SRI LANKAN MEDICINAL PLANT MONOGRAPHS AND ANALYSIS

VOL – 8

ALOE VERA

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ALOE VERA

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Preface

Studies on medicinal plants of Sri Lanka have been carried out in the Herbal Technology Division of Industrial Technology Institute (former Ceylon Institute of Scientific and Industrial Research) for almost two decades. This monograph which is the eighth in this series incorporates information collected from literature surveys, researches and also experiences of the Herbal Technology Division staff. This monograph is intended for a varied reading public, herbal drug manufacturers who need to identify their herbal raw materials, Ayurvedic physicians who need some scientific information on medicinal plants, research workers requiring some quick background information on a plant, industrialists or entrepreneurs pondering on commercial ventures and the inquiring lay readers. We hope this monograph fulfils some requirements of each of them.

The authors wish to thank the members of the Herbal Technology Division for their contribution, the Information Service Center for providing information, Department of Plant Sciences and Department of Zoology of the University of Colombo for assisting in anatomical studies, Food Technology Division of the Industrial Technology Institute for helping in the analysis of powdered plant materials and the Microbiology Laboratory for photographing the slides. They also gratefully acknowledge the sponsor National Science Foundation for the research grant (RG / 2004 / TM / 01).

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Sri Lanka.

Aloe vera Linn.

Family

Liliaceae

Synonyms

Aloe vera (L) Burm. F., *Aloe vera* L. var. *littoralis* Konig ex Bak., *Aloe vera* L. var *chinensis* Berger, *Aloe barbadensis* Mill., *Aloe perfoliata* L. Var. Vara L., *Aloe chinensis* Bak., *Aloe elongata* Murray., *Aloe indica* Royle., *Aloe vulgaris* Lam., *Aloe officinalis* Forsk., *Aloe perfoliata* L., *Aloe rubscens* DC[1, 2,3].

Selected Vernacular Names

Sinhala – Komarika[1,4]

English – Aloe[1,4,5]

Tamil – Angai, Angini, Kodiyan, Kattali, Sirukattalai, Sottukkattalai, Veligam[1,3]

Hindi – Ghiguvara, Ghikumari, Gvarapatha, kumari, kuvarapatha, Ghikunwar[1,3]

Sanskrit – Adala, Ajara, Amara, Ambudhisvara, Aphala, Bahupatri, Bhringeshta, Brahmaghni, Dirghapatrika, Grihakanya, Gritakumari, kantakani, Kanya, Kapila, Kumari, Mandala, Mata, Rama, Rasayani, Saha, Sthaleruha, Sthuladala, Sukantaka, Surasa, suvaha, tarani, Vipulasrava, Vira[1,4]

Bengal- Ghritakumari, Kanya[3]

Malay- Kattuvala, Kattarvala[3]

Arabic – Musabar[5]

Chinese – Lu Hui[5]

French – Aloes[5]

German – Aloe[5]

Pharmacopoeia

Ayurveda Pharmacopoeia[4]

British Pharmacopoeia[6]

Pharmacopoeia of United States of America[7]

European Pharmacopoeia[8]

Indian Pharmacopoeia[9]

Distribution[1, 2]

The plant is native to North Africa and the desert regions of Arabia. It is naturalized in most of the tropics and warmer areas of the world including India, West Indies, Mediterranean countries, China and Sri Lanka. It is commercially cultivated in many countries including United States of America and Venezuela.

Morphology[1]

A perennial herb with a very short, thick, cylindrical, woody stem sending out at the base numerous stolons; roots fibrous and fleshy; leaves not very numerous, sessile, densely crowded on the short stem with wide dilated bases, spreading below and then ascending, 30-45 cm long tapering to a blunt point, very thick and fleshy, flat or rather concave above, convex beneath, the margins set with hard, distinct, somewhat hooked prickles, surface quite smooth and shining, dark glaucous green, sometimes mottled; flowering stem (scape) 90 cm high, oblique at the base, erect, stout, smooth, cylindrical from the center of the leaf-tuft; flowers red, stalked, numerous, erect in bud, afterwards pendulous, arranged in a rather close, narrow, erect, spicate, raceme, terminating the scape, bracts, membranous, triangular, acute, reddish, veined and persistent; perianth gamophylous, tubular, about 3.7 cm long, rather fleshy, deeply cut into 6, oblong, bluntish segments; stamens 6, hypogynous, a little longer than the perianth; anthers small, oblong, dorsifixed near the base, bright orange turning brown; ovary superior, oblong-ovoid, bluntly triangular, 3- locular, with a double row of axile ovules in each chamber.

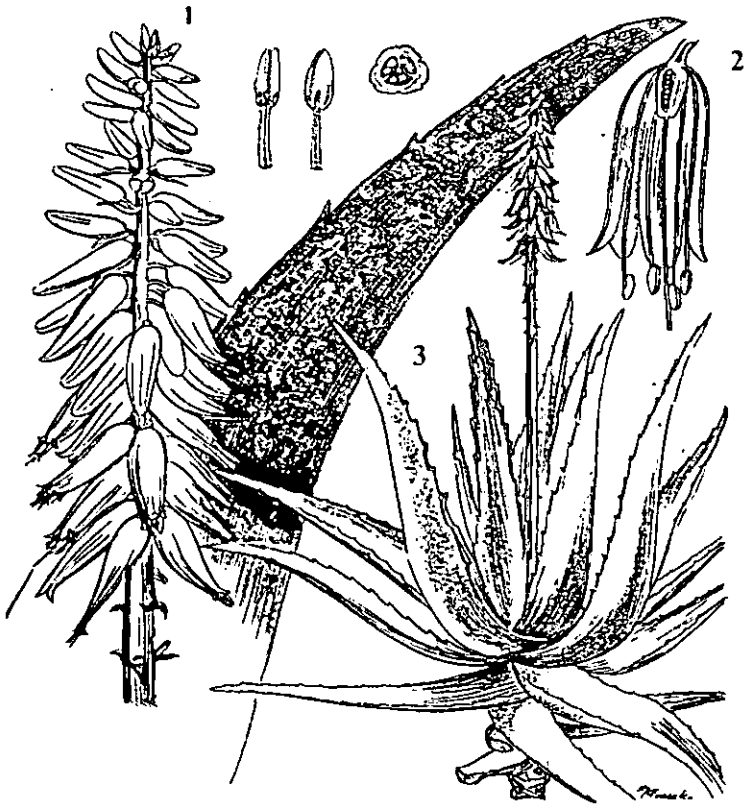


Fig – 1. *Aloe vera* plant

1. Inflorescence 2. Flower 3. Leaf

(Source- Jayaweera D. M. A., (1981). Medicinal plants used in Ceylon, Part III)

Plant Material of Interest

Leaves.

Official Drug

Parenchyma gel of leaves (Aloe gel, Aloe Vera), juice of leaves (exudate). The commercial drug is a hard dark mass (musabber) which is derived from yellow juice (dried juice of leaves)[2,3].

Pharmacognostic Features*

Anatomy

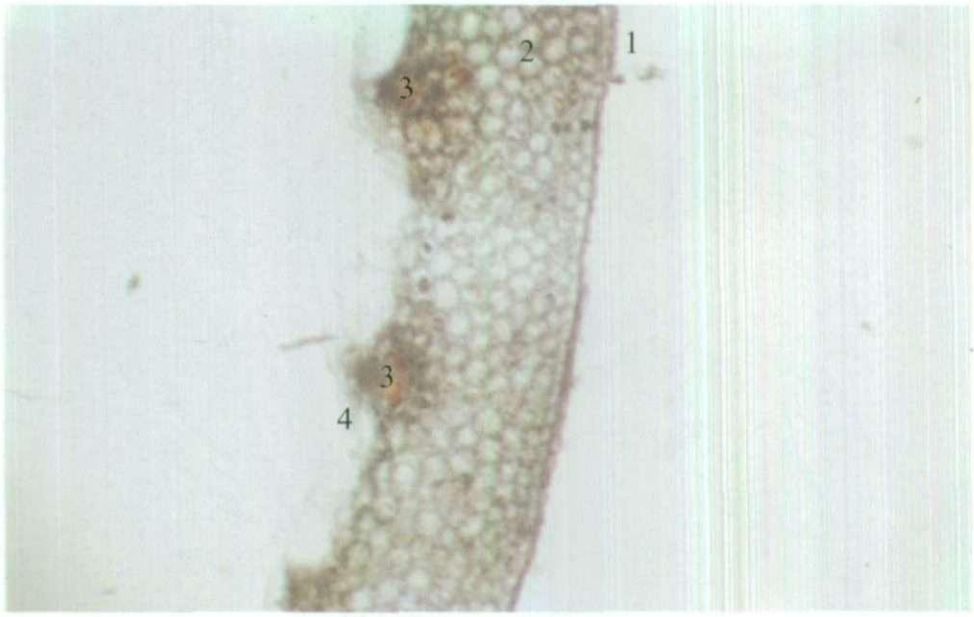


Fig – 2. Cross section of *Aloe vera* leaf (stained with safranine (10 x 10))

1. Epidermis 2. Parenchyma cells containing chloroplasts 3. Vascular bundle
4. Parenchyma (water storage tissue)

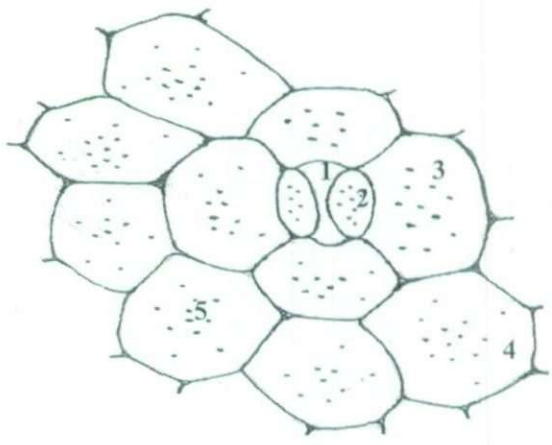


Fig – 3. Schematic diagram of epidermis of leaf

1. Stomatal pore 2. Guard cells 3. Subsidiary cells 4. Epidermal cells 5. Chloroplasts

Powder analysis

Part analyzed – Dried leaf

Organoleptic properties

Colour –Yellowish brown

Odour – Odourless

Taste – Slightly bitter taste

Microscopic characters

Parenchyma cells can be mainly seen. Stomata, Xylem vessels and fibers too can be seen.

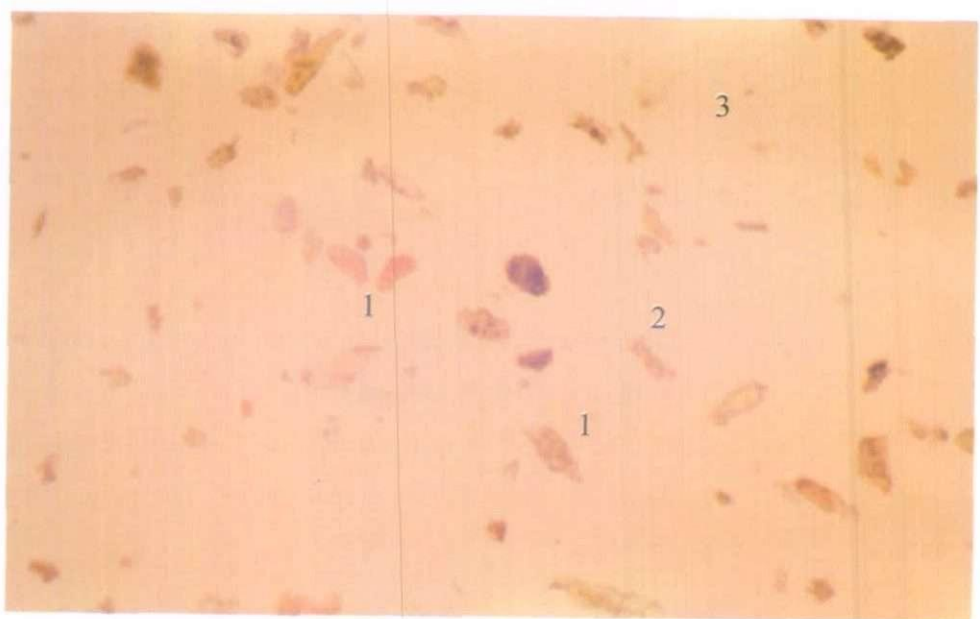


Fig – 4. Powdered plant material (leaf) under the microscope (10 x 4).
1. Parenchyma cells 2. Part of a vessel 3. Part of a fiber

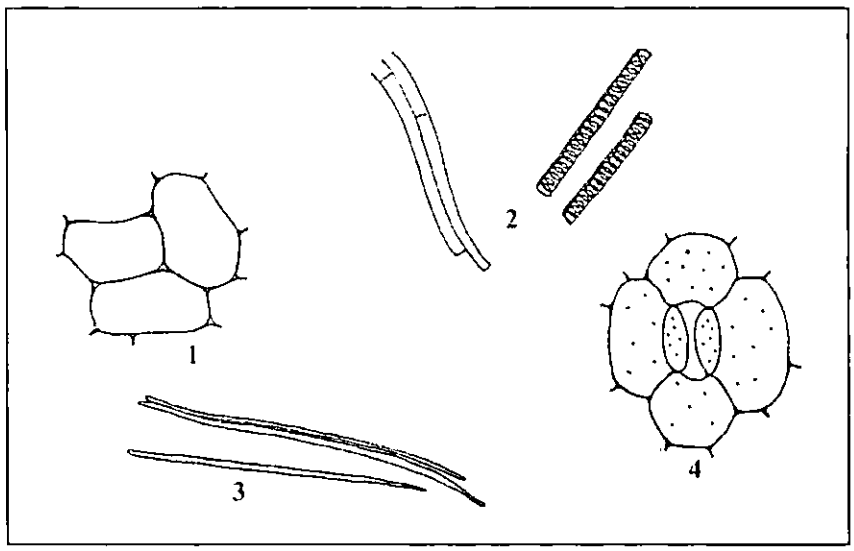


Fig – 5. Schematic diagram of powder microscopy

1. Parenchyma cells 2. Xylem vessels 3. Fibers 4. Stomata with subsidiary cells

Physico-chemical Analysis[156]

Extractable matter

Crushed, dried plant material (about 4 g) was weighed to a glass-stoppered conical flask. Solvent (100 mL) was added, weighed, shaken well and allowed to stand for 1h. It was then boiled for 1h and cooled. The weight was readjusted with specified solvent and filtered. Filtrate (25 mL) was taken, solvent was evaporated and oven dried at 105 ^{0}C for 6h, cooled in a desiccator and weighed.

Total ash

Crushed, air dried plant material (about 4 g) was weighed to a previously ignited crucible. The material was ignited by gradually increasing the temperature to 550 ^{0}C until it was free from carbon. The crucible was cooled and weighed.

* These analysis were carried out by the authors at Industrial Technology Institute and the Dept. of Plant Sciences and Dept. of Zoology of University of Colombo.

Water soluble ash

Water (25 mL) was added to the crucible containing total ash, covered with a watch glass and boiled gently for 5 min. The insoluble matter was collected on an ashless filter paper and washed with hot water. The filter paper containing the insoluble matter was transferred to the original crucible and ignited for 15 min. at a temperature not exceeding 450 ^{0}C. Water soluble ash is the calculated difference in weight between the total ash and the residue remaining after treatment of the total ash with water.

Moisture content of the samples was estimated and all the calculations were done on dry weight basis.

Table 1. Physico-chemical parameters of *Aloe vera* leaf**

Physico-chemical parameter	Amount %
1. Water extractable matter	65.2 – 71.7
2. Ethanol extractable matter	51.4 – 55.3
3. Total ash	7.7 – 10.3
4. Water soluble ash	1.3 – 2.5

(Results are expressed as percentages on dry weight basis)

Thin Layer Chromatographic Profile**

Aloe vera water extract of leaves

Sample preparation : *A. vera* leaves (4 g) were boiled with water (100 mL) for 1h and the extract was filtered and evaporated to dryness. Eight microliters (8 µL) of the diluted extract (65 mg in 3 mL) was spotted on TLC plate.

Absorbent : Silica gel GF_{254}

Solvent system : Ethyl acetate : Methanol : Chloroform (25 : 15 : 20)

Detection

Direct evaluation : UV_{254} nm. R_f values - 0.24, 0.41

UV_{366} nm. R_f values - 0.24, 0.41, 0.62, 0.74

Scanning : Densitometer at 254 nm (before spraying) and 450 nm (after spraying)

Spray reagent : Vanillin sulphate

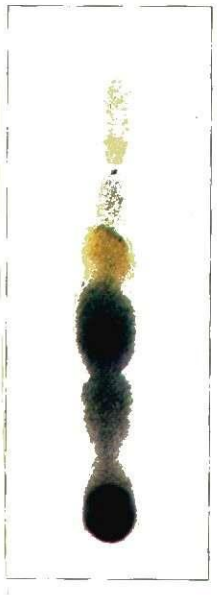
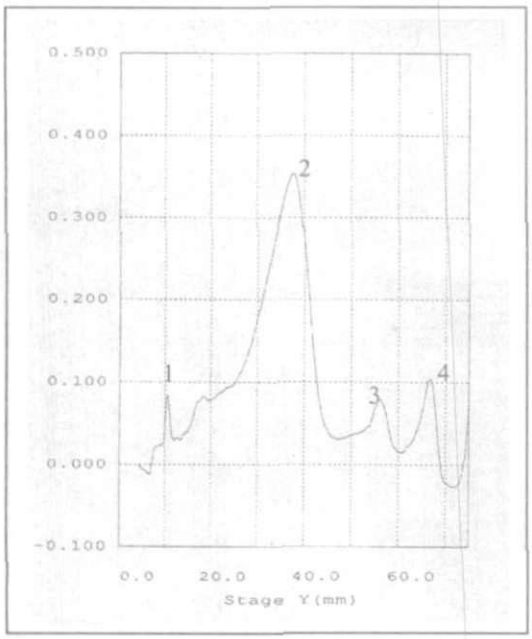


Fig – 4. TLC finger print profile of water extract of *Aloe vera* leaves



Fig–5. Densitogram of TLC finger print profile of water extract of *Aloe vera* leaves at 254 nm

Table 3. Description of densitogram (Fig-6)

Peak no.	Y (mm)	Relative area %
1	10.54	4.08
2	18.36	6.09
3	37.65	69.61
4	65.06	11.95

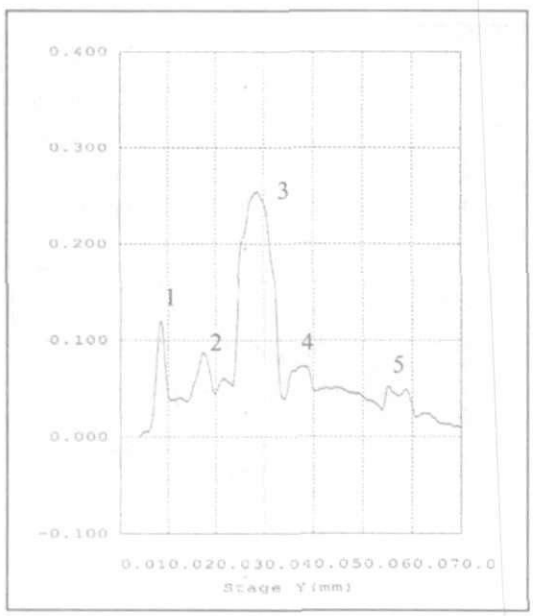


Fig – 6. Densitogram of TLC finger print profile of water extract of *Aloe vera* leaves at 450 nm

Table 3. Description of densitogram (Fig-6)

Peak no.	Y (mm)	Relative area %
1	8.52	7.12
2	12.50	8.64
3	17.46	47.08
4	28.66	9.16
5	55.38	5.84

***Aloe vera* ethanol extract of leaves**

Sample preparation : *A. vera* leaves (4 g) were boiled with 95% ethanol (100 mL) for 1h and the extract was filtered and evaporated to dryness. Eight microliters (8 µL) of the diluted extract (67 mg in 3 mL) was spotted on TLC plate.

Absorbent : Silica gel GF_{254}

Solvent system : Ethyl acetate : Methanol : Chloroform (20 : 15 : 25)

Detection

Direct evaluation : UV 254 nm, R_f values - 0.15, 0.71, 0.95
UV 366 nm, R_f values - 0.15, 0.27, 0.42, 0.71, 0.95

Scanning : Densitometer at 254 nm (before spraying) and 450 nm (after spraying)

Spray reagent : Vanillin sulphate

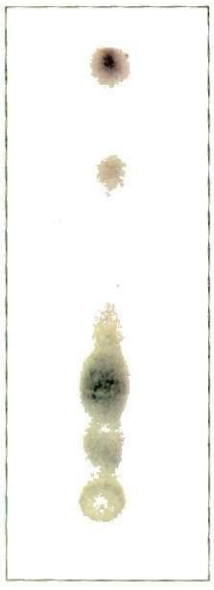


Fig – 7. TLC finger print profile of ethanol extract of *Aloe vera* leaves

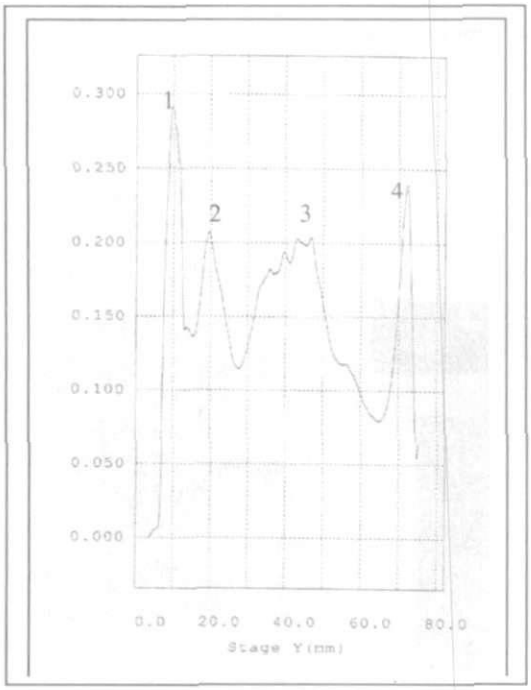


Fig – 8. Densitogram of TLC finger print profile of ethanol extract of *Aloe vera* leaves at 254 nm

Table 4. Description of densitogram (Fig-8)

Peak no.	Y (mm)	Relative area %
1	9.75	24.61
2	19.66	24.55
3	43.13	41.53
4	72.10	20.25

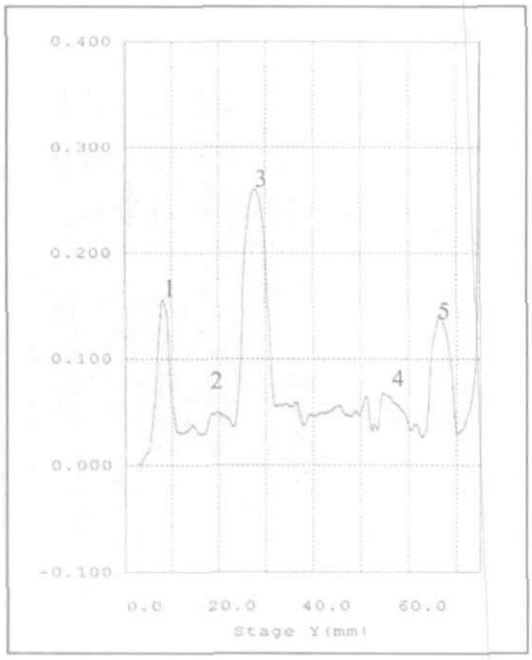


Fig – 9. Densitogram of TLC finger print profile of ethanol extract of *Aloe vera* leaves at 450 nm

Table 5. Description of densitogram (Fig-9)

Peak no.	Y (mm)	Relative area %
1	8.16	14.95
2	19.87	6.54
3	27.76	38.7
4	55.11	6.54
5	66.45	12.91

High Pressure Liquid Chromatographic Profile**

***Aloe vera* water extract of leaves**

Sample preparation : *A. vera* leaves (4 g) were boiled with water (100 mL) for 1h and the extract was filtered and evaporated to dryness. The diluted extract (8 mg in 5 mL) was purified using Sep-pak C18 cartridge.

Injection volume : 20 μL

Apparatus : Shimadzu LC – 10 ADvp pumps and Shimadzu SPD – M 10 Avp uv / vis photodiode array detector.

Column : Inertsil 5U ODS – 2 reverse phase column, (250 x 2.6 mm).

Solvent system : Acetonitrile : Water (30 : 70)

Flow rate : 1 mL/min

Detection : 254 nm

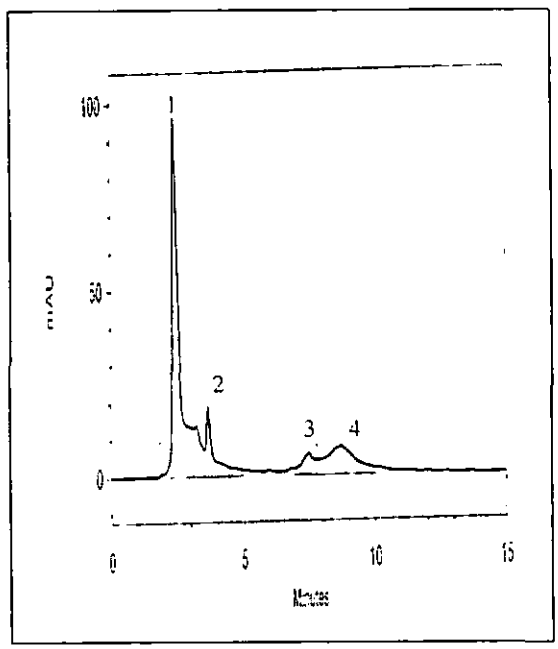


Fig – 10. HPLC finger print profile of water extract of *Aloe vera* leaves

Table 6. Retention time of main peaks.

Peak no.	Retention time (min)	Relative area %
1	2.40	44.76
2	3.66	13.14
3	7.49	6.69
4	8.72	20.00

***Aloe vera* ethanol extract of leaves**

Sample preparation	:	*A. vera* leaves (4 g) were boiled with 95% ethanol (100 mL) for 1h and the extract was filtered and evaporated to dryness. The diluted extract (6 mg in 5 mL) was purified using Sep-pak C18 cartridge.
Injection volume	:	20 μL
Apparatus	:	Shimadzu LC – 10 ADvp pumps and Shimadzu SPD – M 10 Avp uv / vis photodiode array detector.
Column	:	Inertsil 5U ODS – 2 reverse phase column, (250 x 2.6 mm).
Solvent system	:	Methanol : Water (70 : 30)
Flow rate	:	0.5 mL/min
Detection	:	254 nm

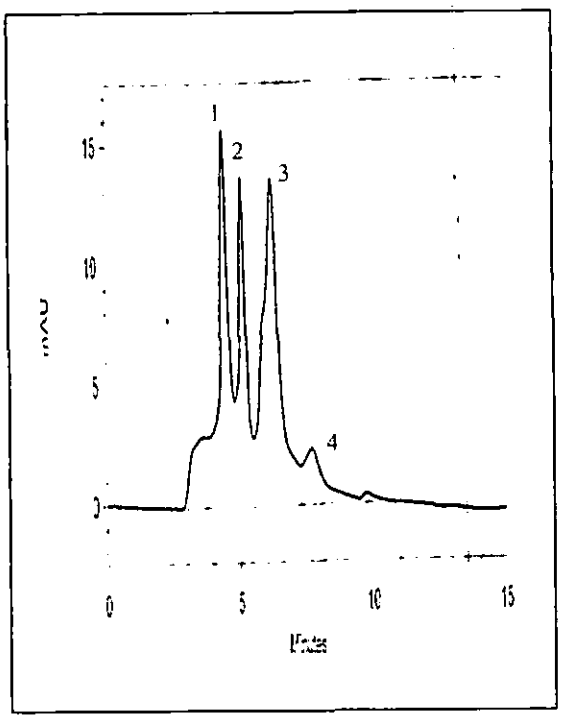


Fig – 11. HPLC finger print profile of ethanol extract of *Aloe vera* leaves

Table 7. Retention time of main peaks.

Peak no.	Retention time (min)	Relative area %
1	4.44	26.14
2	5.12	18.43
3	6.25	38.57
4	7.71	8.37

** These analysis were carried out by the authors at Industrial Technology Institute.

Phytochemistry

The major chemical constituents of *A. vera* are polysaccharides and water.

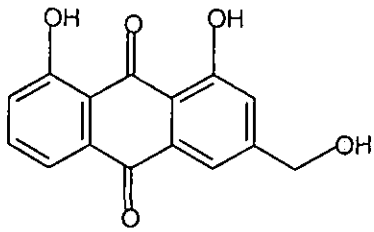
Following chemical constituents are also reported in *A. vera* plant. Iso-barbaloin and nataloin, homonataloin(7), α-cellulose, uronic acid, enzymes (oxidase, catalase, amylase, cellulase, proteinase), xylan, polyuronide, lignin, hydroxymethylanthraquinone, saponin, anthraquinone, polyphenols, triterpenoids, glucosamine, glucomannon, hexauronic acid, casanthranol I and II, aloetic acid, sapogenin, hecogenin, m-protocatechuic aldehyde, imidazole derivatives, erythritol, glycerol, hydrocinnamic acids, pectic acid, flavones, vitamins, minerals[22].

Aloe leaf contains acemannan, aloe-emodin(1), aloesin, aloin, aloin A(5), aloin B(6), anthranol, monosaccharides (glucose, fructose, arabinose, mannose, galactose), barbaloin(2), amino acids (arginine, asparagine, histidine, leucine, isoleucine, thyrocine, valine, lysine), sterols (cholesterol(10), campesterol(11), β-sitosterol(12), lupeol(9)), β-carotene, chrysophanic acid, glutamic acid[12,15,18,19,20,21].

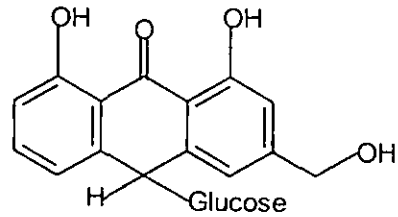
Leaf juice and the gel are parts of *A. vera* leaf. The following chemical constituents have been reported in these parts of leaf.

Aloe leaf juice contains aloe-emdodin(1), anthranol, barbaloin(2), β- barbaloin, chrysophanol(4), p-coumaric acid(3), cystine, histidine, hydroxy proline polysaccharides[11,12].

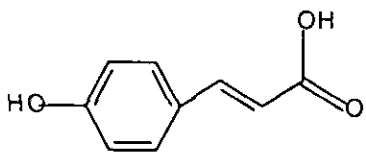
A. vera gel contains aloe-emdodin(1), arachidic acid, arachidic acid methyl ester, arachidonic acid, behenic acid methyl ester, dehydro abetic acid methyl ester, 2(3H)benzothiozolone, cycloeicosane, cyclohexane, N-eicosane, N-docosane, N-heneicosane, freidooleanan-3-one, heneicosanoic acid methyl ester, lauric acid, linoleic acid, margaric acid, myristic acid, palmitic acid, palmitoleic acid methyl ester, pentadecanoic acid, stearic acid, tricosanoic acid methyl ester, N-octadecane, oleic acid methyl ester, oleic acid ethyl ester, uronic acid, enzymes (oxidase, catalase, amylase), galacturonic acid, monosaccharides (glucose, galactose, rhamnose, xylose, arabinose) lactate, salicylic acid, glucomannan, acetylated glucomannan and inorganic ions[12,13,14,15,16,17].



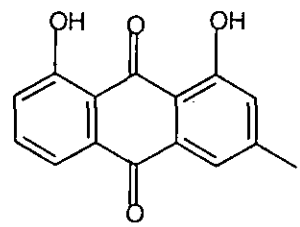
(1) Aloe-emodin



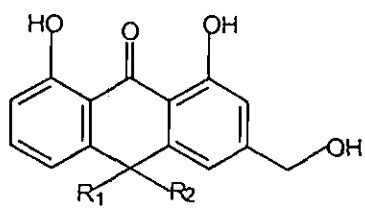
(2) Barbaloin



(3) p-Coumaric acid



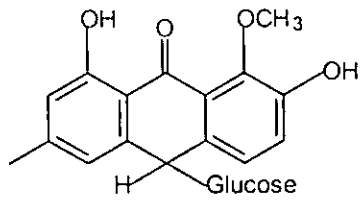
(4) Chrisophanol



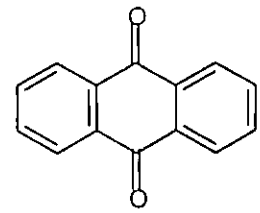
(5) Aloin A - R_1 = H, R_2 = Glucose

(6) Aloin B - R_1 = Glucose, R_2 = H

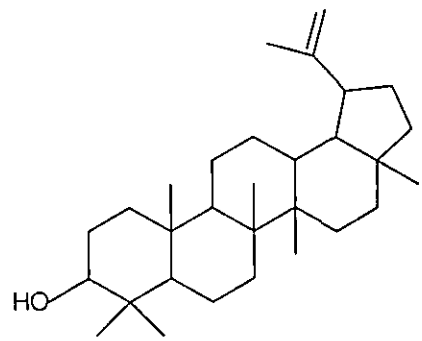
Fig – 12. Compounds present in *Aloe vera*



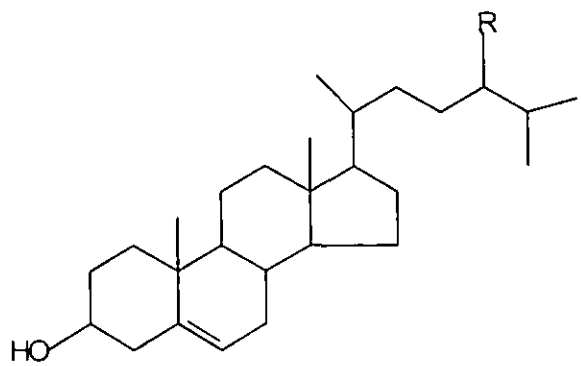
(7) Homonataloin



(8) Anthraquinone



(9) Lupeol



(10) Cholesterol R = H

(11) Campesterol R = CH_3

(12) β-Sitosterol R = CH_2-CH_3

Fig – 13. Compounds present in *Aloe vera*

Medicinal Uses

Uses described in pharmacopoeia and other traditional systems of medicine

According to the traditional systems of medicine *A. vera* has properties of alleviating the "Three Dosas"[23,24,25,26].

The plant is bitter, cooling[3,5,23,24,27], tonic[5,27,28,29], aphrodisiac[5,27], anthelmintic[3,5,23,25], alexiteric[3,5,27], fattening[5,27], aperient, ophthalmic[3]; useful in eye diseases[1,3,5,23,30], tumors[5,23,25], fever[23,25,31], fever due to bronchitis, vomiting, erysipelas, biliousness, leprosy[5], skin diseases[1,3,5,23,25], asthma[1,5], jaundice[5,23], ulcers and pains[5,23,24,25]. Aloe has diuretic properties and is useful in disuria and urinary disorders[23,24,25,26]. It purifies blood[23,24,25], applied on wounds and good for painful inflammations[23,24,25].

A. vera has been used in diseases associated with the digestive system. It is purgative[5,23,25,29,31,32,33,34], carminative[3,5,26,28] and laxative[26,28,33,35,36]; used in dispepsia[1,3,5,23,37], piles[1,5,32,33] and rectal fissures[32,33]; good for distention of abdomen and promotes downward movement of wind in stomach[26]. It is said to improve appetite[23,24,25], promotes digestion[24,226,28] and relieves constipation[1,3,5,25,26,29,37]. It is given for enlargement of spleen and liver complaints[3,5,23,24,25]. Aloe is emmenagogue[3,5,28,29,32,37]. It produces pronounced pelvic congestion[28,33] and used in menstrual suppressions and menstrual pains[5,25,28,29].

The fresh juice of leaves is cathartic[1,5] and cooling[28,29], useful in fevers[5,28], treatment of abrasions, burns and skin irritations[28] and eye diseases[1,5,25].

The dried juice of *A. vera*, "bitter Aloe" or "mussabar" (titta abin in Sinhala) is a very useful drug in the Ayurvedic medicinal system. It is used in a large number of Ayurvedic preparations to treat tumors, spleen and liver troubles, flatus, dysurea, epilepsy, piles, jaundice, abdominal pain, inflammations, asthma, cough and uterine pain[4]. The dried juice is considered to be anthelmintic[3,28], cathartic[28,29] (acting on large intestine), purgative[3,32], emmenagogue[3,28,32], stomachic[28,32] and vermifuge[28].

The cooling mucilage is used as a poultice on inflammations caused by x-ray and other radiation burns. The pulp of leaves is said to possess wound healing activity and is used for intestinal ailments, sore throat and ulcers[28].

The root of the plant is given for colics[29]. A decoction of the root is given for stomach cancer[28].

The flowers are anthelmintic, useful in biliousness and "vata"[5].

Uses in folk medicine

Fresh Aloe leaf gel is applied on burns[23,24,28]. It is kept on closed eyes for headaches with under eye pain[23]. One teaspoonful of Aloe leaf gel at a time is given to dissolve blood clots[23]. The ground mixture of Aloe leaf gel and green gram is eaten with jaggery to soothe the burning sensation in stomach[24]. A mixture of Aloe leaf gel and passion fruit is applied on hair for dandruff[24].

A drink made of leaf pulp of Aloe and *Genipa americana* is a popular remedy for colds in USA[38]. Leaf pulp is a refrigerant medicine in conjunctivitis, with small quantity of sugar-candy. Leaf pulp with addition of burnt alum is being used in ophthalmia. Tender pulp is eaten for rheumatism and also in menstrual suppression and piles[27].

Fresh juice has been used in fevers, liver problems, gonorrhea, methritis and external refrigerant. application for local inflamations[27]. Filtered juice of the mixture of *Terminalia chebula* seed powder and Aloe leaf gel have been put into the eye to prevent tearing[24]. A plaster of the leaf or the leaf juice is said to be a folk remedy for tumors[28]. The throat is washed with Aloe juice for sore throat[23]. Leaf juice mixed with gingerly oil and boiled makes a fine hair-oil used in cases of sleeplessness. It is mixed with opium and applied to forehead to relieve headache[27]. Turmeric with leaf juice is given in glandular enlargement and spleen diseases[27].
A decoction of the root is said to be a remedy for stomach cancer[28].

When sharp thorns pierce the skin, turmeric and scraped coconut are ground together, placed in the middle of the Aloe leaf, kept on warm charcoal and wrapped around the area[23].

A mixture of *Zingiber officinale, Mentha pulegium* (essential oil), *A. vera, Ipomoea purga, Glycyrrhiza glabra* and *Centella alba* is used for amenorrhea[39].

The water extract of Aloe is used against worms[40].

The plant is used as a contraceptive and as an abortifacient[41,42,43,44].

Tender leaves of Aloe mixed with cumin seed and sugar-candy is a remedy for dysentery with bloody stools[27].

In USSR, Aloe juice, Aloe emulsion and Aloe syrup with iron are in use. Aloe juice is used for treating burns, suppurative wounds and tropic ulcers. The thick syrup of Aloe with iron is effective against anaemia and the pulp of the leaves is used for bruises, sunburns, boils and carbuncles[37].

In Philippines the juice is applied to prevent the falling of hair and to cure baldness[1].

In Chinese medicine *A. vera* is used against intestinal parasites, as a laxative and to facilitate digestion. It is also used in cases of chronic constipation and amenorrhea, liver and eye troubles, against piles, infantile intestinal tuberculosis, convulsions, and epilepsy[26].

In western countries *A. vera* is used as a purgative, anti-gripe medicine in connection with other carminatives, laxative, to heal burns and wounds, cuts, sunburn, as a digestive, for hair and scalp care, skin care, varicose veins, psoriasis and eczematous rashes and as cleanser[26].

Aloe is also used in veterinary medicine[23].

Other Uses

A. vera gel is extensively used in shampoos, face creams, lotions, cleansers and ointments[10,27,37].

It is used as an ingredient in most major categories of food products including alcoholic beverages (bitters, liqueurs, vermouths) and nonalcoholic beverages, frozen dairy desserts, candy, baked goods, gelatins and puddings[28].

Bottled *A. vera* is available in the USA for internal consumption as a tonic[10].

The plant is used as a repellent to insect pests (as a white ant repellent)[45].

Aloe leaf is cooked as a vegetable[23].

In home gardens it is grown as an ornamental plant.

Products Developed From *Aloe vera*

Cosmetics and toiletries - Facial moisturizers, Hand and body lotions, Cleansing agents, After bath moisturizers, Make-up removers, Suncare products, Shaving preparations, Hair care products, Mascara and eyelash conditioning products[46].

First aid applications - Topical analgesic / anaesthetic preparations, Anti-acne gel, Bedsore preparations, Antiviral / antibacterial topicals, Lip gel, Wet dressings[46].

Other products- *A. vera* gel, *A. vera* powder, oil extract, Shealoe (*A. vera* gel and Shea butter)[42].

Products developed at Industrial Technology Institute

Cosmetics and toiletries - Shampoo, Body gel, Hand wash, Aloe moisturizer[47].

First aid applications - Burn creams[47]

Food and beverages - Aloe jelly, Aloe drink[47].

Ayurvedic / Traditional Medicinal Preparations

A. vera is used as a constituent of the following Ayurvedic preparations.

Prameha gajankushaya, Ranahansa rasayana, Kumaryasava, Kumari taila, Nayanabharana tila, netrapatala kantiratna tila, Batu tila, bodhisatva tila, Svasavajra tila, kumarika vati, Rajapravatani vati, Kumaripaka, Chandrashura rasa, Pradarantaka rasa, Brihadchandrodaya makaradhwaja (Purna chandrodaya rasa), Hemagarbhapottali rasa, Kumarivati[3,23,48].

Activity Studies

Anti-inflammatory activity

Anti-inflammatory activity of *A. vera* has been investigated by a number of in vitro and *in vivo* studies[49,50,51]. Continuing research into inflammation has shown that it is a complex process involving many biochemical pathways and a variety of agents and mediators. In particular three components are distinguished.

1. Vasoactive substances; agents causing dilation of blood vessels and opening of junctions between cells of the ultimate capillaries, produced by altering contractile elements in endothelial cells. These factors include vasoactive amines, bradykinin and also prostaglandins.
2. Chemotactic factors; these agents cause increased cell motility, especially of white blood cells (leucocytes) into stressed areas. These factors include several proteins and enzymes.
3. Degradative enzymes; these are hydrolytic enzymes breaking down tissue components.

It was also shown that Aloe gel contained both an inhibitory system and a stimulatory system that influenced both inflammatory and immune responses[50,51,53,54].

The gel relieved the inflammatory effect induced by carrageenan, albumin, gelatin, mustard and croton oil either by promoting prostaglandin synthesis or by increasing infiltration of leucocytes[51]. Some studies have shown that the gel exerts its anti-inflammatory activity through bradykinase activity[52] and thromboxane B_2 and prostaglandin F_2 inhibition[14]. Some experiments have shown anti-lipoxygenase activity of *A. vera* extracts. This finding could explain the inhibitory effect of the *A. vera* in acute inflammation process[56]. Three plant sterol compounds in *A. vera* gel reduced inflammation up to 37% in croton oil induced oedema in mice[57]. The externally used aqueous extract of Aloe has shown anti-inflammatory effects[58,59,60,61,62].

Some experiments have shown *A. vera* extract has decreased inflammation due to adjuvant arthritis[52].

Wound healing and burn treatment

A. vera gel has beneficial effects on wound healing[49,60,63,64]. It has been found that externally used Aloe leaf juice can accelerate the wound healing process[65,66,67]. Various mechanisms have been proposed for the alleged healing properties of *A. vera* gel. It is

possible that the gel may have more than one physiological effect. It is commonly suggested that there is a synergistic effect between the various components and the polysaccharide base[10]. Angiogenesis is an essential process in wound healing and some studies suggest that the gel contains angiogenic compounds[68]. It is found that therapeutic effect of the gel includes the prevention of dermal injuries caused by burns, frostbite, electric injury and inadvertent arterial drug abuse[69]. *In vitro* studies have demonstrated that *A. vera* gel promotes wound healing by directly stimulating the activity of microphages and fibroblasts[70]. Increased collagen formation in wounded diabetes rats treated orally and topically with Aloe gel was demonstrated[52]. Healing and control of acute inflammation, distinct from chronic inflammation, was observed following gel treatment of excision and incision wounds in rats[52]. Acemannan, a complex carbohydrate isolated from Aloe leaves, has been shown to accelerate wound healing and reduce radiation induced skin reactions[71]. Acemannan can activate macrophages and macrophages play a considerable part in controlling microorganisms. It was shown that young active macrophages accelerated the rate of wound healing in aged rats[52]. A carbohydrate fraction of *A. vera* showed haematopoietic activity[72].

Effects of *A. vera* on wounds caused by thermal burns and radiation burns have been studied[52,73,74,75,76]. It was found that *A. vera* could inhibit the inflammatory processes following burn injury, as characterized by the reduction of leukocyte adhesion, as well as pro-inflammatory cytokines[77]. *A. vera* gel on burn wounds in guinea pigs have shown promising effects of healing[78].

Antioxidant activity

Antioxidant potential of *A. vera* has been evaluated and it was suggested that the growth stage play a vital role in the composition and the antioxidant activity of *A. vera*[79]. Studies have shown that the synergistic relation between the elements found in the leaf of *A. vera* could be a useful adjunct for maintaining the integrity of the antioxidant status[80]. It was found that the supplementation of *A. vera* extract has preventive effects in attenuating oxidative damage in brain regions of streptozotocin induced diabetes rats via antioxidative mechanism[81].

Anti-tumor activity

Anti-tumor activity of *A. vera* was observed[52] and it was shown that Aloe juice[82], the ethanol extract[83] and the polysaccharides isolated from Aloe[84,85] possess anti-tumor activity. Studies have shown that Aloe-emodin has anti-tumor activity[86].

Anti-diabetes activity

Effect of Aloe gel on blood glucose level of diabetes patients has been investigated. Administration to non-insulin dependent human patients in small trials resulted in a sustained lowering of blood glucose level[52]. *A. vera* leaf gel and pulp extract showed the protective effect on mild damage on kidney tissues[87] and hepatotoxicity of liver[88] caused by type-II diabetes in rats. Studies have confirmed the ethnopharmacological use of *A. vera* in ameliorating the oxidative stress found in diabetic rats[89]. The supplementation of *A. vera* showed the preventive effect in attenuating oxidative damage in brain regions of streptozotocin induced diabetic rats[81]. Hypoglycemic activity was studied in alcoholic extract, aqueous extract and the juice of Aloe[90,91,92]. Anti-hyperglycaemic activity was also studied in Aloe sap and aqueous extract[93,94].

Radioprotective effects

Aloe polysaccharides showed radioprotective effects on non-tumor cells[95]. Aloe polysaccharides exert radioprotective effects *in vitro* and *in vivo* through inhibition of apoptosis[96].

Effects on immune system

Immunomodulatory activity of bitter yellow juice of *A. vera* has been studied in mice bearing murine Lymphoma. In this study, restoration of immunological parameters in cellular immune response and phagocytosis and the stimulation of specific and non specific responses were observed[97]. Immunomodulatory activity has been also observed in aqueous extract of *A. vera* gel[98]. Externally used lyophilized extract of *A. vera* has shown immunostimulant activity[99]. Polysaccharide fraction and Aloe aqueous extract have shown anticomplement activity[100,101,102]. It has also acted as an immunological adjuvant on specific antibody production[102] and enhanced the release of cytokines[159]. Release of these cytokines stimulates the replication of fibroblast in tissue culture and enhances macrophage phagocytosis[159].

Effects on gastrointestinal function and ulcers

Dietary supplement of *A. vera* can suppress age-related increases in hepatic cholesterol[103]. Aloe gel is effective in the treatment of peptic ulcers and has protective effects on gastric mucosa[52,104,105]. *In vitro* studies provided support that it may have a therapeutic effect in inflammatory bowel disease[106]. Preadministration of a water extract of whole *A. vera* leaves to rats, reversed the inhibition by blood ethanol of alcohol dehydrogenase and aldehyde dehydrogenase activities. It also reversed the increase of lactate/pyruate ratio which could decrease NAD supply[52].

Anti-microbial activity

Anti-bacterial activity of *A. vera* was observed against *Proteus vulgaris* and *Pseudomonas aeruginosa*[82]. The fresh juice showed activity against *Corynebacterium xerosis, Bacillus subtilis, Enterobacter* species, *Escherichia coli, Serratia marcescens, Staphylococcus aureus* and *Streptococcus pyogenes*[107,108,109].

Anti-viral activity against Distortion ringspot virus, Mild mosaic virus and Ringspot virus was observed in ethanol extract of *A. vera*[110]. Methanol extract of *A. vera* leaf showed antiviral activity against Herpes simplex 1and 2 virus[111]. Acemannan found in *A. vera* gel has shown to inhibit AIDS virus replication *in vitro* and an injectable form has been found to be of significant benefit in FIV-infected cats[160,161].

Fresh juice of leaves has shown anti-fungal activity against *Candida albicans* (yeast species)[108].

Effects on fertility and pregnancy

Ethanol and petether extract of Aloe showed anti-implantation activity when orally administered to female mice[112]. Embryotoxic effects on pregnant rats have been studied in water extract, ethanol extract, benzene extract and ethanol : water (1:1) extract[113,114]. Some studies have shown Aloe water extract and tincture possess uterine stimulant effects[115,116]. Teratogenic effects were also studied in Aloe water extract[43,117].

Hypocholesterolemic activity

Water extract of *A. vera* has shown hypocholesterolemic activity in rats[91]. Studies have suggested that dietary Aloe supplementation suppresses free radical induced oxidative damage and age related increase in hepatic cholesterol[103].

Analgesic activity

Analgesic activity of *A. vera* was observed in ethanol and water extracts in mice[61,118,119]. Externally used leaf pulp of Aloe has shown analgesic activity in human adults[64].

Stimulation effects

Fresh leaf juice of Aloe has the effect of stimulating the growth of hair[65]. Tincture of Aloe possesses smooth muscle stimulant activity in isolated rat ileum[120].

Plant growth inhibition

Water extract of leaf and dried stem of Aloe possess plant germination inhibition effects[121].

Anti-pyretic activity

Ethanol extract of Aloe has shown antipyretic effect in mouse[118]

The use of *A. vera* gel has also been described in veterinary medicine. It is also used to treat a variety of dental conditions[10].

Safety Evaluation

Plant extract at oral doses of 100 and 200 mg/kg did not show any toxicity in rats. Prolonged use may severely affect the electrolyte balance and loss of potassium ultimately may reduce the laxative action and disturb cardiac rhythm in heart patients. Larger doses lead to accumulation of blood in the pelvic region and reflux stimulation of uterine muscles may bring about abortion or premature birth in late pregnancy. Toxic doses may also cause kidney damage. Active principles generally appear in milk during lactation. Due to these reasons the drug is contraindicated in pregnancy, lactation, kidney complaints and irritable bowel conditions. LD_{50} in mice by *i.v.*, *i.p.* and oral routes were found to be 400 mg/kg, 800 mg/kg and 1600 mg/kg respectively[3].

A. vera has protective effects against some toxicity effects of arsenic in rats[122]

Patent Information

- Skin adhesive cosmetic for removing wrinkles, containing vitamins and Aloe extract[123]
- Improved vitamin A palmitate composition for topical application to the skin[124]
- Chlorine dioxide skin medicating compositions for preventing irritation[125]
- Skin conditioner[126]
- Skin enhancing glove containing *A. vera*[127]
- Post hair removal skin care lotion[128]
- Skin cosmetic[129130]
- Novel skin drug for external use[131]
- Skin and mucosal treatment formulation[132]
- Anti-inflammatory and wound-healing topical skin preparations containing Aloe extract and ellagic acids[133]
- Hair regenerator based on Aloe extract[134]
- Aloe gel possessing anaesthetic activity[135]
- Stabilized *A. vera* gel[136137]
- Analgesic gel composition for temporary relief from symptoms of arthritis[138]
- Lip balm composition[139].
- Medicated gel[140]
- Pad for applying medicaments[141]
- Topical agent and method for the treatment of pseudofolliculitis barbae[142]
- Aloe water preparation. (can be used in cosmetics for treating skin and hair)[143]
- *A. vera* juice containing pellets and the process for preparation of pellets[144]
- Hypoglycemic polysaccharides extraction from Aloe species[145]
- Hand cleanser[146]
- Wet sanitary pad for cleansing[147]
- Detergents and soaps containing Aloe and herbs[148]
- Shaving soap and aftershave gel[149150]
- Decongestant comprising zinc and vegetable oil[151]
- *A. vera* extracts[152]
- Transdermal delivery system[153]
- Preparation for regulating bowel function[154]

- Antibacterial composition and method of using it[155]
- Fibroblast proliferation promoting agent[156]
- Separation of bitter components in Aloe extracts[157]
- *A. vera* processed leather[158]

Cultivation

Aloe vera Linn. Var. littoralis Koen. is the Aloe species found in Sri Lanka. *A. vera* littoralis grows on the poorest soil, has low water requirements and a tolerance to salinity. It can be grown satisfactorily on the seacoast of the dry zone with little agricultural input although financial return from it will be relatively low in comparison to other medicinal plants.

Propagation is carried out through root suckers. Plants may be placed in rows 1 meter apart, each row 1 meter broad containing 3 plants abreast, each row being 30 cm apart from the next row. This arrangement will facilitate harvesting. The preparation of soil need not exceed 20 cm in depth as the root system of this plant is very shallow. Intercultures may be required from time to time. Water should not be allowed to lodge near the plant as this plant is not water loving and rotting takes place easily when waterlogged.

The plant is ready for harvesting in one year, although best yields are obtained during the third year. Harvesting is carried out by lopping off the leaves of the mature plant.

The crude "Aloes" are derived from the juice of the plant. The juice is obtained when the leaf is cut transversely close to the stem and held vertically. The yellowish juice flows out from the pericycle associated with vascular bundles. This juice is very bitter in taste and has an unpleasant odour. The residual Aloe leaf may be used for the preparation of gel (Aloe Vera) by slitting the leaf longitudinally and removing the gel from the green outer covering of the leaf[32].

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