

## Aloe Vera (*Aloe barbadensis* Miller): cultivation, phytochemistry, therapeutic applications, and clinical evidence — A comprehensive review

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### Abstract

Aloe Vera (*Aloe barbadensis* Miller) is one of the most widely used medicinal plants in traditional and modern medicine [1, 2]. The plant contains more than 200 biologically active compounds, including polysaccharides, anthraquinones, vitamins, minerals, enzymes, and amino acids [3-5]. These phytochemicals contribute to a wide range of pharmacological activities including antioxidant, anti-inflammatory, antimicrobial, wound healing, immunomodulatory, and metabolic regulatory effects [6-8].

Aloe Vera has extensive applications in nutraceuticals, pharmaceuticals, dermatology, and cosmetic formulations [9, 11]. Both oral and topical preparations of Aloe Vera have been investigated in clinical trials for conditions such as diabetes, wound healing, gastrointestinal disorders, and inflammatory skin diseases [1, 12, 14]. The primary bioactive compound, acemannan, plays a crucial role in immune modulation and tissue repair [15, 17]. This review summarizes the botany, cultivation, phytochemistry, pharmacological mechanisms, dermatological applications, and clinical evidence supporting the therapeutic use of Aloe Vera [18, 19].

**Keywords:** *Aloe barbadensis* Miller, phytochemistry, acemannan, herbal medicine, wound healing, nutraceuticals

### Introduction

#### Botanical Description and Taxonomy

Aloe Vera belongs to the family Asphodelaceae [2, 20].

#### Taxonomic classification [21, 22]

- **Kingdom:** Plantae
- **Order:** Asparagales
- **Family:** Asphodelaceae
- **Genus:** Aloe
- **Species:** *Aloe barbadensis* Miller

The plant is a succulent perennial herb characterized by [5, 23]

- Thick fleshy leaves
- Serrated margins
- Gel-filled inner parenchyma

The leaves contain three main layers [3, 4]:

- **Outer rind:** protective layer
- **Latex layer:** contains anthraquinones such as aloin
- **Inner gel:** rich in polysaccharides and bioactive compounds [5, 24]

#### Occurrence and Geographical Distribution

Aloe Vera is believed to have originated in North Africa and the Arabian Peninsula, but it is now cultivated worldwide [25, 26].

#### Major cultivation regions include [2, 27]

India, Mexico, China, Thailand, United States, and Caribbean islands.

#### In India, Aloe Vera is widely cultivated in [28, 29]

Rajasthan, Gujarat, Andhra Pradesh, and Tamil Nadu.

The plant thrives in arid and semi-arid climates [22].

#### Cultivation of Aloe Vera

##### Climate Requirements

Optimal growth conditions include [30]:

- **Temperature:** 20–30°C
- **Rainfall:** low to moderate
- **Sunlight:** full sunlight
- **Soil:** well-drained sandy soil

Aloe vera is drought-tolerant and suitable for xerophytic agriculture [22].

#### Propagation

Propagation occurs mainly through vegetative offsets (pups) produced at the base of mature plants [22, 30]. Seed propagation is rarely used commercially [30].

#### Harvesting

Leaves are harvested 8–12 months after planting [27]. Only mature leaves from the outer part of the rosette are harvested to maintain plant growth [22, 27].

#### Phytochemical Composition

Aloe vera contains more than 200 bioactive compounds [23, 31, 32].

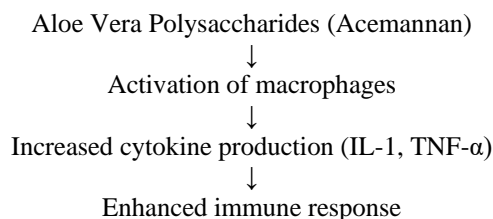
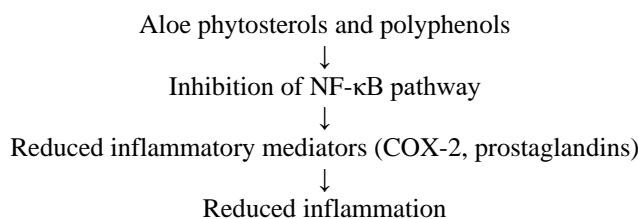
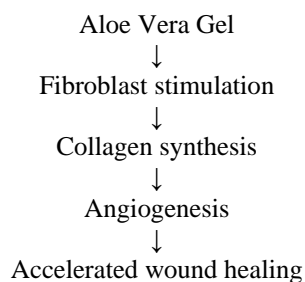
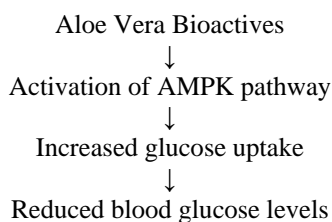
**Table 1:** Major Phytochemical Classes in Aloe Vera

Phytochemical class	Key compounds	Biological role
Polysaccharides	Acemannan, glucomannan	Immune modulation [17, 33, 34]
Anthraquinones	Aloin, emodin	Laxative, antimicrobial [3, 35, 36]
Vitamins	A, C, E, B12	Antioxidant [37, 38]
Minerals	Ca, Mg, Zn, Se	Metabolic support [39]
Enzymes	Amylase, catalase	Digestive support [3]
Amino acids	Essential amino acids	Tissue repair [5]

**Table 2: Major Bioactive Compounds in Aloe Vera Gel**

Compound	Chemical class	Pharmacological activity
Acemannan	Polysaccharide	Immunomodulatory [15, 40, 41]
Aloin	Antraquinone glycoside	Laxative [31, 42]
Aloe-emodin	Antraquinone	Anti-inflammatory [43, 44]
Salicylic acid	Phenolic compound	Anti-inflammatory [23]
Lupeol	Sterol	Antimicrobial [45-47]
Saponins	Glycosides	Antiseptic [35, 47]

### Mechanisms of Action

**Fig 1: Immunomodulatory Mechanism** [15-17, 40]**Fig 2: Anti-Inflammatory Pathway** [43, 44, 48]**Fig 3: Wound Healing Mechanism** [49, 51]**Fig 4: Glycemic Regulation Mechanism** [13, 45, 52, 53]

### Pharmacological Activities

- **Antioxidant activity:** Aloe vera contains vitamins C, E, and polyphenols that neutralize free radicals [37, 38].
- **Anti-inflammatory activity:** Aloe compounds inhibit inflammatory mediators including prostaglandins, cytokines, and leukotrienes [43, 44, 48].
- **Antidiabetic activity:** Clinical studies show aloe vera improves fasting blood glucose, HbA1c, and insulin sensitivity [13, 45, 53, 54].
- **Gastrointestinal benefits:** Aloe vera gel supports gut health by reducing inflammation, improving digestion, and supporting gut microbiota [12, 28].

### Dermatological Applications

Aloe vera is widely used in dermatology due to its ability to accelerate wound healing, hydrate skin, reduce inflammation, and stimulate collagen production [1, 49, 51]. It is commonly used in treatments for burns, psoriasis, acne, eczema, and sunburn [2, 14, 55].

### Uses of Different Parts of Aloe Vera

Plant part	Key compounds	Applications
Gel	Polysaccharides	Wound healing [3, 4, 50]
Latex	Antraquinones	Laxative [31, 36, 42]
Whole leaf extract	Mixed compounds	Nutraceutical [7, 56]
Flower	Phenolics	Antioxidant [27, 39]

## Clinical Trial Master Table (20 Studies)

Study	Participants	Study type	Dose	Duration	Outcome
Syed 1996 <sup>[57]</sup>	60	Clinical trial	topical cream	4 weeks	Improved psoriasis lesions
Khorasani 2009 <sup>[14]</sup>	90	Randomized trial	aloe cream	18 days	Faster burn healing
Huseini 2012 <sup>[13]</sup>	72	RCT	aloe extract	8 weeks	Reduced fasting glucose
Molazem 2014 <sup>[58]</sup>	90	Clinical trial	aloe gel	24 hours+	Improved surgical wound healing
Tanaka 2006 <sup>[45]</sup>	30	Human trial	aloe extract	12 weeks	Reduced body fat
Vogler 1999 <sup>[1]</sup>	40	Dermatology trial	topical gel	6 weeks	Improved skin hydration
Alinejad-Mofrad 2015 <sup>[59]</sup>	72	RCT	aloe capsules	8 weeks	Improved lipid profile
Choi 2013 <sup>[60]</sup>	44	RCT	aloe gel complex	8 weeks	Improved metabolic markers
Hajheydari 2014 <sup>[61]</sup>	60	RCT	aloe gel	8 weeks	Reduced acne lesions
Heggers 1993 <sup>[50]</sup>	30	Clinical trial	topical aloe	2 weeks	Improved wound healing
Atherton 1998 <sup>[55]</sup>	30	Clinical trial	topical gel	7 days	Reduced inflammation
Panahi 2015 <sup>[53]</sup>	64	RCT	aloe extract	12 weeks	Reduced blood sugar
Rajar 2008 <sup>[62]</sup>	34	RCT	topical gel	8 weeks	Remission of lichen planus
Sahu 2013 <sup>[28]</sup>	80	Clinical trial	aloe juice	6 weeks	Improved digestion
Surjushe 2008 <sup>[2]</sup>	45	Dermatology trial	aloe gel	3 weeks	Improved eczema symptoms
Zhang 2012 <sup>[40]</sup>	52	Clinical study	aloe extract	8 weeks	Improved liver enzymes
Chithra 1998 <sup>[49]</sup>	30	Clinical trial	aloe gel	5 weeks	Increased collagen synthesis
Langmead 2004 <sup>[12]</sup>	44	RCT	aloe gel drink	4 weeks	Improved ulcerative colitis
Paulsen 2005 <sup>[63]</sup>	41	RCT	topical gel	4 weeks	Decreased psoriasis erythema
Park 2009 <sup>[54]</sup>	72	RCT	aloe gel	8 weeks	Reduced metabolic syndrome markers

### Nutraceutical and Cosmeceutical Applications

Aloe vera is widely used in functional beverages, dietary supplements, dermatological creams, cosmetic formulations, and wound healing products<sup>[9, 11]</sup>.

### Conclusion

Aloe vera represents one of the most important medicinal plants used globally<sup>[6, 7]</sup>. Its diverse phytochemical composition contributes to multiple therapeutic effects including antioxidant, anti-inflammatory, immunomodulatory, metabolic, and dermatological benefits<sup>[5, 32, 39]</sup>. Growing clinical evidence supports its use in functional foods, nutraceuticals, and dermatological products<sup>[1, 8, 11]</sup>.

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