

# Advances in Aloe Vera Pharmacology: An In-Depth Analysis of its Properties and Principal Active Compounds

Shalini Jiwan Chahande<sup>1</sup>, Anurag Rawat<sup>2</sup>, Swapnil Gupta<sup>3</sup>, Seema Batool<sup>4</sup>, Akshay Kailas Pingale<sup>5</sup>

<sup>1</sup>Department of Biochemistry, Seth Kesarimal Porwal College of Arts and Science and Commerce, Kamptee, Affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Maharashtra, India.

<sup>2</sup>Himalayan Institute of Medical Science, Jolly Grant, Dehradun, Uttarakhand 248016, India.

<sup>3</sup>School of Management Sciences, Varanasi Uttar Pradesh 221011, India.

<sup>4</sup>Universite Paris Saclay Development and Environmental Studies, Arctic Studies, France.

<sup>5</sup>Department of Forest Products YSP UHF Nauni-Solan Himchal Pradesh, India.

**Citation:** Shalini Jiwan Chahande, Anurag Rawat, Swapnil Gupta, Seema Batool, Akshay Kailas Pingale (2023). Advances in Aloe Vera Pharmacology: An In-Depth Analysis of its Properties and Principal Active Compounds. Acta Traditional Medicine. DOI: <https://doi.org/10.51470/ATM.2023.2.2.10>

Corresponding Author: Seema Batool | E-Mail: [seemahaider417@gmail.com](mailto:seemahaider417@gmail.com)

Received 14 July 2023 | Revised 22 September 2023 | Accepted 18 November 2023 | Available Online December 05 2023

## ABSTRACT

*Aloe vera*, traditionally used for treating skin wounds (burns, cuts, insect bites) and digestive ailments, is renowned for its anti-inflammatory, antimicrobial, and wound-healing properties. Recent research focuses on validating these traditional uses and elucidating the mechanisms behind them, with an emphasis on identifying responsible compounds. Key compounds like aloe-emodin, aloin, aloesin, emodin, and acemannan have been extensively studied. Moreover, contemporary research has explored new applications for *Aloe vera* and its active constituents. This review synthesizes the latest pharmacological studies (in vitro, in vivo, and clinical trials) published in English over the past six years (2014–2019). Particularly noteworthy is the emerging pharmacological evidence showing predominant research in anti-cancer activities, skin and digestive system protection, and antimicrobial properties. While most research to date has been in vitro and in vivo, clinical trials have primarily involved *Aloe vera* as a whole, rather than its isolated compounds. Consequently, investigating the clinical effects of key metabolites in various human conditions and diseases could provide valuable insights. The encouraging outcomes of basic research in these areas suggest a need for more extensive clinical trials to evaluate the practical application of *Aloe vera* and its primary compounds, particularly in areas like bone health, cancer, and diabetes management.

**Keywords:** *Aloe vera*, pharmacology, extracts, isolated compounds

## Introduction

*Aloe vera*, a succulent plant species belonging to the *Aloe* genus, has been revered for centuries for its diverse range of medicinal and therapeutic properties. Originating from the Arabian Peninsula, it has since spread to various warm climates around the world. The plant is easily recognizable by its thick, fleshy green leaves, which contain a gel-like substance rich in bioactive compounds. This gel has been the cornerstone of traditional and folk medicine in various cultures, and modern science has begun to validate many of its traditional uses [1].

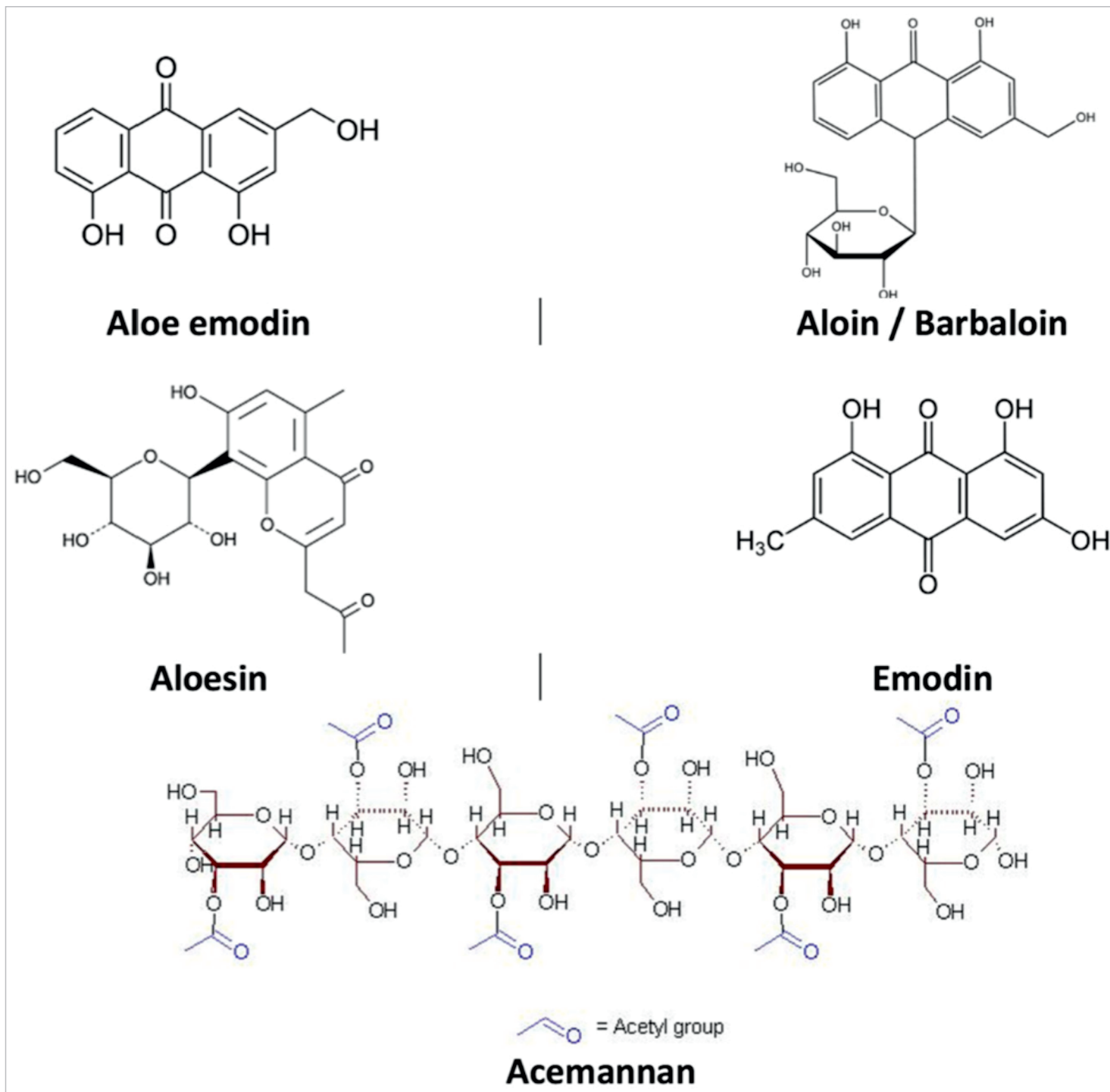
The health benefits of *Aloe vera* are attributed to its complex chemical composition, which includes vitamins, enzymes, minerals, sugars, lignin, saponins, salicylic acids, and amino acids. The plant is particularly known for its healing, soothing, and anti-inflammatory properties, making it a popular ingredient in skincare and cosmetic products. Beyond topical applications, *Aloe vera* has been used internally to treat a range of conditions, including digestive problems, diabetes, and cardiovascular diseases.

Recent scientific research has focused on exploring and understanding the pharmacological properties of *Aloe vera*. Studies have delved into its potential as an antioxidant, antimicrobial, antidiabetic, and immune-boosting agent. The plant's capacity to enhance skin regeneration and its

therapeutic effects on burns and wounds are also areas of significant research interest.

As a natural remedy, *Aloe vera* represents a convergence of traditional knowledge and modern scientific inquiry. This has led to a growing interest in its potential applications in healthcare and wellness industries. However, as with any natural product, it is important to understand its proper use and potential interactions with other treatments. The following discussion provides an in-depth exploration of the various health benefits, applications, and scientific findings related to *Aloe vera*, underscoring its status as a plant of both historical significance and contemporary relevance [2-3].

This review comprehensively updates the pharmacological activities of *Aloe vera*, encompassing in vitro, in vivo, and clinical trials. The publications included in this review were selected from peer-reviewed scientific journals indexed in the Pubmed database, published in English between 2014 and 2019. Articles that discussed *Aloe vera* in combination with other plants or *Aloe* species different from *Aloe vera* were excluded. The review is structured to cover different activities, including in vitro, in vivo, and clinical trials, focusing on research published in the last six years. The order of presentation reflects the interest and significance of studies pertaining to *Aloe vera*. Tables 1 (in vitro studies), 2 (in vivo studies), and 3 (clinical trials) summarize the principal pharmacological findings related to *Aloe vera* and its isolated compounds, as depicted in Figures 1 and 2.



**Fig 1. Chemical structure of a compounds isolated from Aloe Vera with pharmacology activity.**  
*Molecules* 2020, 25(6), 1324; <https://doi.org/10.3390/molecules25061324>

#### Digestive Diseases Protection

The extract of Aloe vera (*Aloe barbadensis* Miller, family Xanthorrhoeaceae) at a concentration of 50% has shown promising results in enhancing the viability of dental pulp stem cells, making it a potential therapeutic agent for avulsed or damaged teeth. This effect is primarily attributed to the presence of polysaccharides, especially acemannan, which stimulate osteogenic-specific gene expressions, DNA synthesis, growth factors, and activate the JAK-STAT pathway. Moreover, Aloe vera administered at a dosage of 225 mg/kg exhibited a radioprotective effect against salivary gland dysfunction in a rodent model, as evidenced by an increase in salivary flow rate [4]. Periodontitis, a prevalent and severe mental condition and bone destruction, can begin with gingivitis caused by dental

plaque. Significant clinical evidence demonstrates that Aloe vera mouthwash and gel are effective in preventing and treating gingivitis and periodontitis. They reduce gingival and plaque indices, probing depth, and contribute to bone fill and regeneration. Aloe vera has proven as effective as other common treatments like chlorhexidine, alendronate, and chlorine dioxide [5].

In a randomized placebo-controlled double-blind study with 20 healthy adults, the impact of Aloe vera mouthwash on postoperative complications following impacted third molar surgery was investigated. The Aloe vera gel significantly reduced swelling and postoperative pain. Another study evaluated the efficacy of Aloe vera gel and mineral trioxide aggregate as pulpotomy agents in primary molar teeth, with

high success rates observed over 3, 6, 9, and 12 months for patients treated with mineral trioxide aggregate.

Furthermore, a cross-sectional randomized interventional study revealed that Aloe vera gel accelerated wound healing and reduced pain in patients requiring atraumatic tooth extractions, outperforming conventional analgesics. Additionally, Aloe vera was identified as a promising cavity disinfecting agent in minimally invasive dentistry in a randomized clinical trial with 10 patients [6].

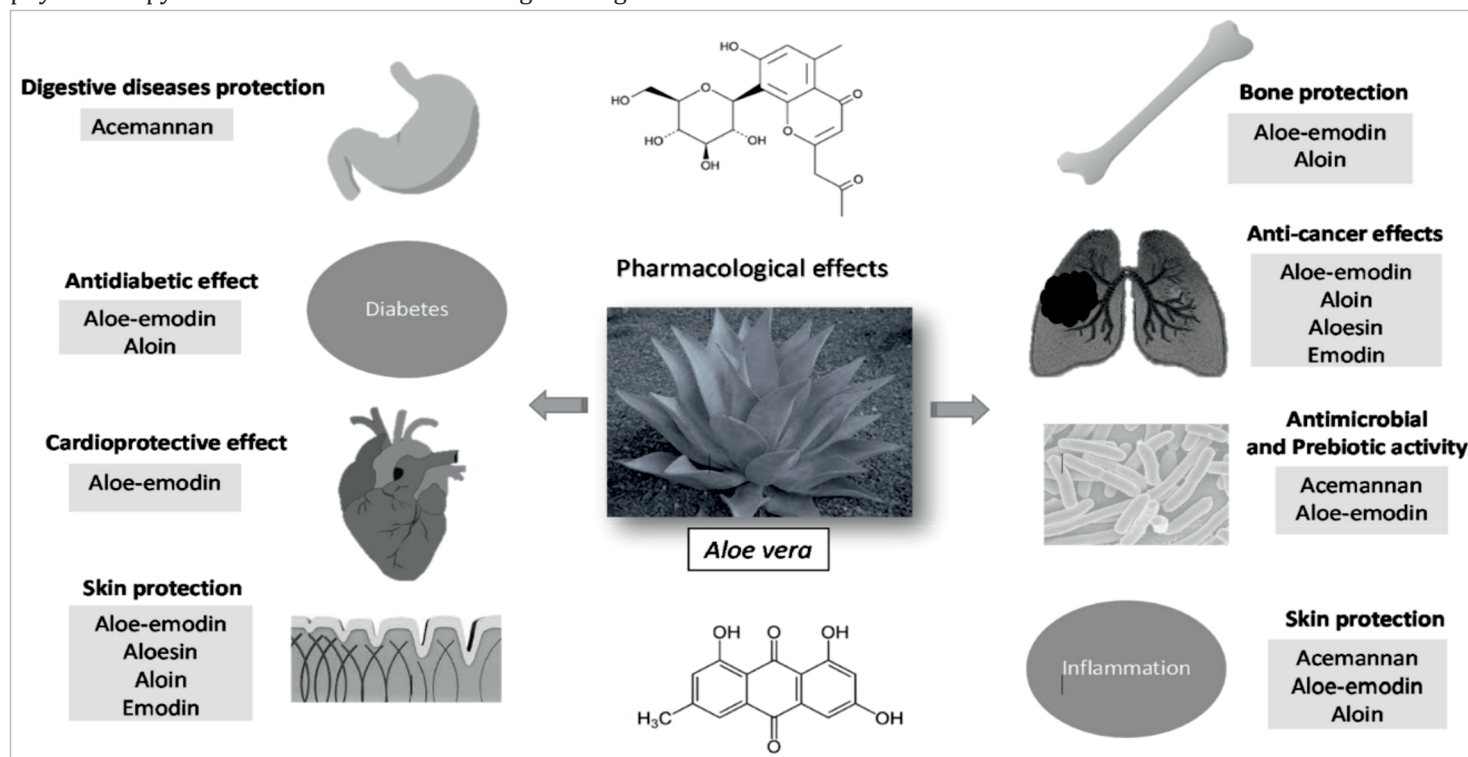
For oral mucositis/stomatitis, a debilitating complication of chemotherapy and radiotherapy affecting oncological patients' quality of life, Aloe vera mouthwash reduced radiation-induced mucositis severity, comparable to the reference benzydamine mouthwash. It also proved effective in treating stomatitis associated with radiotherapy in patients with acute myeloid leukemia and acute lymphocytic leukemia.

Oral submucous fibrosis, a precancerous condition characterized by abnormal collagen deposition and commonly caused by chewing areca nut, prevalent in India and Southeast Asia, was the subject of a study assessing the efficacy of systemic (as juice) and topical (as gel) Aloe vera. Clinical evidence showed that Aloe vera reduced burning sensation and improved cheek flexibility, mouth opening, and tongue protrusion, similar to the reference treatment of hydrocortisone, hyaluronidase, and antioxidant supplements. In another study on oral submucous fibrosis, the combination of Aloe vera gel with physiotherapy was more effective in alleviating burning

sensation and improving tongue protrusion, mouth opening, and cheek flexibility compared to the combination of antioxidant capsules with physiotherapy [7].

In gastroesophageal reflux disease, a common chronic digestive disease, Aloe vera syrup (10 mL/day) for 4 weeks reduced the frequency of symptoms, including heartburn, food regurgitation, dysphagia, flatulence, burping, nausea, and acid regurgitation, without causing significant adverse effects (only one case each of vertigo and abdominal pain reported). In a Balb/c mouse model of alcohol-induced acute gastritis, Aloe vera gel increased matrix metalloproteinase-9 inhibitory activity, protecting against inflammation of the stomach's mucous membrane layer [8].

The topical application of 3% Aloe vera ointment alleviated symptoms of diarrhea and fecal urgency in patients with acute radiation proctitis caused by radiotherapy in the pelvic area. Furthermore, Aloe barbadensis extract (AVH200®) slightly reduced the severity of gastrointestinal symptoms in patients with irritable bowel syndrome compared to a control group. A study revealed that Aloe polysaccharide (15 mg/kg) protected rats from 2,4,6-trinitrobenzene sulfonic acid-induced colitis by increasing JAK2, p-JAK2, STAT-3, and p-STAT3 protein expression. Additionally, Aloe vera cream applied three times daily for 6 weeks reduced chronic anal fissure pain and bleeding after defecation, enhancing wound healing in a prospective double-blind clinical trial [9].



**Fig2. Pharmacological effects of the main constituents of Aloe vera**  
*Molecules* 2020, 25(6), 1324; <https://doi.org/10.3390/molecules25061324>

### Skin Protection

*In vitro* studies focusing on skin protection predominantly examine Aloe vera and its active compounds in wound healing. The most commonly used cell lines for these studies include the immortalized human keratinocyte HaCaT, primary normal human epidermal keratinocytes (HEKa), and various fibroblast cell lines. These studies have revealed that Aloe vera and its major compounds (aloesin, aloin, and emodin) primarily exert their protective effects through antioxidant and anti-inflammatory mechanisms. Aloe vera has been shown to up-

regulate TFGβ1, bFGF, and Vegf-A expression in fibroblasts, enhancing keratinocyte proliferation and differentiation through lysosomal membrane stability. Furthermore, low concentrations ( $\leq 175 \mu\text{g/mL}$ ) of Aloe vera solution have been observed to accelerate corneal wound closure by increasing type IV collagen-degrading activity in primary cultures of corneal epithelial cells. Aloin protects the skin by reducing IL-8 production, DNA damage, lipid peroxidation, and ROS generation, while increasing GSH content and GR activity. Aloesin promotes wound healing by enhancing cell motility via



phosphorylation of Cdc42 and Rak1, and by influencing cytokines and growth factors. Additionally, Aloe polysaccharide (20, 40, and 80 µg/mL for 24 h) has been identified as a potentially beneficial agent in psoriasis, as evidenced by the inhibition of TNF- $\alpha$  levels and IL-8 and IL-12 protein expression in the human keratinocyte HaCaT cell line.

*In vivo* studies often utilize genetically modified organisms (such as BALB/c mice, HR-1 hairless mice, and SKH-1 hairless mice) and models of UV and X-ray skin damage in animals. These studies primarily involve Aloe vera extracts and gels. Topical application of Aloe vera has been shown to favor wound healing in animal models with dermal incisions by reducing inflammatory cell invasion, increasing the CD4+/CD8+ lymphocyte ratio, and improving epidermal thickness and collagen deposition. A study conducted in Indonesia investigated the effects of Nigella sativa oil gel and Aloe vera gel on treating diabetic ulcers. Aloe vera proved more effective in improving wound healing in alloxan-induced diabetic Wistar rats, as indicated by a decrease in necrotic tissue and inflammation and an increase in re-epithelialization. Additionally, a UV-induced mouse model demonstrated that Aloe vera gel powder enhanced epidermal growth factor and hyaluronan synthase expression, while reducing matrix metalloproteinases expression (types 2, 9, and 13). Aloe sterols play a role in this UV protection. Aloe vera has also been shown to protect against X-radiation through antioxidant mechanisms, including increased antioxidant protein activity and GSH content, and reduced ROS production and lipid peroxidation. Among isolated compounds, studies with aloe-emodin and aloesin have indicated that their healing activity is due to angiogenic properties.

In the last six years, several clinical trials have been conducted, many aimed at evaluating the effectiveness of Aloe vera on ulcers. The administration of Aloe vera gel twice daily for 3 months improved and accelerated wound healing, as well as reduced hospitalization time. In a randomized, triple-blind clinical trial with 80 patients hospitalized in the orthopedic ward, it was demonstrated that Aloe vera gel applied twice daily for 10 days prevented the development of pressure ulcers on the hip, sacrum, and heel areas. Additionally, clinical trials have shown that Aloe vera facilitated rapid tissue epithelialization and granulation in burns, improved healing of cesarean wounds, and accelerated wound healing of split-thickness skin graft donor sites.

Furthermore, Aloe vera has been investigated in randomized, double-blind, placebo-controlled studies for its benefits in maintaining healthy skin. Daily oral intake of 40 µg of Aloe sterol (cycloartenol and lophenol) for at least 12 weeks improved skin elasticity in men under 46 years exposed to sunlight but not using sunscreen, reduced facial wrinkles in Japanese women over 40 years old by enhancing hyaluronic acid and collagen production, and increased net elasticity, net resilience, and intrinsic elasticity in women aged 30–59. However, despite clinical evidence on the protective role of Aloe vera in the skin, there are clinical trials that have not found efficacy of this medicinal plant, especially in reducing radiation-induced skin damage. Two clinical trials published between 2014 and 2019 related to this effect found that topical administration of Aloe vera as gel or cream did not reduce the prevalence and severity of radiotherapy-induced dermatitis and skin toxicity in breast

cancer patients compared to the control group [10-11].

### Anti-Inflammatory activity

Aloe vera, renowned for its therapeutic properties, has been extensively studied for its anti-inflammatory activity. This property is attributed to various bioactive compounds present in the plant, including polysaccharides, anthraquinones, vitamins, enzymes, and minerals. The anti-inflammatory action of Aloe vera unfolds through several mechanisms:

1. **Inhibition of Inflammatory Mediators:** Aloe vera suppresses the production and activity of various inflammatory cytokines such as interleukin (IL)-1 $\beta$ , IL-6, IL-8, and tumor necrosis factor-alpha (TNF- $\alpha$ ). It also reduces the expression of inducible nitric oxide synthase (iNOS) and the subsequent production of nitric oxide (NO), a key mediator in inflammatory processes.
1. **Modulation of Signaling Pathways:** The compounds in Aloe vera influence key signaling pathways involved in inflammation. For example, aloin and aloe-emodin have been shown to affect the JAK-STAT pathway, a critical regulator of immune responses. Aloe vera also impacts the MAPK (mitogen-activated protein kinase) pathway, crucial in mediating inflammatory responses.
1. **Antioxidant Effects:** Aloe vera exhibits significant antioxidant activity, helping to neutralize free radicals and reactive oxygen species (ROS) that contribute to inflammation. This antioxidant action is partly due to the presence of vitamins like vitamin C and E and enzymes such as catalase and superoxide dismutase.
1. **Immune System Modulation:** Aloe vera can modulate the immune system, influencing the behavior of immune cells like macrophages and T cells. It can alter cytokine production and T cell activity, thus contributing to its anti-inflammatory effects.
1. **Impact on Gastrointestinal Health:** Aloe vera is particularly known for its soothing effect on gastrointestinal inflammation. It promotes the healing of gastric and intestinal ulcers and reduces inflammation in conditions like irritable bowel syndrome (IBS) and ulcerative colitis.
1. **Skin and Wound Healing:** Topically applied, Aloe vera accelerates the healing of burns, cuts, and other skin injuries, partly due to its anti-inflammatory properties. It reduces redness and swelling in affected areas, promoting faster healing and reducing the risk of infection.
1. **Clinical Applications:** Aloe vera has been explored in clinical settings for its anti-inflammatory potential. It has been used in treating conditions like psoriasis, radiation-induced skin damage, and periodontal diseases, showing varying degrees of efficacy.

The anti-inflammatory activity of Aloe vera, coupled with its safety profile and minimal side effects, makes it a valuable natural remedy in both traditional and modern medicine. However, further clinical research is necessary to fully understand its mechanisms and optimize its therapeutic potential [12-13].

### Anticancer applications from aloe vera

Aloe vera, recognized for its therapeutic properties, has also garnered attention for its potential anticancer applications. Research in this area is ongoing, and while promising, it is important to note that these findings are preliminary and more clinical studies are needed to confirm the efficacy and safety of Aloe vera in cancer treatment. Here are some of the key aspects of Aloe vera's anticancer applications:

1. **Bioactive Compounds with Anticancer Properties:** Aloe vera contains various bioactive compounds, such as aloin, aloe-emodin, barbaloin, and acemannan, which have shown anticancer effects in preclinical studies. These compounds can induce apoptosis (programmed cell death), inhibit cell proliferation, and prevent tumor growth.
2. **Induction of Apoptosis:** Some compounds in Aloe vera can trigger apoptosis in cancer cells. For instance, aloe-emodin has been reported to induce apoptosis in various types of cancer cells, including breast, liver, and lung cancers.
3. **Inhibition of Tumor Growth:** Aloe vera extracts have demonstrated the ability to inhibit the growth of certain types of tumors. For example, acemannan, a polysaccharide found in Aloe vera, has been shown to inhibit the growth of fibrosarcoma cells in animal models.
4. **Enhancing the Efficacy of Chemotherapy:** Aloe vera has been studied for its potential to enhance the effectiveness of certain chemotherapy drugs, helping to reduce the dosage required and potentially minimizing side effects.
5. **Radioprotective Effects:** Aloe vera may offer protection against radiation-induced skin damage in cancer patients undergoing radiotherapy. It could help in healing radiation burns and reducing the severity of skin reactions.
6. **Immunomodulatory Effects:** Aloe vera can modulate the immune system, which plays a critical role in the body's defense against cancer. By enhancing the immune response, Aloe vera might help the body to fight against cancer cells more effectively.
7. **Preclinical and Clinical Studies:** Numerous preclinical studies have shown the potential of Aloe vera in cancer treatment. However, clinical studies are limited and have yielded mixed results. More comprehensive clinical trials are needed to establish the effectiveness and safety of Aloe vera as a complementary treatment in oncology.
8. **Potential in Combination Therapies:** Aloe vera might be used in combination with other cancer treatments to enhance their effectiveness or reduce side effects. However, it is crucial to consult healthcare professionals before using Aloe vera in this context, as it may interact with certain medications.

While the anticancer potential of Aloe vera is promising, it should not be considered a standalone treatment for cancer. Current evidence supports its use more as a complementary therapy, and it's important to approach its use cautiously, always in consultation with healthcare professionals [14-15].

### Antidiabetic Effect

Aloe vera has garnered significant interest in the field of diabetes management due to its potential antidiabetic properties. Several studies have investigated the effects of Aloe vera on blood glucose levels and insulin sensitivity, revealing promising results that suggest it could be a beneficial supplement for individuals with diabetes.

The antidiabetic effect of Aloe vera is primarily attributed to its rich composition of phytochemicals, including polysaccharides, flavonoids, and phenolic compounds. These constituents are believed to enhance glucose metabolism and improve insulin sensitivity. For instance, the polysaccharide content in Aloe vera, particularly acemannan, is thought to play a crucial role in reducing blood glucose levels. Acemannan has been observed to enhance the uptake of glucose into cells, thereby aiding in the regulation of blood sugar. Additionally, some studies suggest that Aloe vera can stimulate the secretion of insulin from the pancreas, which is essential for the management of blood sugar levels.

Research involving both animal models and human clinical trials has shed light on the antidiabetic potential of Aloe vera. In animal studies, Aloe vera extract has demonstrated a significant reduction in fasting blood glucose levels and improvement in glucose tolerance. Human studies, although limited, have shown encouraging results. For instance, a study involving patients with type 2 diabetes reported that supplementation with Aloe vera juice led to a reduction in fasting blood sugar levels and HbA1c, a marker of long-term glucose control. Another notable aspect is Aloe vera's potential in combating the complications associated with diabetes, such as neuropathy and impaired wound healing, due to its anti-inflammatory and antioxidant properties.

However, it is important to approach the use of Aloe vera in diabetes management with caution. The quality of Aloe vera products can vary, and some may contain additives or processing agents that are not suitable for all individuals, particularly those with diabetes. Moreover, Aloe vera can interact with certain medications, including hypoglycemic drugs, potentially leading to hypoglycemia if not monitored properly. Therefore, it is essential for individuals considering Aloe vera as a supplement for diabetes to consult with healthcare professionals to ensure its safe and effective use. While the initial research is promising, more extensive and rigorous clinical trials are needed to fully understand the role of Aloe vera in diabetes management and to establish standardized dosages and formulations [16-17].

### Antioxidant Properties

Aloe vera is widely recognized for its antioxidant properties, which play a crucial role in its health benefits. These properties are primarily attributed to a rich composition of bioactive compounds, including vitamins, enzymes, and phytochemicals, that work synergistically to combat oxidative stress in the body.

1. **Bioactive Components:** Aloe vera contains a variety of antioxidants, such as vitamins C and E, which are well-known for their ability to neutralize free radicals. Free radicals are unstable molecules that can cause cellular damage, leading to chronic diseases and aging. Additionally, Aloe vera is rich in

polyphenols, a group of compounds known for their antioxidant activities. These polyphenols, along with other compounds such as flavonoids and tannins, contribute to the plant's overall antioxidant capacity.

2. **Mechanism of Action:** The antioxidant action of Aloe vera involves scavenging free radicals, chelating metal ions, and enhancing the body's own antioxidant systems. For instance, enzymes like superoxide dismutase and catalase in Aloe vera help in neutralizing superoxide radicals and hydrogen peroxide, respectively. This activity helps in reducing oxidative stress, which is implicated in various chronic conditions like cardiovascular diseases, diabetes, and cancer.
3. **Skin Health:** Aloe vera's antioxidant properties are particularly beneficial for skin health. They help protect the skin from the damaging effects of UV radiation and environmental pollutants. The topical application of Aloe vera can reduce photodamage, improve skin hydration, and promote wound healing, partly due to its antioxidant components.
4. **Supporting Immune Function:** Antioxidants in Aloe vera can also support the immune system. By reducing oxidative stress, they help maintain the integrity of immune cells, allowing them to function optimally. This is particularly beneficial in reducing the inflammatory response and enhancing the body's defense mechanisms.
5. **Protecting against Chronic Diseases:** The antioxidant properties of Aloe vera may also offer protective effects against chronic diseases. By reducing oxidative damage, Aloe vera can potentially play a role in preventing or managing conditions like heart disease, neurodegenerative disorders, and certain types of cancer.

It is important to note that while Aloe vera offers significant antioxidant benefits, it should be used as a complementary approach rather than a standalone treatment for medical conditions. Additionally, the quality and concentration of Aloe vera products can vary, and it's essential to choose high-quality products for optimal benefits. As with any supplement or herbal remedy, it's advisable to consult with healthcare professionals before incorporating Aloe vera into your health regimen, especially if you have existing health conditions or are taking other medications [18-20].

### **Bone Protection**

Aloe vera, traditionally known for its skin-healing properties, is increasingly being recognized for its potential role in bone protection and health. This emerging area of research suggests that Aloe vera may have beneficial effects on bone metabolism, density, and overall skeletal health.

The protective effects on bone health are primarily attributed to the rich array of bioactive compounds in Aloe vera, including vitamins, minerals, and phytohormones. These constituents are believed to contribute to bone remodeling and mineralization. For example, Aloe vera is a source of calcium, which is essential for bone strength and density. Additionally, it contains magnesium and vitamin C, both of which are important for bone formation and the maintenance of bone structure. The phytohormones present in Aloe vera, such as auxins and

gibberellins, may also play a role in stimulating bone growth and healing.

Research indicates that Aloe vera can positively influence bone health in various ways. It has been studied for its potential in accelerating bone healing in fracture cases, with some animal studies showing enhanced bone regeneration and increased bone density when Aloe vera is administered. This is particularly important for individuals with osteoporosis or other bone-related conditions, where bone strength and regeneration are compromised. Moreover, the anti-inflammatory properties of Aloe vera can be beneficial in conditions like osteoarthritis, where inflammation contributes to joint and bone pain. By reducing inflammation, Aloe vera can help alleviate pain and improve joint function.

However, it's important to note that research on Aloe vera's effects on bone health is still in the early stages, with most studies being preclinical. While these initial findings are promising, more extensive human clinical trials are needed to fully understand the potential of Aloe vera in bone protection and to establish appropriate dosages and methods of administration. Until more definitive research is available, Aloe vera should be considered a complementary approach to bone health, used in conjunction with conventional medical treatments and lifestyle modifications such as a balanced diet and regular exercise. As with any supplement, consulting with healthcare professionals is crucial before using Aloe vera for bone health, especially for individuals with existing medical conditions or those taking other medications [21].

### **Cardioprotective Effect**

Aloe vera has been the subject of interest for its potential cardioprotective effects, with research indicating that it may offer several benefits for heart health. These effects are largely attributed to the plant's rich composition of bioactive compounds, including antioxidants, vitamins, minerals, and polysaccharides.

1. **Reduction of Risk Factors for Cardiovascular Disease:** Aloe vera has been shown to positively influence several risk factors associated with cardiovascular diseases. For instance, it can help in reducing hyperlipidemia, a major risk factor for heart disease. Studies have demonstrated that Aloe vera can lower total cholesterol, LDL (bad) cholesterol, and triglyceride levels, while potentially increasing HDL (good) cholesterol. This lipid-modulating effect is crucial in preventing atherosclerosis, a condition where plaque builds up in the arteries, leading to heart attacks and strokes.
2. **Antioxidant Properties:** The antioxidant components in Aloe vera, such as vitamins C and E, can mitigate oxidative stress, a key contributor to heart disease. By neutralizing free radicals, Aloe vera helps protect the heart and vascular system from oxidative damage and inflammation. These antioxidant properties also contribute to the maintenance of endothelial health, ensuring proper blood vessel function.
3. **Anti-inflammatory Effects:** Chronic inflammation is a significant factor in the development of cardiovascular diseases. Aloe vera's anti-inflammatory properties can help



reduce systemic inflammation, thereby potentially lowering the risk of heart conditions. The plant's ability to modulate inflammatory pathways could be particularly beneficial in conditions like myocarditis (inflammation of the heart muscle) and other heart diseases where inflammation plays a central role.

4. **Blood Glucose Regulation:** Aloe vera may also have benefits for blood sugar control, which is essential for heart health, especially in diabetic patients. By improving glucose metabolism and insulin sensitivity, Aloe vera can help in the management of diabetes, a major risk factor for cardiovascular disease.
5. **Potential in Hypertension Management:** Some studies suggest that Aloe vera can help in lowering blood pressure, although the evidence is not conclusive. The potassium content in Aloe vera, along with its diuretic properties, might contribute to this effect.

While these findings are promising, it is important to approach the use of Aloe vera for heart health with caution. Most of the current evidence comes from preclinical studies or small-scale clinical trials, and more extensive research is needed to fully understand its effects and appropriate dosages. Aloe vera should not be used as a substitute for prescribed cardiovascular medications but rather as a complementary approach under the guidance of healthcare professionals. As with any natural supplement, it's crucial to consider potential interactions with other medications and the individual's overall health profile [22].

#### **Antimicrobial and Prebiotic Activity**

Aloe vera has been widely recognized for its antimicrobial and prebiotic activities, making it a valuable natural remedy in various health applications. These properties are attributed to its rich composition of bioactive compounds, including polysaccharides, anthraquinones, and phenolic compounds.

1. **Antimicrobial Activity:** Aloe vera exhibits significant antimicrobial properties against a range of microorganisms, including bacteria, fungi, and viruses. The antimicrobial effects are primarily due to compounds such as aloin and barbaloin, which are found in the plant's latex. These compounds have been shown to inhibit the growth of common pathogens like *Escherichia coli*, *Staphylococcus aureus*, and *Candida albicans*. Aloe vera's antiviral activity is also noteworthy, particularly against viruses such as herpes simplex virus and influenza. This broad-spectrum antimicrobial activity makes Aloe vera a useful natural agent in treating and preventing infections, especially skin infections, and in wound healing.
2. **Prebiotic Effects:** Aloe vera contains a rich supply of polysaccharides, particularly acemannan, which has been identified as having prebiotic properties. Prebiotics are non-digestible food components that beneficially affect the host by selectively stimulating the growth and/or activity of beneficial bacteria in the colon. Acemannan and other polysaccharides in Aloe vera provide a source of nourishment for probiotics (beneficial gut bacteria), such as *Lactobacillus* and *Bifidobacterium* species. By promoting the growth of these beneficial bacteria, Aloe vera can help maintain a healthy gut microbiota, which is

crucial for overall health, including the immune system, digestion, and even mental health.

3. **Synergistic Effects with Probiotics:** The combination of Aloe vera's prebiotic and antimicrobial properties can be particularly beneficial. While its antimicrobial agents can help suppress harmful pathogens, its prebiotic components support the growth of beneficial gut flora. This synergistic effect can contribute to a balanced gut microbiome, enhancing gastrointestinal health and potentially boosting the immune response.
4. **Applications in Health and Cosmetics:** Given its antimicrobial and prebiotic activities, Aloe vera has found applications in a range of health and cosmetic products. It is commonly used in skincare products for its ability to prevent microbial infections and soothe the skin. Additionally, Aloe vera is included in dietary supplements to support digestive health due to its prebiotic properties.

While Aloe vera is a promising natural remedy for enhancing gut health and preventing infections, it is important to use it correctly and in appropriate amounts. Overuse or improper use can lead to side effects, especially in sensitive individuals. As with any natural supplement, it is recommended to consult with healthcare professionals before using Aloe vera for medicinal purposes, particularly for individuals with existing health conditions or those taking other medications [23-24].

#### **Conclusion**

In conclusion, Aloe vera is a versatile and potent natural remedy, offering a wide range of health benefits attributed to its rich composition of bioactive compounds. Its properties extend from antimicrobial and anti-inflammatory actions to antidiabetic, antioxidant, and cardioprotective effects. Aloe vera's ability to promote skin and wound healing, coupled with its potential in managing chronic diseases like diabetes and heart conditions, underscores its value in both traditional and modern medicine.

The plant's prebiotic properties also highlight its role in supporting gut health and maintaining a balanced microbiome, further amplifying its health benefits. While the antimicrobial activities of Aloe vera make it a useful agent in combating infections, its prebiotic effects enhance gut flora, contributing to overall health and wellness.

However, it is important to approach the use of Aloe vera with a balanced perspective. While it offers numerous health benefits, Aloe vera should not be seen as a cure-all or a substitute for conventional medical treatments. Its use should complement, not replace, traditional healthcare practices. Moreover, the quality and concentration of Aloe vera products can vary, and it's essential to choose high-quality products for optimal benefits.

Before incorporating Aloe vera into your health regimen, especially for medicinal purposes, consulting with healthcare professionals is crucial. This is particularly important for individuals with existing health conditions or those taking other medications, to avoid potential interactions and side effects.

In summary, Aloe vera stands out as a remarkable natural resource with a multitude of therapeutic applications. Continued research and clinical studies are essential to fully understand its mechanisms and optimize its use in healthcare.

As our understanding of Aloe vera grows, so too will its potential to contribute to health and wellbeing in diverse and meaningful ways.

## References

- Martínez-Burgos, W. J., Serra, J. L., Marsiglia, F. R. M., Montoya, P., Sarmiento-Vásquez, Z., Marin, O., ... & Paternina-Arboleda, C. D. (2022). Aloe vera: From ancient knowledge to the patent and innovation landscape—A review. *South African Journal of Botany*, *147*, 993-1006.
- Adetunji, T. L., Olisah, C., Adegba, O. D., Olawale, F., Adetunji, A. E., Siebert, F., & Siebert, S. (2022). The genus Aloe: A bibliometric analysis of global research outputs (2001–2020) and summary of recent research reports on its biological activities. *South African Journal of Botany*, *147*, 953-975.
- Sharma, M. K., Chauhan, J., Kumar, M., Joshi, C. K., Sharma, S., & Lal, C. (2021). Prospects of Aloe vera and its Bioactive Compounds in Diabetes: Critical Review. *Journal of Pure & Applied Microbiology*, *15*(4).
- Liang, J., Cui, L., Li, J., Guan, S., Zhang, K., & Li, J. (2021). Aloe vera: a medicinal plant used in skin wound healing. *Tissue Engineering Part B: Reviews*, *27*(5), 455-474.
- Fallahi, H.R.; Hamadzade, H.; Nezhad, A.M.; Zandian, D.; Taghizadeh, M. Effect of Aloe vera mouthwash on postoperative complications after impacted third molar surgery: A randomized, double-blind clinical trial. *J. Oral Maxillofac. Surg. Med. Path.* 2016, *28*, 392–396.
- Prabhakar, A.R.; Karuna, Y.M.; Yavagal, C.; Deepak, B.M. Cavity disinfection in minimally invasive dentistry-comparative evaluation of Aloe vera and propolis: A randomized clinical trial. *Contemp. Clin. Dent.* 2015, *6*, S24–S31.
- Bai, Y., Niu, Y., Qin, S., & Ma, G. (2023). A new biomaterial derived from Aloe vera—Acemannan from basic studies to clinical application. *Pharmaceutics*, *15*(7), 1913.
- Park, C.H.; Son, H.U.; Yoo, C.Y.; Lee, S.H. Low molecular-weight gel fraction of Aloe vera exhibits gastroprotection by inducing matrix metalloproteinase-9 inhibitory activity in alcohol-induced acute gastric lesion tissues. *Pharm. Biol.* 2017, *55*, 2110–2115.
- Rahmani, N.; Khademloo, M.; Vosoughi, K.; Assadpour, S. Effects of Aloe vera cream on chronic anal fissure pain, wound healing and hemorrhaging upon defecation: A prospective double blind clinical trial. *Eur. Rev. Med. Pharmacol. Sci.* 2014, *18*, 1078–1084.
- Negahdari, S.; Galehdari, H.; Kesmati, M.; Rezaie, A.; Shariati, G. Wound healing activity of extracts and formulations of Aloe vera, henna, adiantum capillus-veneris, and myrrh on mouse dermal fibroblast cells. *Int. J. Prevent. Med.* 2017, *8*, 18.
- Curto, E.M.; Labelle, A.; Chandler, H.L. Aloe vera: An in vitro study of effects on corneal wound closure and collagenase activity. *Vet. Ophthalmol.* 2014, *17*, 403–410
- Singh, K., Ajao, A. A. N., & Sabiu, S. (2022). Ethnobotanical, phytochemistry, toxicological and pharmacological significance of the underutilized indigenous Aloe species of West Africa. *South African Journal of Botany*, *147*, 1007-1015.
- Takzaree, N.; Hadjiakhondi, A.; Hassanzadeh, G.; Rouini, M.R.; Manayi, A.; Zolbin, M.M. Transforming growth factor- $\beta$  (TGF- $\beta$ ) activation in cutaneous wounds after topical application of Aloe vera gel. *Can. J. Physiol. Pharm.* 2016, *94*, 1285–1290.
- Saito, M.; Tanaka, M.; Misawa, E.; Yao, R.; Nabeshima, K.; Yamauchi, K.; Furukawa, F. Oral administration of Aloe vera gel powder prevents UVB-induced decrease in skin elasticity via suppression of overexpression of MMPs in hairless mice. *Biosci. Biotech. Biochem.* 2016, *80*, 1416–1424.
- Lin, L.X.; Wang, P.; Wang, Y.T.; Huang, Y.; Jiang, L.; Wang, X.M. Aloe vera and Vitis vinifera improve wound healing in an in vivo rat burn wound model. *Mol. Med. Rep.* 2016, *13*, 1070–1076
- Nandy, S., Mukherjee, A., Pandey, D. K., Ray, P., & Dey, A. (2020). Indian Sarsaparilla (Hemidesmus indicus): Recent progress in research on ethnobotany, phytochemistry and pharmacology. *Journal of ethnopharmacology*, *254*, 112609.
- Tanaka, M.; Yamamoto, Y.; Misawa, E.; Nabeshima, K.; Saito, M.; Yamauchi, K.; Furukawa, F. Aloe sterol supplementation improves skin elasticity in Japanese men with sunlight-exposed skin: A 12-week double-blind, randomized controlled trial. *Clin. Cosmet. Invest. Dermat.* 2016, *9*, 435–442.
- Ma, Y.; Tang, T.; Sheng, L.; Wang, Z.; Tao, H.; Zhang, Q.; Qi, Z. Aloin suppresses lipopolysaccharide-induced inflammation by inhibiting JAK1-STAT1/3 activation and ROS production in RAW264.7 cells. *Int. J. Mol. Med.* 2018, *42*, 1925–1934.
- Ruhela, G., Dhama, P., Shanker, K., Ding, X., & Sharma, A. (2023). Exploration of metabolomics of Phyllanthus emblica: From Ayurveda food to modern prospectives in quality control. *Food Chemistry Advances*, *3*, 100330.
- Werawatganon, D.; Linlawan, S.; Thanapirom, K.; Somanawat, K.; Klaikeaw, N.; Rerknimitr, R.; Siriviriyakul, P. Aloe vera attenuated liver injury in mice with acetaminophen-induced hepatitis. *BMC Complement. Altern. Med.* 2014, *14*, 229.
- Luo, J.; Yuan, Y.; Chang, P.; Li, D.; Liu, Z.; Qu, Y. Combination of aloe-emodin with radiation enhances radiation effects and improves differentiation in human cervical cancer cells. *Mol. Med. Rep.* 2014, *10*, 731–736.
- Ruhela, G., Dhama, P., Shanker, K., Ding, X., & Sharma, A. (2023). Exploration of metabolomics of Phyllanthus emblica: From Ayurveda food to modern prospectives in quality control. *Food Chemistry Advances*, *3*, 100330.
- Zhang, L.Q.; Lv, R.W.; Qu, X.D.; Chen, X.J.; Lu, H.S.; Wang, Y. Aloesin Suppresses Cell Growth and Metastasis in Ovarian Cancer SKOV3 Cells through the Inhibition of the MAPK Signaling Pathway. *Anal. Cell Pathol.* 2017, *2017*.
- Sharifi-Rad, J., Rayess, Y. E., Rizk, A. A., Sadaka, C., Zgheib, R., Zam, W & Martins, N. (2020). Turmeric and its major compound curcumin on health: bioactive effects and safety profiles for food, pharmaceutical, biotechnological and medicinal applications. *Frontiers in pharmacology*, *11*, 1021.