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Aloe: medicinal properties and botanical characteristics

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Abstract

Aloe plants have been studied and used to treat many diseases for thousands of years. Since ancient times it has been used to cure human ailments. Over the last few decades, several studies have shed light on the characteristics of this plant, which seems to want to hide its secrets behind botanical and pharmacological riddles that are only now beginning to be answered. The medicinal abilities of Aloe plants have been known to man since ancient times. Therefore, we can consider Aloe a food and medicine: if you decide to take Aloe, know that you have opted for complete food. Aloe plants are a reservoir of important substances for the human body, particularly vitamins, catalyzing enzymes, sugars and medicinal oils. The German Pharmacopoeia, in its 1873 edition, at the time of Bismark, already recorded more than 300 pharmaceutical elements contained in Aloe. Modern medical literature confirms this today, with lists and lists of such ingredients, the result of research by laboratories working honestly, objectively seeking the truth. Studies show the presence of certain secondary metabolites in Aloe that can cause problems. In particular, the presence of aloin, in *Aloe vera*, is a compound that can be metabolised by the human gut and can cause various harmful effects such as carcinogenic, genotoxic, nephrotic and digestive problems. The presence of certain alkaloids and polysaccharides are also reported to cause liver and reproductive problems. This paper examines the botanical, cultivation and medicinal properties associated with this very important plant.

Keywords**:** *aloe chemistry; aloe history; biodiversity; medicinal plants; medicinal properties; sustainable agriculture*

1. Introduction

Aloe has a history stretching back thousands of years, and many ancient texts document its use and therapeutic properties. Information on the use of Aloe can be found in ancient Egyptian papyri, mentioned in the Old Testament, and various documents of Asian and Arabic origin. The plant is also known in Japanese, Filipino and Hawaiian cultures (Haroon, Shahid, Hussain, & Raza, 2018). The ancient Assyrian people used Aloe juice to eliminate the annoying symptoms of eating lousy food and intestinal gas. On Sumerian tablets found in 2000 BC, writings about Aloe were identified (Heng, Zulfakar, & Ng, 2018).

Therefore, the Assyrians were familiar with the plant and some of its properties and mainly used the variety *barbadensis Miller*, better known as Vera (Babu, & Noor, 2020). Several ancient books describe the medicinal virtues of Aloe, in particular the 'Papyrus of Ebers', Egyptian writing dating back to 1550 BC, which describes several formulas for mixing the plant to treat various diseases (Karpagam, Sugunabai, Gomathi, & Muhamad, 2019). The ancient Egyptians referred to Aloe as the plant of immortality and planted some as a good omen in front of the pharaohs' pyramids . As was the case for Pharaoh Ramses II, Aloe was often used in the embalming process. The consideration of this plant was such that it was included in the funerary gifts of the pharaohs. The word Aloe is derived from the Greek word for salt, as the taste is very similar to saltwater from the sea. In the past, it is remembered that Alexander the Great set out to conquer Socotra in order to get hold of many *Aloe succotrina* plants (Shi et al., 2018).

In the past, Pliny the Elder valued the medicinal virtues of aloe plants, which were used to treat skin diseases and digestive problems (Miramon-Ortíz et al., 2019).). In the East, Tibetan culture and medicine use a species of Aloe with a large trunk to produce therapeutic remedies and meditation incense, still used today to generate calm harmony and serenity. Ayurvedic medicine uses the bark of the *Aloe aquilaria agallocha* to formulate remedies that treat ear infections, eye infections, and open wounds (Rehman, Al-Riyami, Hussain, Ali, Khan, & Al-Harrasi, 2019). Between 1700 and 1800, many connoisseurs in the Old Continent of Europe realized the importance of this plant. Imports multiplied, and a modus pensandi spread among the old aristocracy and the newly emerging middle class, seeing Aloe as one of the most highly valued plants in botanical collections (Sudhakar et al., 2018). Many English aristocrats created prestigious and refined greenhouses of succulent plants, among which several species of Aloe emerged (Sánchez-Machado, López-Cervantes, Sendón, & Sanches-Silva, 2017).

About aloe, and particularly *Aloe vera*, the juice and gel obtained from the fleshy leaves are mainly used. The plant has enjoyed a certain popularity since the distant past because of the many properties that were and still are ascribed to it. It should be pointed out, however, that not all properties attributed to aloe are confirmed; some, in fact, are being studied while others remain unsupported by scientific evidence (Park, & Jo, 2006; Steenkamp, & Stewart, 2007).

There is a great deal of information concerning the applications of aloe in the medical and industrial fields, with data that are often untrue and misleading, or do not correspond to reality (Grindlay, & Reynolds, 1986; Yamaguchi, Mega, & Sanada, 1993). The main objective of this review is to tell the reader about the capabilities of aloe, describing its various fields of use and medicinal properties, in order to make the countless properties of this plant, which is fundamental to people's lives, more understandable and to promote its correct use.

2. Aloe as used today

Active ingredients with medicinal effects were first studied by Smith and Stenhouse, who identified aloin in 1951 (Quan et al., 2019). Aloin and aloemodine extracts are mentioned in the British Pharmaceutical Codex of 1907, with main indications of use, under purgative actions (Gansukh et al., 2018). After 1930, Aloe became the subject of extensive studies, mainly in the United States of America and Russia. In 1935, two doctors from Maryland, Creston Collins and his son revealed the possible use of Aloe to counteract the devastating effects of radiation in a later famous report. In the 1940s, Professor Tom Rowe conducted the first analyses to assess the medicinal properties of Aloe plants (Liang, Cui, Li, Guan, Zhang, & Li, 2020). At the end of the 1950s, Texan pharmacist Bill Coats succeeded in stabilizing the pulp using a natural process (Wu et al., 2020). The discovery of the stabilisation process opened the door to the industrial marketing of Aloe products. Previously, the limitations were the oxidation of the juice, which could not be stored for long, as it rapidly deteriorated when cold extracted from the plant (Meshram, Bhowate, Madke, & Sune, 2018). Some researchers tried to solve the problem by exposing the gel to ultraviolet light, but this altered its chemical composition; they also tried pasteurizing the gel at temperatures above 60°C after adding hydrogen peroxide, but this also failed. Bill Coats was the first to develop a process to preserve the enzymes and vitamins in Aloe (Gulati, College, & Sahib, 2021). The protocol involved incubating the gel with added vitamin C, vitamin E and sorbitol. In the 1960s, the US Department of Health documented and conclusively certified the apparent regenerative capacity of Aloe preparations for skin tissue. Subsequently, since the 1970s, research has increased enormously, and the fields of use have become broader and wider (Uda et al., 2018). The anti-cancer properties of Aloe plants were first investigated around the 1980s by Kupchan and Karim. Investigations into the anti-tumour and anti-leukemic properties began, and in a subsequent publication by Suzuki and Saito and co-workers, the active biological components of the plant were described (Adeleye et al., 2021). These studies explained some possible mechanisms of Aloe's action and helped to stimulate further studies. In the 1980s and 1990s, publications on the plant's properties and related studies increased rapidly (Prakoso, Setiyo Rini, & Wirjaatmadja, 2018).

3. Botany and chemical composition of Aloe

The Aloe was originally classified in the Liliaceae because it resembles lilies to an original bulb. However, Tom Reynolds, a London-based researcher, has drawn up a new classification that

places Aloe in the botanical family Aloaceae (Thakur, Jilariya, Gunaga, & Singh, 2018). Aloe belongs to a large class of plants known as xerophytes, so-called because they can close their stomata to ensure the plant's water balance (Hoffmann et al., 2020). This ability to store water internally allows them to survive prolonged dry weather or even drought periods. Furthermore, particular chemical components also have the extraordinary knowledge to close up almost instantaneously any wound or damage to the epidermis, preventing the precious water from escaping (Prisa, & Gobbino 2021a). This self-healing power may have provided ancient civilizations with clues to discovering Aloe's therapeutic virtues (Arora, Sarup, Tomar, Singh, & Kumar, 2019). It is a genus of evergreen, shrubby, perennial or climbing plants, with flowers of different colours depending on the species (Prisa, & Gobbino, 2021b). The Aloaceae family comprises about three hundred and fifty varieties of plants all over the planet (Table 1) (López et al., 2019). In 1955, 132 species were catalogued in South Africa alone. The others are distributed in other parts of the African continent, Asia, the Caribbean, Spain, Central and South America, North America, and Mexico (Khan, & Siddiqui, 2020). A botanical distinction can be made by looking at the trunk (Figure 1) and the leaves. Aloe groups are identified as acauleas, subcauleas and cauleas (Prisa, & Gobbino, 2021c).

Figure 1 Aloe Vera roots growth details

Table 1 Most popular Aloes (Abouelela et al., 2021)

Family Aloaceae - Genus Aloe					
A. arborescens	*A. excelsa*	*A. castanea*	*A. nobilis*	*A. perryi*	*A. pictifolia*
A. aristata	*A. ferox*	*A. ciliaris*	*A. pillansii*	*A. plicatilis*	*A. polyphylla*
A. brevifolia	*A. barberae*	*A. angelica*	*A. pratensis*	*A. ramosissima*	*A. saponaria*
A. comosa	*A. dinteri*	*A. distans*	*A. speciosa*	*A. squarrosa*	*A. striata*
A. glauca	*A. humilis*	*A. khamiensis*	*A. tauri*	*A. variegata*	*A. vera*
A. longistyla	*A. maculata*	*A. mitriformis*	*A. zebrina*	*A. sinkatana*	*A. tomentosa*

4. Aloe plant characteristics

Aloe leaves are characterized by an outer structure called the skin, which is 2 mm thick and contains elastic membranes that protect the gel, which is transparent and rich in medicinal properties (Abouelela et al., 2021). Reproduction of aloe plants occurs through pollination by insects and birds, as these plants are self-sterile and must receive fertilization material from other plants (Kar, & Bera, 2018). The plant also reproduces using stolons and shoots that grow at the base of the stem of the main plant to form colonies. Its habitat is typical of arid and desert areas, and it can reach heights ranging from a few centimetres to twenty meters, depending on the species. Spaces intended for the commercial cultivation of Aloe must have a

warm climate, with temperatures during the winter not falling below 8°C. Ideal growing temperatures are around 20-24 °C (Saleh et al., 2019). Aloe is a drought-tolerant plant but has problems in environments where waterlogging is present. Therefore, it needs a sub-acidic pH and water with low sodium content. These conditions can only be found in southern Texas, southern Florida, and southern California in the USA. Crops are also found in Mexico, Australia, Africa, and Central America. In Europe, they are found in southern Spain, Portugal, Greece, and recently in Italy. Typically, the leaves of plants grown in the Rio Grande Valley or South Florida weigh between 600 g and 1 kg. Each plant needs a space of approximately one square meter, so one hectare can accommodate between 10000 and 12000 plants (Figure 2), (Banerjee et al., 2018). Under normal conditions, each plant yields 15 to 30 kg of leaves per year. In commercial Aloe cultivation, insecticides and pesticides are not usually necessary, as the bitter taste of the sap is sufficient to eradicate insects and other possible predators. Aloe plants are more vulnerable during flowering, as during this time the sap leaves the leaves and moves to the stem and flowers and pathogens can attack it more easily (Banerjee et al., 2018).

Figure 2 Aloe Vera in greenhouse cultivation

5. Harvesting, washing, and extracting Aloe gel

The ripe leaves are harvested strictly by hand to ensure that the rind is not broken. The inner gel oxidizes immediately in contact with air, resulting in some of its nutrients being lost. The outer leaves are removed with a precision cut (Choudhri et al., 2018). Inaccurate cutting of the leaf and poor storage leads to immediate spoilage of the gel with problems for the whole process. The leaves are then carefully placed in spacious baskets so that they do not crush each other. Immediately after harvesting, the Aloe leaves have to be sent to the nearest factory, where gel processing occurs (Sharma, Minocha, & Kushwaha, 2020). The first step is to wash the leaves using suitable methods so as not to damage the properties of the Aloe in any way. After the first general washing, a second step follows in which each leaf is scrupulously washed and cleaned by hand (Figure 3) (Yadav et al., 2020). The process of washing and cleaning the leaves removes aloin, an irritant substance found just under the skin. Finally, the peels are pulped and used as a natural fertilizer (Debnath et al., 2018). After washing and cleaning, the gel undergoes a stabilization process to maintain the quality and nutritional profile of the product. Once stabilized, the gel begins its journey to the packaging and production sites (Ibrahim, Al Sadah, Ahmad, Ahmad, & Naqvi, 2019). The leaf consists of a very thick green cuticle and an inner gel. If the leaves are not processed, the result is a greenish pulp with a bitter taste and rich in anthraquinones (Yohannes, 2018; Bhoye, Somkuwar, Sarode, Dubey, & Harke, 2021).

Figure 3 *Aloe vera* gel extraction

6. Aloe gel stabilization and transport

In stabilizing the Aloe gel, manufacturers typically introduce an enzyme, cellulase, into the gelatinous mass to dissolve its bonds, turning it into juice. Other manufacturers use heat, breaking the polysaccharides' bonds and allowing fluidization (Feinberg et al., 2018; Moradi, Abbaszadeh, Shahsavari, Alizadeh, & Beyranvand, 2018). The most useful medicinal herbs to treat diabetes. Often the heat reaches high temperatures, around 70°C, typical of pasteurization processes (Liang et al., 2020). After the manufacturing process, the product is bottled in special containers that protect it from the sun's rays. Aloe gel and derivatives are processed in light-free environments, as light environments can alter the quality of the gel, causing problems throughout the production

process (Sánchez, González-Burgos, Iglesias, & Gómez-Serranillos, 2020). However, the raw material should be transported from the processing plant by refrigerated means, as traditional transport, especially in the summer months, could cause the product to reach over 60°C, with harmful effects on the raw material. The material produced from the crushed gel can be used internally as food or externally to produce beauty products (Álvares et al., 2018). In addition, the juice is used to produce medicinal derivatives that are of particular interest today (Dziewulska, Stenzel, Śmiałek, Tykałowski, & Koncicki, 2018).

7. Aloe gel processing and derived products

Aloe juice is an extremely valuable raw material that can be used in various fields, from cosmetics to the production of medicines to remedy even serious problems (Toro et al., 2018). However, there is a problem with companies that produce low-quality material where the Aloe content in the products is very low (Atanu, Avwioroko, & Momoh, 2018). The substances present in the juice are unstable and difficult to analyze. The purity of the products can be assessed based on the consistency of the liquids. However, there are methodologies to circumvent the controls (Sobrinho et al., 2018). today, the Aloe market is in continuous expansion, also based on consumer demands for high-quality juices with different nutraceutical properties (Table 2). Gels with undisputed skin repairing and disinfecting properties are also produced, which can be applied directly to areas where protection from wounds and burns is needed without contraindications (Table 3). These compounds have soothing and sanitizing properties and can also be used to resolve many serious dermatological conditions (Banik, & Sharangi, 2019). Long-stored and poorly processed products do not have the same characteristics and medicinal properties as fresh products. Daily application of the gel regenerates the skin, promotes blood circulation and protects against external agents that can lead to degeneration of epithelial tissues (Table 4), (Giannakoudakis et al., 2018). Some enzymes in the gel, such as bradykinase, can block the development of inflammatory processes, boosting the immune system. Some substances, such as barbaloin, have antibiotic and antibacterial effects, such as acemannan can accelerate wound healing and increase collagen production (Karpagam et al., 2019).

Table 2 Chemical constituents for Aloe Vera (Sharma et al., 2020).

Chemical constituents	Activity
Aminoacids	Body construction
Sugars	Antiviral activity
Vitamin	Antioxidant (A,C,E), neutralizes free radicals
Steroid	Anti-inflammatory agents, antiseptic and analgesic properties
Anthraquinones	Analgesic, antibacterial
Enzymes	Antifungal and antiviral activity
Minerals	Essential for good health.
Salicylic acid	Analgesic
Saponin	Cleansing, antiseptic and Anti-inflammatory agents

Table 3 Chemical constituents of curry leaves (Sharma et al., 2020).

Constituents	Activity
Isomahanine	Anticaries
Mahanine	Anti-microbial
Murrayanine	Antifungal
Girinimbine	Anti-cancer, Antifungal, Antibacterial
Lutein	Antioxidant activity
Tocopherol	Antioxidant activity, Hepatoprotective
Carotene	Antioxidant activity
Koenimbine	Antioxidant activity

Table 4 Pharmacological activities of Aloe Vera (Sharma et al., 2020).

Aloe Vera Effect
Anti-Diabetic
Skin Protection and Hydration Activity
Anti-Ageing Effect
Anti-inflammatory
Anti-oxidant activity
Anti-microbial
Anti-tumour effect
Hepatoprotective

8. Medicinal properties of the Aloe plant

The benefits of *Aloe vera* are many and varied. Depending on how it is used (in juice or gel, for internal or external use), aloe can be used as: i) moisturising, emollient and healing for the skin;ii) gastroprotector; iii) anti-inflammatory, healing and soothing for mucous membranes (Luta, &

McAnalley, 2005). Aloe juice contains mainly anthraquinone glycosides with laxative action and was once used in cases of constipation and sluggish bowel. Anthraquinones are active ingredients of aloe but also of other plant species including *senna rhubarb*, laxative remedies that have the same effects as aloe. These molecules work on the intestinal mucosa, irritating it and stimulating peristalsis and, consequently, faecal evacuation (Heng et al., 2018).

Aloe vera gel and juice, on the other hand, are rich in mucilage and are still used for external use in the treatment of various dermatological and oral cavity problems and, internally, for gastric disorders.

The benefits of aloe gel are very varied: or gastrointestinal complaints, food-grade aloe gel is administered at doses of 25-100 millilitres once or twice a day. In the case of mouth ulcers, gingivitis and stomatitis, food-grade aloe gel pure or diluted in water is used externally to rinse the oral cavity (Sánchez-Machado et al., 2017).

The thicker aloe gel for cosmetic use is instead used for localised applications on the skin or as a face and body cream. Externally, *Aloe vera* gel is used purely for dermatitis, psoriasis, sunburn, wounds and sores, but also for treating dry, damaged skin and in cases of sunburn or to relieve itching and swelling caused by insect bites and hives. Indeed, the skin application of aloe gel helps soothe inflammation, pain and redness and speeds healing and healing (Boudreau, & Beland, 2006). Diluted aloe gel or aloe juice can also be used for rinsing the oral cavity to help relieve the pain caused by gingivitis, stomatitis and mouth ulcers. The vaginal mucosa can also benefit from washes with *Aloe vera* gel in cases of inflammation, burning and itching. For internal use, on the other hand, drinking *Aloe vera* has a healing, anti-inflammatory and protective effect on the gastric and intestinal mucosa and is useful for alleviating symptoms related to gastric ulcer and ulcerative colitis (Gulati et al., 2021).

9. Conclusions

Aloe is a medicinal plant used in many different areas and is essential in several countries worldwide. The largest producers of Aloe derivatives are Europe, Australia, and the USA, which provide quality products growing exponentially. The fields of application of Aloe Vera include medicine and cosmetics, and extensive scientific research has been carried out in America and Europe in particular to establish the pharmacological basis. Its countless health and beauty benefits have earned it a leading role in natural medicine.

Aloe plants have been used for many centuries for their medicinal properties, particularly as a traditional remedy to treat various health disorders such as heart disease, skin disorders, ulcers, digestive problems and diabetes. In addition to the pharmaceutical industry, it is also used in cosmetics and health products such as creams, shampoos, disinfectants and sunscreens. Aloe gel, for example, is used to treat eczema and dry skin. Some studies, however, describe Aloe as a plant with toxic effects mainly due to the presence of various anthraquinones such as aloin. Plants and bacteria are not able to utilise aloin while the microflora of the intestinal tract can do so. leading to alterations in the activity of the colon, with possible inflammation. Considering the studies carried out, it seems that the consumption and application of Aloe in any form seems inappropriate, given the controversial results and the presence of side effects. Further research is needed to eliminate or diminish the activity of those components of Aloe that can cause harm to human health, so that the consumption of this plant is safe.

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