point	235.3°C
Bioactivity	<ul style="list-style-type: none"> <li>- Antioxidant</li> <li>- Anti-inflammatory</li> <li>- Anticancer</li> <li>- Antimicrobial</li> <li>- Hepatoprotective</li> <li>- Immunomodulatory properties</li> </ul>
Therapeutic Potential	Used in traditional medicine for immune system enhancement, fever reduction, liver protection, and anti-inflammatory purposes.

## 1.3. TRADITIONAL AND MODERN USES:

*Andrographis paniculata* has been utilized as a miraculous remedy in conventional Ayurvedic medicine and Siddha, as well as in tribal medicine in India and other countries, for various clinical purposes since ancient times. *Andrographis paniculata* is listed in the IP (Indian Pharmacopoeia) and is a key ingredient in numerous Siddha, Ayurvedic, and Unani remedies<sup>10</sup>. Local people commonly use fresh or dried *Andrographis paniculata* for treating snake bites, flu, diarrhoea, malaria, dysentery, cough, liver diseases, common cold, and certain skin infections Table 6. The plant has been conventionally utilized for its antioxidant, antibacterial, antipyretic, anti-diabetic, antiparasitic, anti-inflammatory, hepatoprotective, antispasmodic, antipyretic, anti-carcinogenic, antidiarrheal, nematicidal, and various infectious diseases including dysentery and malaria<sup>11</sup> Table 7. *Andrographis paniculata* (powder and extract) was recognized as kalmegh in the IP (Indian Pharmacopoeia) in 2007 and again in the 2014 edition, being classified as

a hepatoprotective agent. *Andrographis paniculata* and its extracts are recognized in the CP (Chinese Pharmacopoeia) as "Chuan-Chin-Lian Andrographolide drop pill", "Chuanxinlian capsule", and "Chuanxinlian tablet"<sup>3</sup>. The Tamil Nadu government distributes this plant extract in various forms like nilavembu kudineer, nilavembu juice, nilavembu kashayam, nilavembu tonic, nilavembu kudineer chooranam, and nilavembu choornam Table 8. These products primarily consist of *Andrographis paniculata*, either by itself or combined with neem or papaya juice/extract, for treating dengue fever, malarial fever, common flu, and chikungunya through hospitals and health camps<sup>11</sup>.

**Table 6: Traditional uses of kalmegh**

Immune booster	thought to aid in the body's defense against diseases and illnesses
Liver health	Utilized for jaundice and liver issues.
Fever reduction	It is used in Ayurveda to lower fever and ease the symptoms of a number of feverish illnesses.
Digestive aid	helps with gastrointestinal problems, such as diarrhea, and enhances digestion.
Anti-inflammatory	Decreases inflammation, which makes it a treatment for ailments such as arthritis and other inflammatory conditions.
Respiratory conditions	Frequently used in the management of lung infections and conditions like asthma.

**Table 7: Modern medicinal uses kalmegh<sup>5,25</sup>**

Immune modulation	Aids in controlling the immune system, which could be useful for managing autoimmune diseases.
Antibacterial and Antiviral	Potential for treating different infections such as the common cold, flu, and even HIV-1.
Hepatoprotective effects	It has the ability to shield the liver from harm brought about by toxic substances and free radicals
Anti-inflammatory	Its ability to reduce inflammation could provide benefits for conditions like osteoarthritis, rheumatoid arthritis
Anti-cancer	Capable of fighting infectious and oncogenic pathogens, cytotoxic, inducing cancer cell maturation or differentiation and impeding the growth of malignant cells.
Malaria treatment	Andrographolide has shown promising potential effects against malaria
Cardiovascular health	Enhancing cardiovascular health through reducing cholesterol levels and increasing the function of blood vessels
Antioxidant activity	It contains substances like flavonoids and tannins that have antioxidant qualities and may help shield cells from harm caused by free radicals species



**Table 8: Traditional use of kalmegh in Tamil Nadu by tribes as folk medicine<sup>1</sup>.**

S.No	Therapeutic uses	Formulation	Dosage
1.	Malaria	Mix 20 grams of powdered whole herb in water and strain.	Administered two times daily within the body
2.	Jaundice	A 10g herb extract in water, heated by adding a hot stone.	Three times daily.
3.	Gonorrhoea	2 grams of the powdered form and the juice extracted from the plant.	Administered internally and used externally on wounds
4.	Infected wounds	Blend of herb mixed with turmeric	Used topically on injuries
5.	Eczema	2 grams of powder	Administered two times daily for a duration of 40 days

**1.3.1. MEDICINAL PROPERTIES OF KALMEGH:****Table 9: List of medicinal properties of Kalmegh<sup>2,4</sup>**

<b>Analgesic</b>	(pain reliever) decreases inflammation and lowers exudation from capillaries; anti-inflammatory effects likely facilitated, in part, by adrenal activity.
<b>Antiperiodic</b>	mitigates seasonal/intermittent illnesses, like malaria
<b>Antibacterial</b>	combats bacterial activity; while <i>Andrographis</i> seems to exhibit minimal direct antibacterial properties, it significantly helps in alleviating diarrhea and symptoms associated with bacterial infections.
<b>Antithrombotic</b>	clot-preventing agent
<b>Antiviral</b>	viral growth suppressant
<b>Antipyretic</b>	fever reliever - in both animals and humans, triggered by various infections or by toxins.
<b>Cardioprotective</b>	protects heart muscles
<b>Cancerolytic</b>	Fights and kills cancer cells
<b>Choleretic</b>	modifies the characteristics and movement of bile
<b>Digestive</b>	improves digestion

<b>Depurative</b>	detoxifies and purifies the body, especially the blood
<b>Expectorant</b>	facilitates the removal of mucus from the respiratory tract
<b>Hypoglycemic</b>	blood sugar reducer
<b>Hepatoprotective</b>	protects the liver and gall bladder
<b>Immune Enhancement</b>	enhances the ability of white blood cells to phagocytize, suppresses HIV-1 replication, and boosts CD4 and T-cell levels.
<b>Laxative</b>	supports bowel movement
<b>Sedative</b>	herb that promotes relaxation, but not to the same degree as common sedatives like valerian root, hops, or skullcap
<b>Thrombolytic</b>	Clot-removal agent

### 1.3.2. MARKETED FORMULATIONS OF KALMEGH:

**Table 10: Commercially available formulations<sup>12,23</sup>**

Formulation Type	Product Name/Brand	Uses	Dosage Form
Capsules/Tablets	Andrographis Capsules (Himalaya)	Immune support, liver health, common cold	Capsules
	KalmCold (Arlak Biotech)	Common cold, immunity boosting	Tablets
	Andrographis Plus (Herbal Hills)	Immunity, anti-inflammatory	Tablets
Syrups	Andrographis Syrup (Ayurvedant)	Respiratory tract infections, fever relief	Liquid Syrup
Extract Powder	Andrographis Powder (Organic India)	Immune modulator, antioxidant properties	Powder
Softgel Capsules	Andrographis Softgel (Amway)	Immune booster, digestion support	Softgel Capsules
Combination Products	Kalmegh Compound (Baidyanath)	Liver health, digestion	Tablets
	Liv 52 (Himalaya)	Liver disorders (contains Andrographis blend)	Tablets/Liquid
Tea/Herbal Infusions	Kalmegh Herbal Tea (Zandu)	Detoxification, general wellness	Tea Bags



### 1.3.3. FUTURE ADVANCEMENTS IN FORMULATION WITH NANOEMULSION TECHNOLOGY:

Nanoemulsions are colloidal systems that improve the solubility and bioavailability of drugs with low solubility. conventional forms of andrographolide, such as powders or capsules, exhibit low bioavailability because of the compound's limited solubility in water, which is crucial for its effectiveness. The nanoemulsion formulation greatly improves the absorption and bioavailability of andrographolide by decreasing particle size and enhancing dissolvability<sup>13</sup>.

#### 1.3.3.1. METHOD FOR THE FORMULATION OF ANDROGRAPHOLIDE NANOEMULSION:

Nanoemulsions are generally created by using two methods one is high-energy techniques, such as ultrasonication and high-pressure homogenization, and low-energy techniques, including phase inversion temperature (PIT) and spontaneous emulsification<sup>14,24</sup>.

## 2. PHARMACOLOGICAL ACTIVITIES :

The current review article centers on the pharmacological effects such as antiviral, anti-inflammatory, and immunomodulatory activities of andrographolide<sup>15,22</sup>.

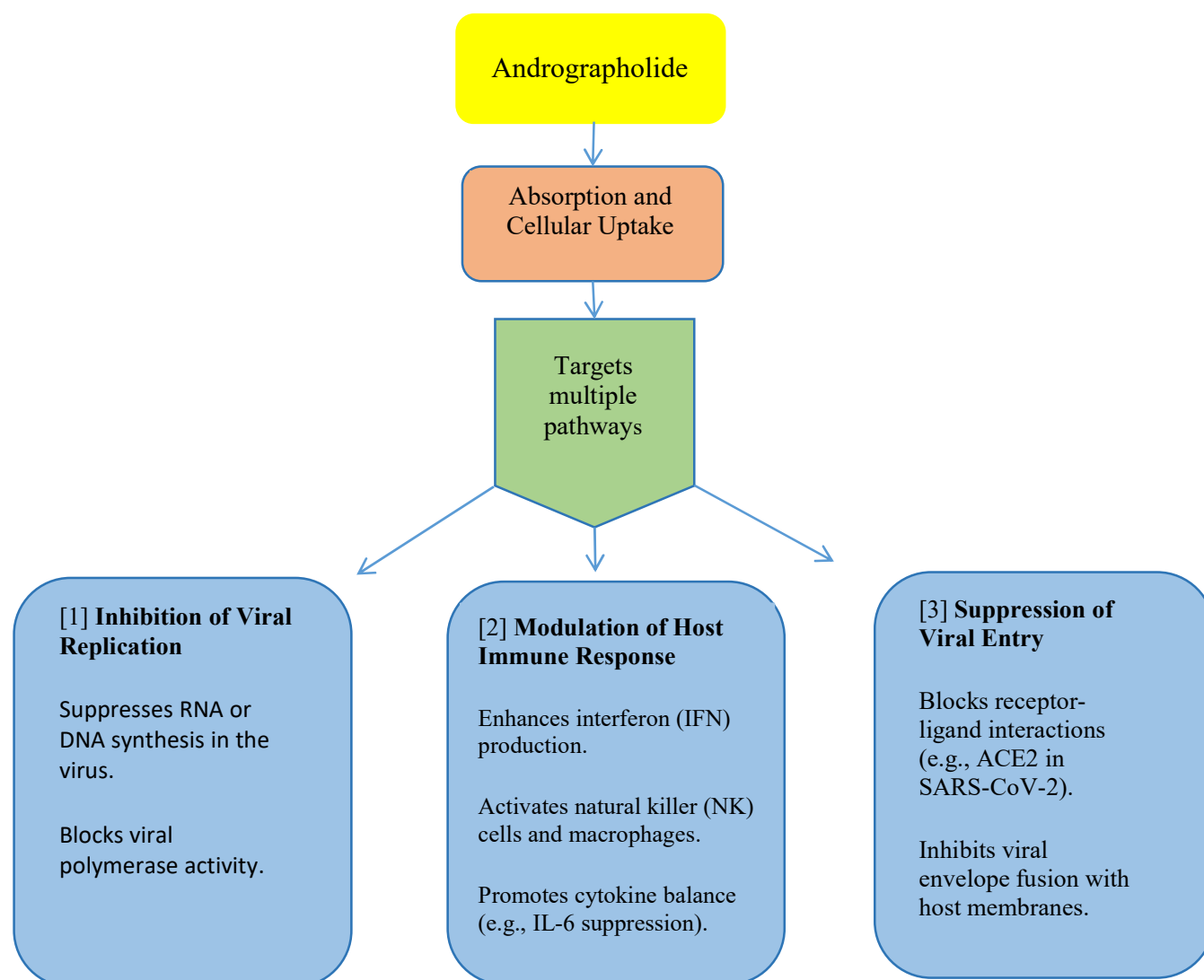
### 2.1. ANTIVIRAL ACTIVITY:

It is thought that viruses, which are microscopic infectious organisms that can only multiply in live host cells, have coexisted alongside living creatures since the start of life. The novel SARS-CoV-2, responsible for causing Coronavirus Disease 2019 (COVID-19), emerged in the past three years. Its symptoms are similar to those seen in SARS-CoV infections and it primarily affects the respiratory tract. As of September 29, 2021, the new virus has killed four million individuals and infected 233.75 million people globally. Viral infections have developed resistant to many medications due to the life cycle of a virus that keeps evolving, making them the main source of health problems worldwide. *A. paniculata* is one example of how herbal plant-based treatment has significantly advanced the medical field. Andrographolide, the plant's primary constituent, has a wide spectrum of antiviral properties. Evaluating the antiviral potential of *Andrographis paniculata* and its key compounds could provide fresh insights for the development of new antiviral treatments<sup>16</sup>. *A. paniculata* antiviral properties, such as its anti-HIV, anti-HSV, anti-dengue, anti-influenza, and anti-SARS-CoV-2 properties, were compiled in the Table 11.

**Table 11: Chemical component ,extract of *A. paniculata* and their target cell with their antiviral activities<sup>8,3</sup>.**

Antivirals	Cell Target	<i>A. paniculata</i> (Chemical Compounds and Extract)
Anti-influenza	Bronchial epithelial cell line (16HBE) A549 and MDCK cells	Andrographolide  14-Deoxy-11,12-didehydroandrographolide
Anti-dengue	C6/C3 cell line  HepG2 and HeLa cells	Andrographolide  Andrographolide
Anti-herpes simplex	Vero E6 Vero cell  Vero cell	Methanolic extract Andrographolide  Neoandrographolide 14-Deoxy-11,12-didehydroandrographolide
Anti-SARS-CoV-2	Calu-3 cell	Ethanolic extract Andrographolide
Anti-HIV	Human T cell  HL2/3 cell  MT2 cell  MT2 cell	Ethanolic extract  Andrographolide  14-Deoxy-11,12-didehydroandrographolide

### 2.1.1. ANTIVIRAL MECHANISM OF ACTION OF ANDROGRAPHOLIDE<sup>8,17</sup>

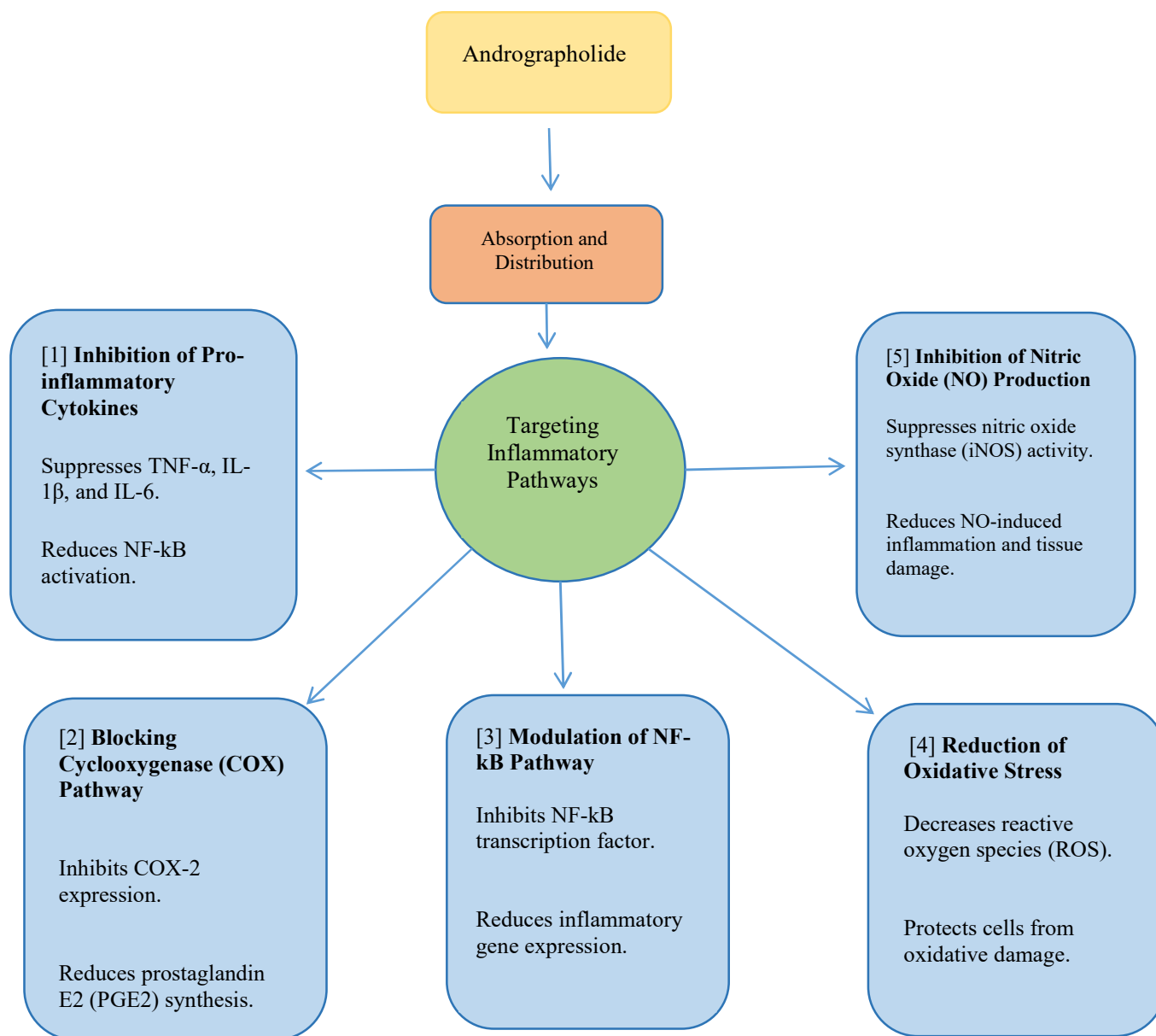


### 2.2. ANTI-INFLAMMATORY ACTIVITY:

The Inflammation-reducing properties of *Andrographis paniculata* extract, its bioactive ingredients, and identical synthetic substances have been investigated against both endogenous and exogenous sources. The anti-inflammatory effects of andrographolide, the main compound, are due to several mechanisms. These include blocking the expression of ICAM-1, reducing the Phosphoinositide 3-kinase/Protein Kinase B signaling pathway, and preventing the adhesion of endothelial cells to monocytes, all of which are triggered by tumor necrosis factor- $\alpha$  (TNF). It also stops NF- $\kappa$ B activation, reduces pro-inflammatory proteins by preventing NF- $\kappa$ B (Nuclear Factor kappa-light-chain-enhancer of activated B cells) from attaching to DNA, suppresses Nuclear Factor kappa-light-chain-enhancer of activated B cells and nitric oxide (NO), and changes the activity of neutrophils and macrophages. Dehydroandrographolide and neoandrographolide, two diterpenoids that were extracted from *A. paniculata*, as well as andrographolide, also showed anti-inflammatory effects. They do this by affecting COX-1 and COX-2 enzymes and reducing the expression of genes involved in inflammation, including chemokines, the JAK/STAT signaling pathway, cytokine receptors, the TLR family, cytokines, and NF- $\kappa$ B. Furthermore, *A. paniculata* crude extract had strong inhibitory effects on inflammatory (PGE2 and TXB2) and pro-inflammatory substances such as nitric oxide, Interleukin-6, and Interleukin-1 beta mediators<sup>12</sup>. Multiple studies suggest that *Andrographis paniculata* extract and its pure compounds, especially

andrographolide, offer anti-inflammatory benefits for conditions like rheumatoid arthritis, cancer (breast, lung, colon), and angiogenesis. Additionally, these compounds have shown protective effects against cell and organ damage, including intestinal toxicity caused by cyclophosphamide (CTX), neurotoxicity caused by lipopolysaccharide, and toxicity in the liver and hepatorenal system. Andrographolide is a potent anti-inflammatory substance that may be better than many other plant-derived substances in some situations because of its many different mechanisms, which include immune response regulation, cytokine suppression, and antioxidant benefits<sup>3</sup>.

**2.2.1. ANTI-INFLAMMATORY MECHANISM OF ACTION OF ANDROGRAPHOLIDE<sup>18,19</sup>.**

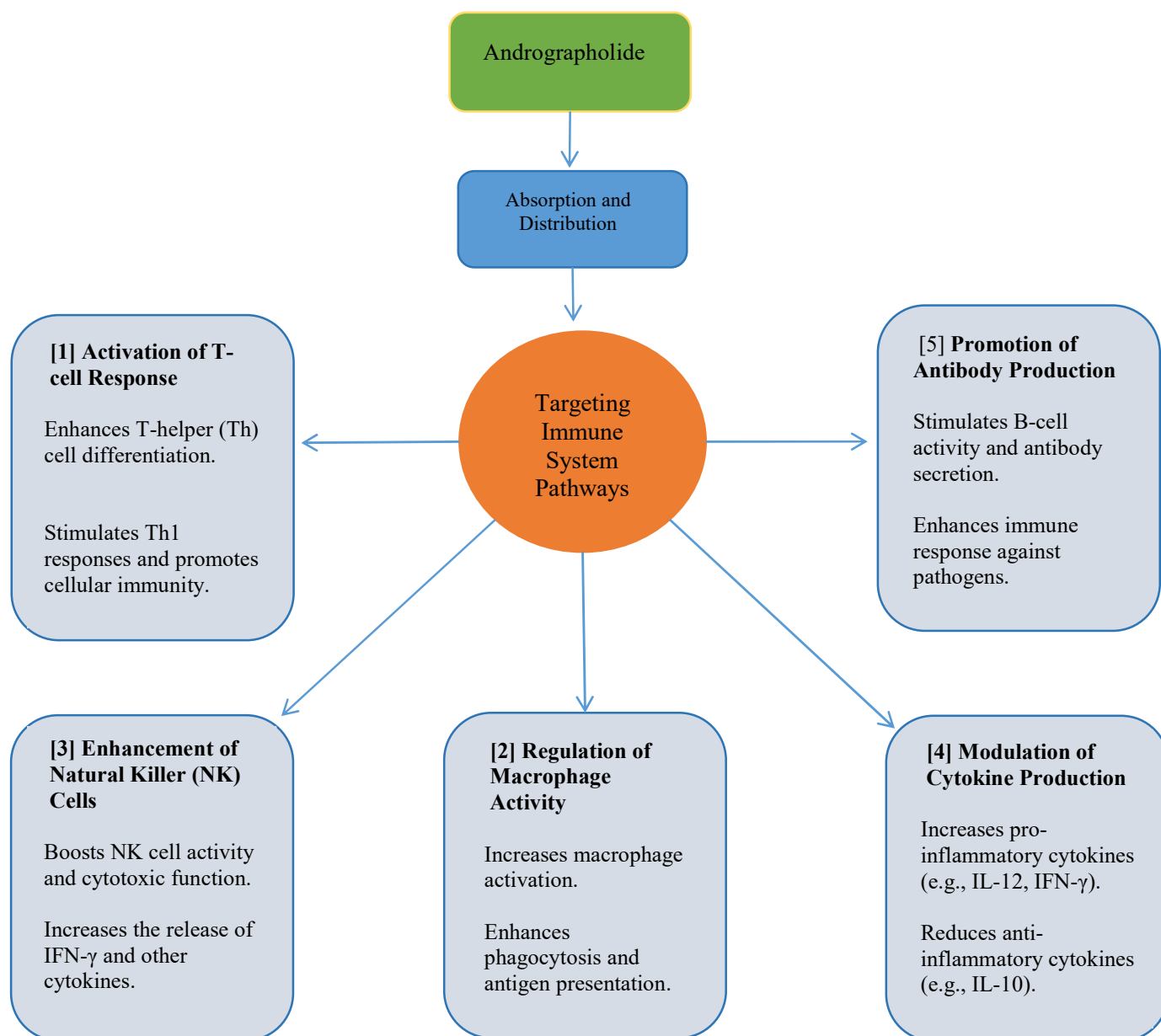


**2.3. IMMUNOMODULATORY ACTIVITY:**

Reports indicate that andrographolide possesses both immunostimulant and immunosuppressive characteristics. It is thought that the immune-boosting characteristics of *Andrographis paniculata* account for its wide range of health benefits, especially its ability to reduce inflammation, combat infections, and even inhibit the growth of cancer cells. The immunomodulatory effects of andrographolide are connected to the enhanced growth of specific immune cells in the blood (called peripheral blood lymphocytes), higher production of important immune system signals (cytokines), and a rise in blood cell counts, which leads to the activation of immune markers like interferon-neopterin and  $\beta$ 2-microglobulin. Experiment has shown that the immune stimulatory activity of andrographolide, as observed in vitro, enhances the human peripheral blood lymphocytes when stimulated by phytohemagglutinin, leading to increased interleukin-2 production and cellular multiplication. Additionally, andrographolide has been shown to suppress the

production of Interleukin-12 and Tumor Necrosis Factor in macrophages activated by lipopolysaccharides. Andrographolide can effectively modulate immune responses by inhibiting T-cell activation, a key process in the immune system. In both cell culture (in vitro) and living organism (in vivo) studies, andrographolide has shown the ability to reduce T-cell activation, potentially offering therapeutic benefits in conditions where excessive or harmful T-cell responses are involved, such as autoimmune diseases or organ transplant rejection. The plant is also said to be a potent immune system booster<sup>15</sup>. According to a recent study on *A. paniculata* as an immunostimulant for Coronavirus Disease 2019 patients found that its components exhibited immune-boosting and antiviral effects through several pathways, including MAP kinase, PI3/AKT, and toll-like receptor pathways, which could provide benefits against upper respiratory infections (URTIs) and SARS-CoV-2<sup>3</sup>.

**2.3.1. IMMUNOMODULATORY MECHANISM OF ACTION OF ANDROGRAPHOLIDE<sup>20</sup>.**



### 3. ADVERSE EFFECTS:

Vomiting, stomach pain, and appetite loss were triggered by an overdose of *A. paniculata* extract, which may have been brought on by the herb's very bitter flavor. Despite being safe, this plant or its extract should not be consumed during pregnant because it is categorized under class 2b in the botanical safety handbook<sup>11</sup>.

### 4. CONCLUSIONS:

The *Andrographis paniculata* is a highly significant medicinal plant because of its strong pharmacological properties, anti-inflammatory, potent antiviral, and immunomodulatory effects are just a few of the many therapeutic qualities that make *Andrographis paniculata* an extraordinary medicinal plant. This plant's key ingredient, andrographolide, has a major impact on a number of immunological pathways, strengthening the body's defenses while also controlling inflammation. It promise as a useful remedy for the management of viral infections, chronic inflammation, and immune-related illnesses because of its capacity to suppress viral replication, lower pro-inflammatory cytokines, and alter immune cell function, therefore, a thorough and systematic review of the plant is presented here to help researchers and government officials to gain a thorough understanding of the plant.

### 5. ACKNOWLEDGEMENT:

I sincerely acknowledge the guidance and support of my mentor, Miss Kanchan Singh, at Dev Bhoomi Uttarakhand University. I am also grateful to my peers for their valuable insights and to my family for their constant encouragement throughout this work.

### 6. CONFLICT OF INTEREST:

The author declares no conflict of interest related to this review article.

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