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*Aloe*s: a journey from traditional herb to modern panacea

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Aloe vera, the most popular member of the genus *Aloe* L., is a wonderful healing plant that has been used for the last 6000 years since ancient Egyptian times for its wide of range of pharmaceutical and nutraceutical applications. However, most of the available literature emphasizes on the properties of this one species only. Most probably, due to its early introduction to the world, it becomes dominant in the use, even though several other species also have great therapeutic potential. Emphasizing the broader significance of *Aloe* species beyond *Aloe vera* is crucial for unlocking their diverse applications. *Aloe arborescens*, *Aloe ferox*, and *Aloe excelsa* showcase potent antimicrobial properties, contributing significantly to skincare. *Aloe secundiflora* addresses kidney problems, while *Aloe deserti* and *Aloe secundiflora* find traditional use against malaria. Recent scientific studies underscore *Aloe vera*'s potential in dentistry, diabetes management, anti-inflammatory actions, and anti-cancer effects. Species such as *Aloe claviflora* and *Aloe littoralis* reveal impressive antioxidant capabilities. *Aloe vera* and *Aloe ferox* lead in cosmetics, with their unique properties. *Aloe trinervis* leaves are consumed as food. Additionally, *Aloe vera* waste proves beneficial in environmental management, particularly in phytoremediation for arsenic toxicity. Caution is crucial due to their potential toxicity, emphasizing the need for careful application. Exploring the diverse *Aloe* genus is imperative for comprehending their specific applications and unlocking untapped industrial potential, promising a wealth of possibilities for various fields.

Keywords: *Aloe*, Species, Phytoremediation, Traditional, Toxicity

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The genus '*Aloe*' is commonly known as – 'Miracle plant', 'Plant of immortality', 'The wand of Heaven' 'Lily of the desert', 'Wonder plant', 'Nature's Own First Aid Kit', and 'Natural healer'[1]. The word, *Aloe*, has come from the Arabic word "alloeh" or Hebrew word "Allal" meaning 'bitter shiny substance'[2]. The plant has the Arabic name 'Saber' ('Sabir' in Persian), which literally refers to sword; of course, due the shape of the leaf[3,4]. It is also termed as 'Burn plant' as it rapidly heals the burnt skin[5]. The genus comprises over 500 species grown in African continent, Madagascar, Arabian Peninsula and Indian Ocean Islands[6-8]. Among them *Aloe vera* is a leafy succulent, cactus-like plant with green, dagger-like leaves that are fleshy, dentate, tapering, and filled with a clear dense gel.

Historical background

The historical evidence of the *Aloe* used by humans is at least 6000 years ago. The plant was reported from an engraving in an Egyptian temple dated back to 4000 B.C.[9]. It was gifted as 'The immortality Plant' in Egypt and mentioned as a protected plant[10,11]. Egyptian ancient text mentioned *Aloe* as a laxative and effective against skin infections[12]. The earliest document with a detailed medicinal description of *Aloe* is *Papyrus Ebrus* from Egypt, mentioning the laxative properties of *Aloe* in 1552 B.C.[2]. Romans, Greeks, Arabs, and Indians were also aware of the medicinal use of *Aloe*[13]. *Aloe* was used for wound healing by the soldiers during wars. Aristotle knew the special characteristics of *Aloe vera* and his disciple Alexander had enough knowledge about *Aloe* to cure the wounds of his soldiers in the 4th century[4]. This implies antimicrobial activity of *Aloe* and it was well known in Greece. Columbus also kept *Aloe* in his ship for its medicinal purpose[4]. In ancient times, the elite people used *Aloe* for their beauty enhancements. Egyptian queen Cleopatra employed *Aloe* in 69-30 B.C., and also Nefertiti for beauty enhancements[14]. *Aloe* was utilized as medication in Northern Africa from 20-30 B.C. In 50 B.C., *Aloe* was brought into Western medication basically as a diuretic. The

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earliest itemized depiction of the medicinal impacts of *Aloe* was in a Greek herbal formulation composed by Dioscorides, a Greek physician (from 41 to 68 A.D.). In that era, fresh leaf and sap could not be stored longer, the sap (bitter juice) was boiled to reduce into a black mass for storing purposes, transported and marketed for healing power, sleep induction, bowel cleansing, curing boils and ulcerated reproductive organs, healing foreskin and dry itchy skin[15].

The reason behind the huge popularity of *A. vera* over other species is its nativity to the Arabian Peninsula which made its introduction comparatively far before to the various regions of the world[16]. *Aloe* was introduced to the Asian region in around 300-400 B.C. when Alexander invaded Persia and China. The first documentation in China was *Materia Medica* probably written during the era of the Song Dynasty (700-800 A.D.), mentioning the plant's effective uses for sinus treatment, dermal problems, fevers, and convulsions in children. In Mandarin, *Aloe* is called 'Lu-hui' which refers to 'black deposit'. The name also indicates that Chinese people earlier were familiar to the dried black *Aloe* sap but not the plant, as the plant was introduced for growth in the region late in 1817 A.D. It is believed that *Aloe* was introduced to Korea from China during the Dang or song Dynasty. The similarity between Korean and Japanese names of *Aloe*, ("Nowhe", and "Roeh") having same meaning to "Lu-hui" also suggest the exchange of *Aloe* between Korea, Japan, and China. Most probably *Aloe* was introduced in these countries by foreign traders. Japanese text has mentioned the import of the black resin of *Aloe* for killing insects. In Japan *Aloe* was famed as 'the plant which turns a doctor of no need', and cultivated in gardens. Though *Aloe* is believed to be imported from the west, however the main species of *Aloe* cultivated in Japan is *A. arborescens* ('Kitachi' *Aloe*), that is different from westerns species *A. vera*[9]. An English translation of Dioscorides' Medical De Materia Medica by John Goodyew in 1655 A.D. was the pioneer reference in regard to *Aloe vera*. In 1800s, *Aloe* was commonly used as a laxative; however, a major breakthrough was in mid 1930s when it was used to cure side effects of prolonged radiation exposure[17]. Recently, a drug named as 'Qmatrix', was prepared from gel of *A. vera* and was tested how safe it was to be taken as proprietary drug; the investigation resulted in the finding that drug did not cause any kind of serious harm to the rats and was completely safe[18].

The cultivators in Aruba, a South American island, boiled the juice upon open fire or steam pans. However, in Africa the leaf juice was fermented before evaporating in the air. The dense residue left was then placed into various containers, and allowed to solidify prior to export. A British, Jonathan Pereira (1804-1853), kept notes of many varieties of commercial *Aloe* in the mid-19th century[19].

The ethnobotanical value of *Aloe* L. in Africa is clear in the documented cultural practices[20,21]. African communities used *Aloe* species for various purposes, prominently, human and cattle medicine, hedging, fencing, cosmetics, weaning off children from breast-feeding and in traditional rituals[20,22,23]. Some species of *Aloe* are very poisonous; species like *Aloe ruspoliana* Bak., is employed to poison wild animals in northern Kenya[24], and there is always danger of poisoning thanks to wrong identification of plant. The major piece of documentation of *Aloe* from South Africa was mentioned by Reynolds (1950) in his book 'The *Aloe*s of South Africa'. It has been reported that during East India Company's regime, beautiful gardens in the cape of South Africa was maintained[8]. Along with other native plants from the region species of *Aloe* were also cultivated in the garden. Illustrations of some *Aloe* species prepared those times are still preserved in the museum in South Africa. The company's garden was beautified by the superintendent, Hendrick Bernard Oldenland (1695). His herbarium or 'Kruid Boek' contains a list of 28 plant species of the genus *Aloe*. A chronological overview of key developments in the use of *Aloe*, highlighting significant milestones from its traditional applications to its modern advancements is presented in Table 1. This timeline provides a structured insight into the evolution of *Aloe's* usage over time.

Medicinal properties of *Aloe* have been cited in Indian text, Ayurveda. In Ayurveda, *Aloe vera* is known as 'Ghrit Kumari' ('Ghrit'=ghee for the reason of its gel, 'Kumari'= young lady). The name 'Kumari' suggests its restorative properties and efficacy as anti-aging medicine since *Aloe* is thought to give back the youthful energy and femininity. It is a tonic for female reproductive system, purgative, rejuvenating, and all in one solution for balancing *Vatta, Pitta* and *Kapha*. It has been reported to be used for the treatment of constipation, dermal problems, worm infestation and microbial infections in folk medicine. Also, it is known for using as laxative, anthelmintic wound treatment, and labor stimulant[25]. Throughout

Table 1 — Chronology of traditional and recent utilization of *Aloe* species as drug

Time interval	*Aloe* utilization	Reference
4000 B.C	*Aloe* plants were gifted to deceased during the funeral as a 'plant of immortality' in Egyptian culture.	[9]
2200 B.C.	Earliest documentation of medicinal use in Sumerian clay tablets.	[12]
1550 B.C.	Healing benefits of *Aloe* for internal and external use was described in Egyptian 'Ebrus Papyrus'	[2]
400 B.C.	Trade of *Aloe* in east and Asia become extensive.	[3]
356~323 B.C.	Alexander the Great used to treat the wounds of his soldiers with *Aloe* leaves. He also conquered Island of Socotra to grab A. perryi trade.	[4]
69~51 B.C.	Egyptian queens Cleopatra, and Nefertiti used it for beauty enhancements.	[14]
27 B.C.~14 A.D.	*Aloe* was introduced into Greco-Roman system of medicine.	[3]
First Century A.C.	"*Aloe*s" are mentioned in the Holy Bible as the substance used to anoint the body of Jesus Christ.	[8]
41-68	Pharmacological effects *Aloe* were described in "De Materia Medica" of Dioscorides.	[17]
23-129	"Naturalis Historica" of P.T. Elder reported uses of *Aloe* in leprous wounds.	[9]
618-907	Chinese people used *Aloe* for dermatitis.	[9]
960-1279	Meteria Medica of Song dynasty explains the use of *A. vera* leaves for skin diseases, sinusitis and fever.	[11]
14-16 Centuries	*Aloe*, was introduced to English and European medicine system.	[3]
1492	Christopher Columbus introduced *Aloe* to the New World.	[15]
1650-1742	*Aloe vera* was placed in London Pharmacopeia was named "Barbados *Aloe*".	[9]
1753	Linnaeus named *Aloe vera* without complete description, as a variety of *Aloe perfoliata*.	[9]
1768	P. Miller also independently described the *Aloe perfoliata* var. *vera* as *A. barbadensis*; So the correct name of the plant is *Aloe vera* (L.) Burm. F.	[65]
1810-1820	United States Pharmacopoeia (U.S.P.) accepted *Aloe vera* as cure for dermal problems and, laxative	[3]
1851	Smith and Smith extracted aloin from the leaves.	[3]
1867	*Aloe vera* "juice" introduced in the British Pharmacopeia.	[20]
1912	Commercial cultivation of A. *vera* in Florida (USA) began.	[20]
1935	Collins & Collins (1935) reported the efficacy of *A. vera* therapy against radiation-induced skin burns.	[17]
1959	US FDA listed *Aloe vera* as food supplement.	[20]
1975	*Aloe* juice was introduced to the European Pharmacopeia.	[12]
2010	*Aloe*s of World project was initiated by SANBI and National Herbarium of Ethiopia	[3]
2015	The genus *Aloe* was finally placed under the family Asphodelaceae after so many changes from Liliaceae, Aloaceae, and Xanthorhoeaceae.	[6]
Present	New pharmacological potential, crop improvement, and cosmetics development of *Aloe* species under investigated and reported	[61]

India, many other *Aloe* species are cultivated as either ornamentals, or by horticulture enthusiasts. There are sufficient literatures available about the use and application of *Aloe,* however, most of it is dedicated to *Aloe vera* only. This article is an attempt to emphasize the potential use and applications of *Aloe* species other than *Aloe vera* as well.

Phylogenetic studies of plant use and leaf succulence among *Aloe*s have yielded new explanations for the extraordinary market dominance of *Aloe vera*. Sufficient scientific evidence has been shown for the laxative, anti-herpes, and anti-dermatitis potential of *A. vera*[26]. The industry preference for *Aloe vera* appears to be due to its proximity to important historic trade routes, and early introduction[16].

The chief useful contents of the *Aloe* plants are

Leaf gel

The mucilaginous, transparent, semisolid gel from the parenchymatous cells of the leaf mesophyll. It is more or less not bitter.

Leaf exudate

A shiny, bitter, yellowish liquid that exudes from the injured leaf, also known as aloin leaf juice, and sap[3]. The quantity of gel and aloin varies from species to species.

***Aloe* species' traditional uses and recent scientific validation**

Antiseptic Uses

The vital amino acids and nutrients found in *Aloe vera* gel aid in the repair of damaged skin. It creates a barrier that keeps germs out and speeds up skin healing. *Aloe vera* is used by Assamese tribal people to cure burns[27]. Gram-positive bacteria have been demonstrated to be susceptible to *A. arborescens*, *A. excelsa*, and *A. ferox*; their ethanolic extracts have also been found to be effective against gram-negative bacteria, including *P. vulgaris* and *E. coli*[28]. According to recent research, *A. ferox* inhibits the growth of bacteria and fungi with strong antibacterial action that is similar to that of *A. vera*[29]. Bacteriostatic effect of *A. vera* was investigated even longer ago[30].

Skin disorders

In dermatology, *Aloe vera* is frequently used to treat skin ailments like burns, psoriasis, acne, and herpes. In addition, it lessens wrinkles, softens the skin, and guards against infections[31-33]. *Aloe vera* is traditionally utilized by the Kani tribal people of Tamil Nadu to heal hair problems, stomach troubles, and body heat (*A. christianii* and *A. lateritia*)[34]. These applications are supported by scientific studies, which demonstrate the anti-inflammatory and antioxidant qualities of *Aloe vera*, which lessen skin irritation and accelerate healing[35].

Digestive disorders

Constipation and poor digestion have long been treated with *Aloe vera*, *Aloe chabaudii*, *Aloe secundiflora*, and *Aloe volkensi*[22,36]. Typhoid and diarrhea have been treated with *A. lateritia* and *A. secundiflora*[22]. *Aloe vera* used orally has been demonstrated to lessen gastric acid levels and ease discomfort in people with irritable bowel syndrome (IBS)[37,38]. Tea prepared from the leaves of *A. marlothii* is remedy for stomach ailments[39]. Leaf preparation of *A. maculata* is ethnoveterinary remedy to relieve gut problems[40]. Furthermore, current research supports *Aloe vera*'s laxative properties and beneficial effects on gut health[41].

Dental health

Aloe vera has long been used to treat dental conditions like gingivitis and periodontitis as well as ease toothaches[42,43]. The roots of *A. chabaudii* are used to treat toothaches in Zimbabwe[44]. *Aloe vera* is a promising treatment for dental care, as recent research indicates that it possesses antibacterial qualities that may help treat oral illnesses[45].

Testicular and scrotal cancer

Traditional Tanzanian medicine has utilized *A. flexifolia* in the treatment of testicular and scrotal cancer[24]. *Aloe vera* has anti-ulcer properties comparable to those of common medications like omeprazole[44], and it has been found in human cell lines to have anticancer potential[46-48].

Gynecological uses

Aloe vera juice is said to have abortive qualities in Ayurveda, while *A. chabaudii* is traditionally used for the same purpose in Malawi[23]. In Burundian traditional medicine[22], *A. lateritia* and *A. christianii* are used to lessen labor pain and speed up delivery. *Aloe vera* has been shown to be beneficial in treating microbiological infections and vaginal ulcers, hence providing scientific legitimacy for its use in the treatment of genital tract illnesses[49]. *Aloe arborescens* and *Aloe greatheadii* were taken as purgatives taken during pregnancy[8,50]. *A. vera* leaf juice in combination with molasses is used to cure leucorrhoea[51].

Pain relief

A. ngongensis is used for stomach and backaches in Kenya, whereas *A. deserti* is utilized for chest pain[24]. There have been reports of analgesic effects from *A. secundiflora* leaf sap and exudate[22]. Research has confirmed the traditional usage of *Aloe vera* leaf extracts for pain treatment by demonstrating their analgesic qualities[52].

Ocular problems

In Kenya and Tanzania, *A. volkensii* and *A. secundiflora* have long been used as traditional remedies for ocular conjunctivitis and other eye conditions[23,36]. While new research indicates that *Aloe vera* has antioxidant qualities that may help with cataracts and retinal degeneration[7], *A. lateritia* is used to treat eye infections[7].

Respiratory disorders

In Namibia, *A. hereroensis* is traditionally used to cure chest ailments, and *A. secundiflora* is commonly utilized for respiratory concerns. The Zulu people use *A. maculata* to cure fever and colds in children[53]. *Aloe* species have antibacterial properties that can treat cough, cold, flu, and pneumonia, according to recent studies[21,23].

Malaria

It has been shown that certain *Aloe* species are traditionally used to cure malaria, especially in Kenya, where *A. deserti* and *A. secundiflora* are widely employed[32]. Positive findings have been reported in scientific studies that have investigated the potential of *Aloe* species as antimalarial medicines[54].

Liver and kidney disorders

Traditionally, *A. secundiflora* leaf exudate has been utilized to treat liver and kidney issues[22,24]. *Aloe vera* in excessive dosages may be hepatotoxic, however, diluted *Aloe* juice has been shown to have liver-repairing properties[55]. *Aloe vera's* effectiveness against kidney stones is further supported by studies[55].

Brain disorders

A decoction prepared from the leaves of *Aloe asperifolia* is taken for epilepsy[56].

Cardiovascular disorders

A. asperifolia was used for treatment of arteriosclerosis[56].

Anti-inflammatory action

Aloe vera leaf juice helps relieve ulcerative colitis and other inflammatory bowel conditions[41]. Additionally, recent research demonstrates that *A. ferox* can lessen parasite-induced gastrointestinal irritation[29].

Strong antioxidant and anti-cancer properties

Phenolic chemicals found in *Aloe vera* and other species of *Aloe* have potent antioxidant properties. Significant suppression of lipid peroxidation has been shown by *A. claviflora*, *A. cryptopoda*, *A. desertii*, and other species; this inhibition is comparable to that of vitamins D and C[57]. *Aloe vera* extracts have demonstrated antiproliferative properties against multiple cancer cell lines[46-48] in cancer research.

Cosmetics

Aloe has been used to improve appearance since ancient times. *Aloe vera* is reported to have been utilized by Egyptian Queen Cleopatra for skincare[35]. Due to its antioxidant qualities, it is a common ingredient in contemporary cosmetics that are used to treat wrinkles, acne, and sunburns. *Aloe vera* and *A. ferox* have seen increased commercial use recently; the seed oil of *A. ferox* is rich in essential oil applications[58].

Environment management

It has been demonstrated that *Aloe vera* waste biomass is useful in phytoremediation, especially when it comes to eliminating arsenic toxicity from soil and water. Heavy metals and other contaminants have been shown to be extracted by waste leaf sorbents[59]. *Aloe* cultivation can better be utilized for restoration of salf affected land reclamation[60].

As cuisine

Leaves of *Aloe trinervis* which is also popular as 'Meetha Gwaar' ('sweet *Aloe*') in Rajasthan, India, are consumed as vegetable and for making pickles[61]. Unlike *Aloe vera*, the leaves of this species are not bitter in taste, and therefore edible. Local people differentiate *Aloe vera* and *Aloe trinervis* as 'bitter' and 'sweet' types of *Aloe*, respectively.

Toxic effects of Aloe

Aloe species offer remarkable benefits for nearly every part of the body. It contains anthraquinones as the chief phenolic compounds in the aloin. These compounds contribute to the antimicrobial, and antioxidant power of *Aloe* but in low concentrations. High doses have been proven to be toxic and shown hazardous results when investigated on experimental rats. *Aloe vera* leaf extract was reported for carcinogenic activity in rats and was labeled by the International Agency for Research on Cancer, as a possible human carcinogen[62]. There are many cases of *Aloe* poisoning due to the misidentification of species. Therefore, the application of *Aloe* products, specially prepared from exudate needs proper guidance from experts. The plant has also been reported as a potential bio-repellant for maize storage pests[63]. In India, *Aloe vera* has been reported for almost all above-mentioned uses/applications over time[2,64]. The genus *Aloe* comprises more than 500 species till date (APG IV), but in general only two species, *A. vera* and *A. ferox* are known for their commercial utilization. Rest of the species are less explored or unexplored for their application at industrial level. This area of research needs to be addressed.

Aloe species are noted for their low water requirements and strong pest resistance, making them ideal for sustainable agriculture. However, it is crucial to note that many *Aloe* kinds might be harmful if used inappropriately. As a result, the use of *Aloe* should always be directed by expert counsel to guarantee safety, especially for medical or cosmetic purposes. Growers should focus on well-drained soils and prevent over fertilization, which can be detrimental to plant health. Regular disease monitoring and crop rotation can help to improve soil fertility and minimize pest occurrence. Proper spacing between plants enhances ventilation, lowering the danger of fungal diseases. Growers may improve the resilience and sustainability of *Aloe* production by implementing certain agronomic methods, while also protecting human health.

Conclusion

Various *Aloe* species are known to be used traditionally for a wide range of health problems. Medicinal potential of especially *Aloe vera* and a few other species has also been validated through phytochemical investigation in the recent studies. However, the potential of most of the species as modern medicine is unexplored. Even though so many other *Aloe* species are cultivated in India, by horticulture enthusiasts, yet there is a lack of

their phytochemical profiles. This is perhaps due to lack of proper identification of these species. A thorough taxonomic and phytochemical study is being carried out by CSIR-National Botanical Research Institute (CSIR-NBRI), Lucknow for recognition of ecologically, economically and pharmacologically better *Aloe* species for Indian climate.

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Conflict of Interest

Authors have no competing or conflict of interest.

Author Contributions

SKB: Reference collection, drafting, and compilation of manuscript, LB: Conceptualization, improvement in the manuscript and project administration.

Data Availability

The data availability is based on the available references in the public domain.

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