

Indian Aloe



P.L. Saroj
D.G. Dhandar
R.S. Singh



Central Institute for Arid Horticulture

Bikaner (Rajasthan) - 334006, INDIA

Indian Aloe

Dr. P.L. Saroj
Senior Scientist (Horticulture)

Dr. D.G. Dhandar
Director

Dr. R.S. Singh
Scientist SG (Horticulture)



Central Institute for Arid Horticulture
Bikaner (Rajasthan) - 334006, INDIA

First Edition 2004

Published by

Dr. D.G. Dhandar

Director

Central Institute for Arid Horticulture

Beechwal, Bikaner (Rajasthan)-334006, INDIA

Phone : 0151-2250960, 0151-2250147

Fax : 0151-2250145

E-mail : ciah@hub.nic.in

Computer Processing and Photography

Sh. B.R. Khatri

Sh. Sanjay Patil

Printed by

Rahul Printers

9- Sadul Colony,

Near Tulsi Circle

Bikaner (Rajasthan)

Ph.2526852

Content

1. Introduction	1-2
2. Historical perspective	2-3
3. Composition and uses	3-6
4. Taxonomy	6-10
5. Crop improvement	11
6. Climate and soil	11
7. Agrotechniques	12-16
7.1 Planting	12
7.2 Irrigation	13-14
7.3 Nutrition	14-15
7.4 Interculture	15
7.5 Intercropping	16
8. Physiological disorder	17
9. Pest and disease management	17
10. Harvesting and marketing	17-19
11. Processing	19-23
11.1 Preparation of 'Aloe' product	19
11.2 Preparation of vegetable	21
11.3 Preparation of <i>Laddu</i>	22
11.4 Preparation of pickle	23
12. Economics of Aloe cultivation	24-25
13. References	26-27
Annexure-I	28
Annexure-II	29
Acknowledgement	30

1. Introduction

Indian Aloe (*Aloe barbadensis* Mill.) popularly known as *Ghrit Kumari* in Sanskrit and Bangla, *Ghikwar* in Hindi, *Aloe* in English, *Ghiquara* in Urdu, *Darkhtesibra* in Persian, *Sabbarat* in Arbi, *Guarpatha* in Rajasthani, *Koryed*, *Korkanta* and *Elwa* in Marathi, *Kunwargandal* in Punjabi, *Lolesara* and *Katthaligida* in Kannada, *Kattavala* in Malyalam, *Sirukanthli*, *Sirukattashai*, *Kattazhai*, *Sorttukathali* and *Chirukattali* in Tamil, *Kalawand*, *Manjikattali*, *Pinngorisht Kalvand* and *Chinnakalabanda* in Telgu, *Kumari* and *Mushaboro* in Oriya and *Musabbar* in Kashmiri.

The word 'Aloe' is derived from the Arabic word 'Alloeh', means 'bitter and shiny substance'. Aloe is native to North Africa but found abundantly throughout the warmer part of the world. It is found in wild forms in southern and eastern Africa and the shores of the Red Sea. It is cultivated in the West Indies, Italy, Malta, Sicily; it has been naturalized in Barbados and been found in the Zapata region of Texas (USA). It is reported to grow wild on the island of Cyprus, Malta, Sicily, the Canary Cape, Cape verde and have naturalized over arid tracts all over India. Out of 275 species of Aloe, 42 belongs to Madagascar region (Africa), 12-15 to Arabian Peninsula and rest are distributed over tropical South Africa. In India, only 4 species are reported to occur and of these *Aloe barbadensis* is the most widely naturalized (Anon., 1962). Its spread could be explained by Sumerian's extensive trade with Egypt, from where, it reached rest of the world. The Spanish took Aloe to the new world South America and the Caribbean. The virtues of the plant have been recorded by many great civilizations, from those of Persia and Egypt in the Middle East, to those of Greece and Italy in Europe, to those of India and the African continent. The plant is widely known in Asia and the Pacific, and is found in the folklore of the Japanese, the Philippines and the Hawaiians. The Spanish used Aloe, and carried it with them to their new world colonies in South America and the Caribbean.

In India, although the commercial farming of Aloe is still in its primary stages but in the recent past its cultivation in the semi-arid and arid regions of Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh, Maharastra, Tamil Nadu

and Karnataka is fast catching up. In Rajasthan, Aloe is very popular in Bikaner region and forms an integral part of kitchen gardens and also grown on a limited scale in Alwar (Rajasthan), Satnapalli (Andhra Pradesh), Rajpipla, Ahmedabad, Sardar Krushi nagar and Kachchh region (Gujarat) and Kangayam (Tamil Nadu). Though, exact data are not available about area and production of Aloe, but as an estimate, in India it is occupied about 75 ha area with annual production of 1400 tonnes, out of which about 17 ha area is under Aloe cultivation in Bikaner region only.

2. Historical perspective

The Aloe is one of the most popular natural occurring plants with superb therapeutic uses. The healing properties of the Aloe have been exploited for centuries. In fact, records of its medicinal uses date back over 4000 years. The earliest reference to Aloe is found in the form of *Sumerian Clay Tablets*, in one of the oldest civilizations, the Sumerian civilization located along the rivers 'Tigris' and 'Euphrates' - that date back to 2200-1700 BC, where it is mentioned as a laxative. The Egyptian concoctions for internal and external healing. Aloe was used by ancient Persian healers. It was also used extensively by ancient Indian civilizations for its cathartic, emmenagogue (promotion of menstrual flow) and anti-helmentic (de-worming) properties. Because of its nutritional qualities, anti-oxidant and medicinal properties, it is often called as 'The Miracle Plant', 'The Natural Healer', 'The Health Plant' and by many other names.

It has been mentioned that Aristotle persuaded Alexander the great to capture the Island of Socotra in the Indian Ocean to get the rich supply of Aloe to heal his wounded soldiers. The Egyptian queen also used Aloe in beauty therapy. The mention of medicinal uses of Aloe is also found in Russian, Greek and Romans transcripts. The Bible speaks of Aloe in over a dozen passages, referring to it as the bitter herbs. Greek and Roman physician prescribed Aloe for various ailments between 40 AD and 90 AD. Chinese and Japanese civilizations have also taken advantages of *Aloe vera*'s medicinal properties for centuries.

The studies on clinical applications were started since the inclusion of Aloe in the United States in Pharmacopoeia in 1820. George Ebers in 1862 first discovered its antiquity in an ancient Egyptian papyrus about 3500 B.C., which

was in fact a collection of herbal remedies. Collins and Collins (1935) first described *Aloe vera* in the treatment of radio-dermatitis. Wright (1936) described the use of Aloe in the treatment of radiation ulcers. In 1941, Rowe *et al.*, noted that Aloe helped heal burns faster than any other treatment available at that time. Lushbaugh and Hale (1953) reported further evidence of improved healing in radiation dermatitis and ulcers.

In India the work on Aloe was started in 1990's. The NBPGR, New Delhi, NBRI, Lucknow, NRC on Medicinal and Aromatic Plants, Anand and CAZRI, Jodhpur initiated the work on collection, conservation and evaluation of Aloe germplasm while CIAH, Bikaner initiated work in 1999 on production technology of *Aloe barbadensis* under arid conditions.

3. Composition and uses

The active principle of Aloe is a mixture of glycosides called 'aloin' varies in different species of Aloe. The chief constituent of 'aloin' is 'barbaloin' [Barbaloin-10(1)-deoxyglucosyl aloë-emodin anthrone, $C_{21}H_{22}O_9 \cdot H_2O$, MP-148°-99° (anhyd.)], which is a pale yellow, crystalline glycoside, soluble in water. The other constituents include 'Iso barbaloin', 'Aloe- emodin' (a hydrolytic product of barbaloin), resins and some water-soluble substances. The characteristic odour of gel is due to the traces of an essential oil (Anon., 1959).

The phytochemical analysis of Aloe reveals the presence of aloin, aloë-emodin, monosaccharides, glycosides, sterols triterpenes etc. Pulp/juice i.e. water-soluble fraction contains about 17 amino acids, D-mannose, uranic acid etc. The aloin group of glycosides is the major constituents of Aloe juice or pulp. The percentage of aloin may vary from 10-30%. Besides, some resins and aromatic oils are also found in it. Barbaloin is the main glycoside in aloin which is water soluble. According to Chopra *et al.* (1982) Aloe contain a glucoside group named aloin, which is the active constituent of the drug. It is maximum (30%) in *Curacao* aloes, lesser in *socotrine* and only 10% in cape aloes. Dried juice of aloë leaves is known as 'aloes'. It is also called Kumarisar or Mussabar. The pharmacopia recognizes three types of aloes *Curacao* aloes (obtained from *Aloe barbadensis*), *socotrine* aloes (obtained from *Aloe perryi*) and cape

aloes (obtained from *Aloe ferox*) (Pareek, 1990). The percentage of barbaloin present in different types of Aloe varies to a great extent. Estimation of barbaloin in Indian Aloe obtained from *Aloe vera* var. *officinalis* shows that the Indian species contains less quantity (3.8%) as compared to *Curacao aloe*, which contains about 22%.

The gel prepared from the leaf sap of Aloe contains as many as 75 known ingredients. The rich cocktail of nutritional elements, whose combined action and balance produce a more powerful effect together than, would be expected from the addition of the individual components.

The leaf of Aloe is a treasure house of vitamins, minerals, enzymes, amino acids, sterols and anthroquinones. It contains a wide range of other useful metabolic substances. Aloe is one of the few plant sources in the world of Vitamin B₁₂. It also contains a good amount of Vitamin C, E and β -carotene – a precursor of Vitamin A. The leaves of *Aloe vera* contain protein (3.2 g), fibre (15.2 g), iron (9.4 g) and phosphorus (198.93 mg), which were remarkably high as compared to several vegetables (Sharma and Pareek, 2003).

The minerals including Magnesium, Manganese, Zinc, Copper, Chromium, Calcium, Sodium, Potassium and Iron are also found in considerable amount. Aloe contains 20 amino acids with all the 8 essential amino acids that are not synthesized by human body. The long chain polysaccharides sugars are present in Aloe, which act on the immune system of the body to boost its effect. Among the anthroquinones, the most important one is '*Aloe-emodin*', but altogether, they are strong painkillers and are known to possess anti-bacterial and virucidal activity. In their pure forms, they are very powerful laxatives. Besides these, Aloe leaves also contain salicylic acid, saponins, lignin, etc.

Aloe is being used for curing several ailments for over centuries. In *Ayurvedic* medicines, it is considered as purgative, fattening tonic, aphrodisiac, anthelmintic and alexipharmic. Apart from bactericidal, virucidal and fungicidal properties, the gel is also used as natural cleanser and moisturizer. In India, private sectors are coming forward for preparation of herbal shampoo and now there is high demand of raw materials in form of gel paste.

Now, it is familiar ingredient in range of health care and cosmetic products (Annexure-I). The anti-inflammatory and local anesthetic qualities of aloe gel have made it a household name.

The plant produces at least 6 antiseptic agents such as lupeol, salicylic acid, urea nitrogen, cinnamonic acid, phenols, and sulphur. All of these substances are recognized as antiseptics because they kill or control mould, bacteria, fungus, and viruses. Lupeol and salicylic acid present in the juice are two very effective pain-killer. It contains at least three anti-inflammatory fatty acids, cholesterol, campersterol and B-sitosterol (plant sterols). These are highly effective in treatment for burns, cuts, scrapes, abrasions, allergic reactions, rheumatoid arthritis, rheumatic fever, acid indigestion, ulcers plus many inflammatory conditions of the digestive system and other internal organs, including the stomach, small intestine, colon, liver, kidney and pancreas. Bsitosterol is also a powerful anti-cholestromatic, which helps to lower harmful cholesterol levels, helping to explain its many benefits for heart patients. About 23 polypeptides (immune stimulators) are present in Aloe juice, which helps to control a broad spectrum of immune system diseases and disorders. The polypeptids plus the antitumor agents, Aloe emodin and Aloe lectins, are now also used in treatment of cancer.

Aloe based soft drinks are very popular in California, Japan, Korea and some European countries. The juice of fresh leaf quite popular as elio, is a household remedy for intestinal worms in children and anti-dysenteric. Its local application on painful inflammations of the body and in chronic ulcers is also useful. Kirtikar and Basu (1989) reported that fresh juice of the leaves is cathartic and cooling. Squash made from extract of Aloe is used as tonic. The strained mixture of juice and rose water is useful as eyewash for catarrhal and purulent of ophthalmia and other eye disorders. Regular use of pulp is also useful in abdominal tumours, dropsy, piles, sciatica, rheumatism and retention of urine in fever. The pulp mixed with honey and turmeric powder is also recommended in cough and cold. It is mentioned that Aloe extract is useful in curing of kidney ailments, to develop the mammary glands, to enhance sexual excitement, treatment of tuberculosis, cancer and AIDS etc. but proper clinical studies are needed to verify and to quantify the dose for not only these diseases but also in

several other uses. It has been reported that for ulcers use of 50 ml Aloe juice, for burns and eczema application of gel liberally twice a day and for stimulation of appetite use of 5 drops of tincture in water before meal (Anon., 1996). Nadkerni (1976) also stated various preparations of *Aloe barbadensis* like confection, lotion and juice are useful remedies for curing various diseases.

The leaves of Aloe are also eaten as vegetable. Pickle made by small pieces of leaf pad is a common preparation in western Rajasthan. The immature flower stalk that are completely free from bitter content, are also used for vegetable purpose. Fresh fleshy leaf pad is a part of green *salad* and helpful in treatment of indigestion and constipation. (Sharma and Goel, 2002) standardized the recipes of various Aloe products viz., vegetable, pickles, *laddo*, jam, squash, biscuits and *churna* by using sensory evaluation technique. Saroj and Purohit (2004) standardized the recipe for preparation of some culinary products from sweet type Aloe (*Aloe barbadensis*).

The juice and pulp of Aloe leaves are used in veterinary medicines. Feeding of about 250-500 g mixture of boiled Aloe leaf pad + *gur* daily helps in relief of body swelling, fever and dullness in buffalos. The feeding of Aloe leaf mix with other green fodder and concentrates also improve milk yield in cattle.

The plants of Aloe is very attractive and the leaves are arranged in such a way that it resemble with the lotus petals. It is used as pot plant and also occupy premium place in 'Desert Garden' and 'Rock Gardens'.

4. Taxonomy

Aloe belong to family Liliaceae, is a xerophytic, succulent and perennial plant with multiple tuberous roots and many fibrous supporting roots. It is short, thick, erect and cylindrical perennial plant with a height of 30 to 150 cm. numerous stolon emerge from the base of simple, soft woody stem. The plant has a thick, fibrous root system, which produces large basal leaves. The thick, fleshy, mucilaginous leaves called pads are sessile, densely crowded on the short stem with wide dilated base. The leaves are of spreading nature than ascending

prickles. The leaf surface is quite smooth and shining, dark glaucous green or pale green on both surfaces. Sometimes, mottled leaves are also found in aloe plants (Bentley and Trimen, 2000). The vascular bundles in the leaf are isolated and form a line parallel with the epidermis within the mesophyll. Each bundle has a pericycle formed of large thin walled cells filled with yellowish fluid. The mature leaves are 20-24 inches in height and 4-6 inches across the base, tapering to a point at the end.

The full grown plant produces a single unbranched and/or branched flowering stalk (scape)/inflorescence of 50-100 cm long that is topped by a cluster of bright yellow, red purple or pale striped flowers cylindrical, bisexual with epi-calyx, corolla and six stamens (basifixed, didephous), protogynous, ovary superior, trilocular with axile placentation, buds in the inflorescence is dense racemes terminating the scapes. The flowers are present for most of the year, growing in a long raceme at the top of the scape (Bentley and Trimen, 2000). Flowering stems are oblique at base, erect, stout, smooth, flowers stalked, numerous, erect in the bud afterwards pendulous, arranged in a rather close, narrow erect raceme terminating the scape, bracts exceeding the pedicels, membranous, triangular, acute, reddish, veined and persistent. The fruits are triangular capsules containing numerous seeds. Most of the species are male sterile, with scarcely any fertile pollen, hence plant does not produce many viable seeds.

There are over 350 species of Aloe worldwide, ranging from tiny stem less little plants to tree like plants in south-west Africa, growing several feet in height. Out of 350 different species of the genus 'Aloe' known to exist throughout the world, only five of them are considered to possess therapeutic properties viz., *Aloe barbadensis* (Syn. *Aloe vera*), *Aloe arborensis*, *Aloe saponaria*, *Aloe ferro* and *Aloe perryi*. (Anon, 1959). A number of species have been introduced in India of which *Aloe barbadensis* has become naturalized almost in all parts of the country. It is the most prominently used and studied in most parts of the world, while Japanese have done significant research on *Aloe arborensis* and *Aloe saponaria*. *Aloe ferro* and *Aloe perryi* are used in some parts of Africa. Other species also occur as wild/ornamental at some places. Four types of Aloe are official in Indian Pharmacopoeia i.e. i) *Curacao* Aloe

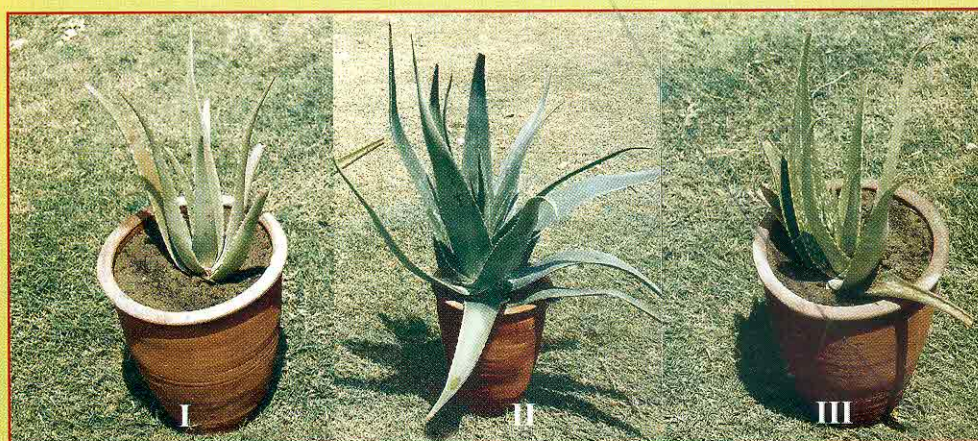
obtained from *Aloe barbadensis*; ii) *Socotrine* Aloe obtained from *Aloe perryi*; iii) *Zanziabar* Aloe; and iv) *Cap* Aloe from *Aloe ferox* and its hybrids (Anon., 2002).

It is pertinent to mention that though there are about 350 species in genus Aloe mentioned in the literature but no distinguishing characters have been given to identify all of them. The existence of 350 species is also under question. However, under natural population, a lot of variability particularly in morphological characters like leaf colour, size, thickness, spininess and presence of spots; growth habit of leaves; taste of leaf flesh; colour of inflorescence etc. were observed. Moreover, these characters are also influenced much by environmental conditions. Therefore, apart from morphometric parameters; bio-chemical and cyto-genetical characterization are essentially required for proper cataloguing of these variable types.

In the Nursery Unit of CIAH, Bikaner (Rajasthan), there are three types of Aloe collected and maintained as given in table 1 and fig. 1 These are supposed to be strain of *Aloe barbadensis*. However sweet and bitter type of Aloe found in north-western part of Rajasthan can easily be distinguished by their leaf thickness and flower colour. The popular sweet type Indian Aloe produces comparatively thinner leaf pad, branched inflorescence and purple colour flower petals while bitter type produces thick narrowly leaf pad, unbranched inflorescence stalk and dark orange colour flowers petals.

Table 1. Characteristic features of three types of Aloe.

Characters	Type-I	Type-II	Type-III
Leaf size	Longer, broader and less acute	Longer, broader and less acute	Shorter, narrower and less acute
Leaf thickness	Thicker	Thinner	Thicker
Pattern of leaf thickness	Basipital	Basipital	Uniform
Leaf colour	Light pale green and translucent	Dark green	Pale green and translucent
Growth habit of leaf	Inwardly	Slightly outwardly	Inwardly
Taste of leaf flesh	Sweet	Bitter	Bitter
Flower colour	Purple	Dark orange	Orange
Use	Culinary, Cosmetic, Medicinal	Cosmetic Medicinal	Cosmetic Medicinal

**Fig. 1 Different types of Indian Aloe**

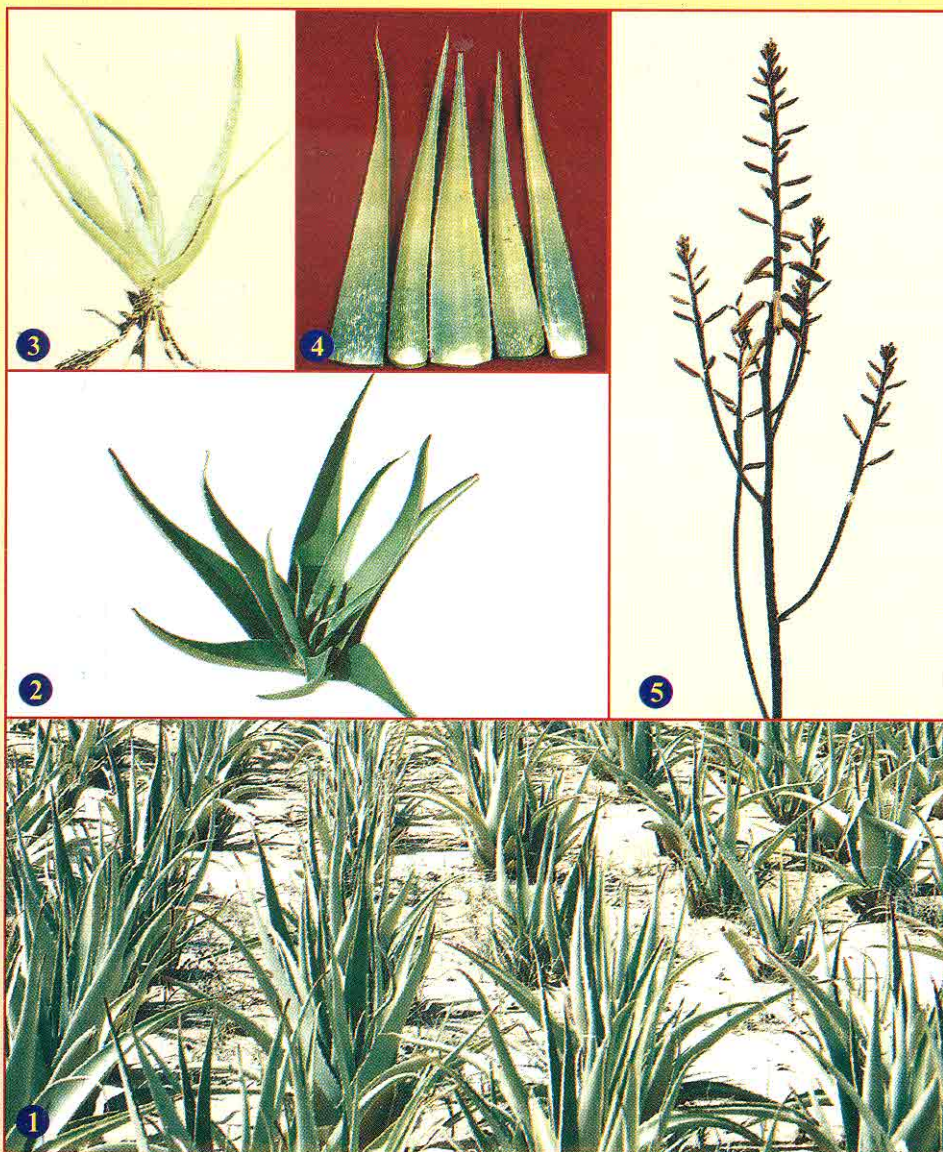


Plate 1. A view of Aloe (*Aloe barbadensis*- sweet type strain) cultivation (1), A Grown-up plant of Aloe (2), Sucker of Aloe (3), Harvested leaf pads (4) and Inflorescence of Indian Aloe (5)

5. Crop improvement

So far no defined cultivar of Aloe is available as it is propagated by suckers owing to least chances of variability but under natural population cross pollination is common. So far no work has been done on the sexual compatibility phenomena of Aloe. Sixteen accessions of Aloe are being maintained at CIMAP, Lucknow. One improved high yielding selection, Akanchha (AL-1) having better quality is under evaluation before release (Anon., 2002). Some high aloin content (20.7-22.8%) genotypes such as IC 111271, IC 111280, IC 111269 and IC 111273 and accessions with high gel content such as IC 111267, IC111266, IC 111280, IC 111272 and IC 111277 were identified by NBPGR, New Delhi; may be cultivated for medicinal and cosmetic purposes. Since, there is a high demand of Indian Aloe for cosmetic and medicine industries as well as culinary purposes, therefore, there is need to evolve varieties based on users group. The sweet type Indian Aloe (*Aloe barbadensis*) is popular mainly in Bikaner region of Rajasthan (Saroj and Purohit, 2004).

6. Climate and Soil

The Aloe grows well in entire tropical, sub-tropical and arid regions of the country, even under constant drought conditions. Hot and dry climate is good for its growth. It can be grown easily in other fertile land also but the plants do not develop in cold climate (Chandra and Pandey, 1989). Since, its water requirement is very low, it is best suited for cultivation in arid and semi-arid regions especially in Rajasthan, Gujarat, Haryana, Punjab, Madhya Pradesh and Maharashtra. However, the *Aloe barbadensis* which is grown in north-western India mainly for vegetable purpose can grow well under irrigated conditions, since only thick and leathery leaf pads are used for the purpose (Saroj and Purohit, 2004).

Aloe can be grown successfully on a variety of soils including marginal to sub marginal soils having low fertility. However, it does well on light well drained sandy loam to rich loam soils. The plants have tendency to tolerate slightly high pH (up to 8.5) and 35-40 ESP level with high Na and K salts. It is also observed that its growth is good under medium fertile heavier soils such as black cotton soils of central India.

7. Agrotechniques

The agrotechniques mentioned below are based on the field experimentation carried out for cultivation of sweet type Indian Aloe (*Aloe barbadensis*) under hot arid irrigated conditions of north-western Rajasthan.

7.1 Planting: The cultivation of Aloe on scientific line is yet to be standardized for different agro-ecological situations. For cultivation of Aloe, the soil preparations need not to be very deep, as the fibrous root system of Aloe does not penetrate to the greater depths. Before planting, the field should be well leveled and made free from boulders and roots of perennial shrubs and trees. Well rotten FYM or compost (15-20 t/ha) should be mixed during field preparation for improving initial soil fertility status of the field. Field may be divided into suitable size plots (6-10 m x 3 m) considering the slope and source of irrigation available.

The Aloe is propagated by suckers, arising near the base of the plant from rhizome (Fig. 2). The healthy suckers with roots having 4-5 leaves are separated from the mother plant and directly planted in the field at a spacing of 60 x 60 cm. The treatment of the base of the suckers by fungicide before planting is also recommended. The closer planting of 50 x 40 cm and 40 x 30 cm under low fertility and water stress situations (Anon., 2002) and 30x30 cm in sandy soils of north-western Rajasthan (Pareek and Mohan, 1995) were also suggested but spacing less than 60 x 60 cm is not advisable for growing of vegetable type Aloe under irrigated conditions (Saroj *et. al.*, 2003). Suckers should be planted in July-August in order to get better field survival and subsequent growth of the plants. However, under irrigated condition, planting can be done any time round the year except in winter months (December-February). Planting during extreme summer (May-June) should also be avoided. After planting of suckers, the soil around the root zone must be firmly pressed followed by irrigation.

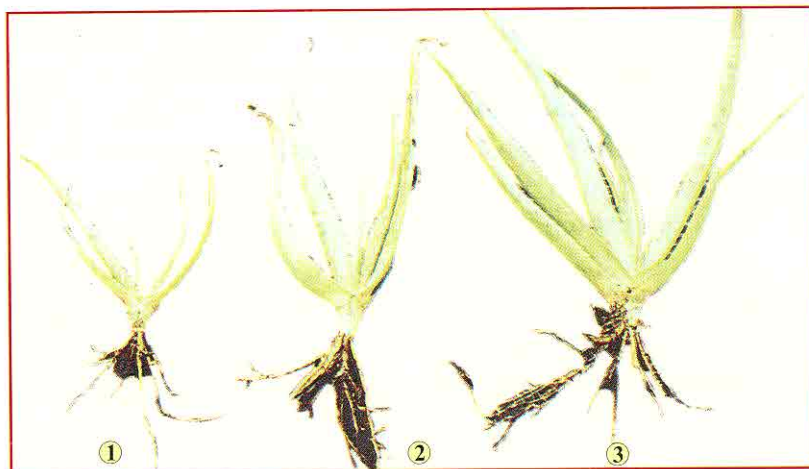


Fig. 2. Sucker of Indian Aloe used for planting
(1. under size, 2. Ideal size and 3. over size)

7.2 Irrigation: The crop withstands water stress condition very well but to get good crop, irrigation at critical stages of growth must be given. First irrigation is required just after planting of suckers followed by 2-3 irrigations at weekly intervals till plant gets established. In general, 2-3 irrigations in summer and 1-2 irrigations in winter may be enough for proper growth of the plants. In semi-arid conditions, once plant is established it can grow even without irrigation. Winter irrigation is helpful to protect the plant from frost. Moreover, the thickness of leaf pad and gel composition is highly influenced by irrigation water applied to the crop. Therefore, apart from soil type, climatic conditions and availability of irrigation water; the quantity and frequency of irrigation depends on the purpose for which crop is grown.

However, if Aloe is to be grown for vegetable purpose, the succulence, thick and tender leaf pad is desired. In a study at CIAH, Bikaner (Rajasthan) under hot arid ecosystem of virgin sandy soils with low water holding capacity and poor fertility status; good response was obtained when it was irrigated at weekly intervals. Though, the irrigation at alternate day interval had given highest leaf pad yield but it is neither feasible nor economical. The quantity of

irrigation water can be minimized by using sprinkler system of irrigation without any adverse effect on the yield. The water use efficiency can be further improved with the use of grass mulches, crop residues and application of FYM and/or compost. It is also suggested that water-logging condition should be avoided. Scheduled irrigation not only increase the productivity of quality leaf pad but also helps in synchronized and uniform growth. The sucker production is also better under proper irrigation management. After every harvesting of leaf pads, irrigation is must. As such it can be grown well in arid and semi-arid climate where the available irrigation water from well is saline or brackish but for luxuriant growth and sweet flesh use of quality irrigation water is suggested.

7.3 Nutrition: The exact doses and type of manures and fertilizers for Aloe cultivation is yet to be worked out. In traditional cultivation practices, the crop responds well to application of manure (FYM or compost). About 10-15 t/ha of FYM may be applied at the time of soil preparation and also in subsequent years as per availability and conditions of field where crop is being grown. Use of wood/dung cake ash in the pits while planting suckers and also in the standing crops of Aloe is an indigenous practice in Bikaner (Rajasthan) region, which must be assessed scientifically. The wood ash applied in the pits at the time of planting helps in establishment of plants and their subsequent growth. However, preliminary trials at some places have shown that the crop responds to the application of nitrogenous and phosphatic fertilizers long with FYM or compost (Singh *et al.*, 1995). Application of nitrogenous and phosphatic fertilizers increases vegetative growth and flesh content of Aloe. Thus, quantification of optimum doses of fertilizers will help to obtain maximum productivity and quality crop (Pareek *et al.*, 1999).

The entire dose of FYM (100 t ha⁻¹) and phosphorus in the form of DAP (125 kg ha⁻¹) is applied as basal dose at the time of plantation. The nitrogenous fertilizer in the form of urea (125 kg ha⁻¹) is applied in split doses i.e. at the time of planting and remaining after each picking of pads (Vishal Nath and Singh, 1999). The yield of leave pad by using different doses of nitrogen, phosphorus along with organic manures is given in table 2.

Table 2. Effect of nitrogen, phosphorus and organic manures on the yield of Indian Aloe.

Treatment	Yield (t ha ⁻¹)
T ₁ (Control)	10.90
T ₂ (100 t FYM)	24.70
T ₃ (125 kg P ₂ O ₅ ha ⁻¹)	20.65
T ₄ (125 kg N ha ⁻¹)	32.85
T ₅ (100 t FYM + 125 kg P ₂ O ₅ ha ⁻¹)	26.07
T ₆ (100 t FYM + 125 kg P ₂ O ₅ ha ⁻¹ + 125 kg N ha ⁻¹)	43.95
SEm ±	1.25
CD (p=0.05)	2.56

It has also been reported that in very poor soils, 50 kg of nitrogen and 25 kg each of phosphorous and potassium are applied before planting. In the second and third years of the crop growth, 40 kg nitrogen is top dressed after irrigation for better yield from the crops. Because of the slow growing nature of the crop, application of NPK with FYM (5-10 ton ha⁻¹) is more useful for restoring and sustaining crop productivity and soil health (Anon., 2002).

7.4 Interculture: Timely hoeing and weeding is beneficial for a good crop. This practice not only destroys weeds in standing crop but also helps in breaking hard surface of soil to facilitate air and moisture penetration to the root zone. Therefore, the field should be kept weed free throughout the growing period of crop. Two to three hand weeding followed by light hoeing per year promote growth and suckering. Two weeding cum light hoeing in each year found to be sufficient to minimize the weed population in the field. Weed growth can also be checked by use of herbicide like atrazine (0.5 kg a.i/ha) as pre-emergence.

The earthing of plants is also useful for better plant growth, improve suckering and to check lodging of plants. After uprooting of suckers, proper earthing is very essential. Earthing is feasible practice when planting has been done in rows at desired spacing. Therefore, this practice of earthing should be adopted in order to get better yield and followed atleast twice in a year under sandy soils.

7.5 Intercropping: There is a little scope of intercropping with Aloe, however, during first season suitable leguminous or less competitive intercrops like cluster bean, mothbean, sesame etc. could be grown under arid conditions and cowpea, moong, beans, fenugreek, coriander etc. under semi-arid conditions that can generate additional income without any adverse effect to main crop.

Though, Aloe is perennial crop but it can also be grown as intercrop with woody perennials after adopting appropriate management practices. The work done at CIAH, Bikaner (Rajasthan) indicated that Indian Aloe is a economical crop when grown with establishing ber orchard of cv. Gola as intercrop (Fig. 3). Growing of Indian Aloe as intercrop had positive response on the growth and vigour of ber plants (Saroj *et al.*, 2003). However, proper selection of overstorey component with Aloe is very essential. It was observed that when Aloe was grown as intercrop with lasoda (*Cardia myxa*) and eucalyptus, the size and weight of leaf pad was reduced to a great extent.



Fig. 3 Indian Aloe as an economical groundstorey component with ber.

8. Physiological disorders

Sometimes, drying of tip and margin as well as reduction in chlorophyll content of leaf pads is observed under field conditions. The problem is severe under high temperature and water stress conditions. Therefore, growing under partial shade as ground storey component of an agro-forestry system is suggested after ascertaining proper combination of the components or micro-climatic moderations by use of wind breaks particularly under hot arid climate. If the tip portion of the plant is damaged then more number of smaller leaves with multiple sprouts is formed as mottled leaves, resulting in unmarketable leaf pads. The plants are also affected by frost during winter and the color of the leaves is faded.

9. Pest and disease management

Indian Aloe is very hardy to biotic stresses and no serious pest and disease has been reported. However, field sanitation is useful not only in preventing menaces of pest and disease but also to improve quality and productivity of crop. Under arid conditions of Rajasthan, pad spot disease caused by *Nigrospora oryza* was reported by CIAH, Bikaner for the first time. The disease starts as circular and spindle shape spots on leaf pad and spread all over the leaf surface, thereby marketability is affected. In another report, leaf spot disease of *Aloe vera* is the main disease, which not only affects the growth and yield but also affects its quality as foul odour of the gel. It is caused by *Alternaria alternata* and *Fusarium solani*. Just after the disease appearance, 2-3 foliar spray of Dithane M-45 (0.2%) at weekly intervals can minimize the disease.

Besides, this sucker rotting was also observed while planting of young suckers in new blocks. The young suckers with thin base were more prone to rotting. Some farmers also removing top of the leaf pads (1-2 cm) few days before harvesting to increase the weight of leaf pad. After removing the top portion, in some pads blackening and partial rotting were observed. The practice needs to be assessed scientifically and the cause of rotting yet to be investigated.

10. Harvesting and marketing

An Aloe plantation start yielding just after 6-8 month of transplanting under proper management conditions, however commercial yield could be obtained after one year, and can continue till fifth year of transplanting. Thereafter, it requires replanting. Meanwhile, some farmers in Bikaner

(Rajasthan) are taking yield of Indian Aloe without replanting from the last more than 10 years, though the yield is in decreasing order. Generally, 3-4 pickings per year can be taken up depending upon the growth of plants. On an average 20-25 t/ha fresh leaf pad is obtained from second year plantation. However, well-managed irrigated crop can give up to 50-60 t/ha fresh leaf pads/year. Fully developed mature leaf pads should be harvested manually by cutting with sharp edge knife from the base of the plant. Due care is essential not to damage the main stem while harvesting leaf pads as wounded stem may adversely affect the vigour and production in subsequent picking (Fig. 4.). After harvesting of leaf pads prophylactic spray of fungicides is recommended to avoid any fungal infection on plants. Besides leaf pads, the suckers arising from the base of the plants are additional source of income. After one year of transplanting, on an average 3-4 suckers per plant can be harvested every year.

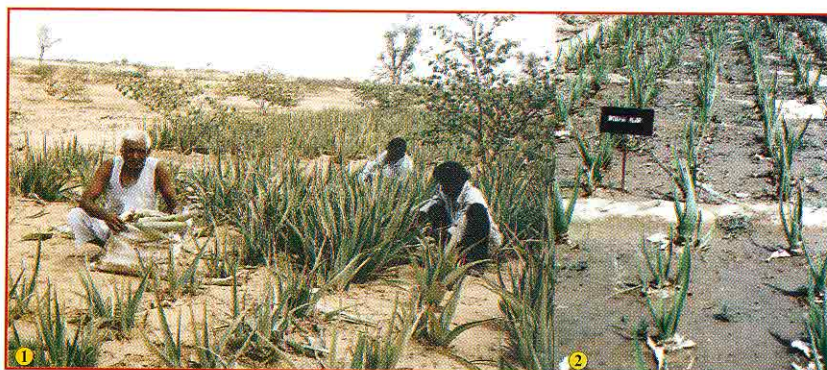


Fig. 4. Harvesting in progress (1) and harvested field (2)

The harvested, healthy leaves are washed with water and packed properly in layers of 25 leaves in a stack. For distant market, good packaging is required so that the leaves may not bruise (Pareek and Inder Mohan, 1995). Packaging is done in gunny bags. Though, marketing of Aloe is not well organized in our country but in recent years, considerable interest has been shown for its cultivation and domestic needs in north-western Rajasthan. The buyers are taking leaf pads from field itself for local consumption (Fig. 5). The retail price for fresh leaf pad in Bikaner (Rajasthan) market is about Rs.10-15/kg, while whole sale price is Rs. 4-5/kg.



Fig. 5. Transportation of harvested leaf pad for local market.

Most of the industries dealing with Aloe products either for cosmetics or medicinal purposes are in need of Aloe in form of gel but for extraction of gel from the fresh leaf pads, the low cost machineries are not available in the local market. Therefore, there is a need not only the development of low cost processing machineries but also proper linkage between growers and industries dealing with Aloe products for proper disposal of produce.

11. Processing

11.1 Preparation of 'Aloe' product

Aloe has long been in use for curing a number of diseases, particularly that of digestive system. It has also long been in use for curing wounds, burns and skin disorders. The term 'Aloe', used in medicine, stands for dried juice prepared from exudes of leaves. The bitter juice is contained in vessels placed longitudinally beneath the epidermis of the thick, fleshy leaves. The activity of juice doubtless varies with the age of leaf and the season of the year; juice appears to be most active during the spring season.

For preparation of 'Aloe', the juice is allowed to drain from the cut leaves into a suitable vessel and then concentrated by evaporation, either spontaneously or more frequently by boiling. When the leaf is broken or cut transversely, the exuding juice is nearly colourless, but it quickly acquires a brownish-yellow colour from exposure to the air (Anon., 1959). The nature of 'Aloe' depends upon the species from which it is prepared and the manner in which the juice is concentrated. The superior quality of 'Aloe' is obtained by evaporating the juice in the Sun or concentrated over a low fire. If pressure is employed to drain the juice from the leaves, the 'aloetic' juice becomes mixed with the colourless, tasteless, mucilagenous liquid with which the cells, constituting the pulp of leaf are filled, resulting into inferior kind of 'Aloe'. Hence, for quality 'Aloe', the juice is evaporated to a proper consistency by exposing to Sun or by applying artificial heat with low fire. Thus, the end product is an amorphous, opaque, waxy extract called 'hepatic' or 'livery aloe'. If the juice is concentrated rapidly over a strong fire, the end product obtained on cooling is amorphous and semi transparent, called 'glassy' or 'vitreous aloe' (Anon., 1959).

In north-western Rajasthan, delicious preparations such as vegetable, pickles and *Laddu* from Aloe leaf pad are very popular. The small scale pickle industries are developing well in Bikaner (Rajasthan) and now it is being popular in other states of the country because of its medicinal value. The simple recipe in form of flow chart and ingredients has been standardized and given below (Saroj and Purohit, 2004);

11.2 Preparation of vegetable

Flow Chart

Aloe leaf pad
↓
Wash thoroughly
↓
Peel after removing top and side portion
↓
Cut into smaller pieces
↓
Boil in water till it becomes soft by adding
one-teaspoon salt
↓
Fry the pieces in *Ghee*/edible oil
↓
Fry spices in *Ghee*/refined groundnut/
mustard oil
(Turmeric, chilli and coriander powder,
cumin, nigella, bay leaves, fenugreek,
clove etc.)
↓
While frying spices, add dried fruits
(Cashew, raisin, coconut powder,
etc.)
↓
Mix the pieces with fried spices +
dried fruits
↓
Add desired quantity of salt
↓
Warm it by closing the lid of pan
(10 minutes)
↓
Ready to serve after mild cooling

Ingredient

Aloe leaf pad	01 kg
Ghee/oil	150 ml
Fenugreek	75 g
Cumin	10 g
Nigella	05 g
Coriander powder	10 g
Turmeric	01 ts
Chilli powder	01 ts
Clove	05 No.
Bay leaves	05 No.
Cashew nut	100 g
Raisin	50 g
Coconut powder	50 g
Salt	As per taste



11.2 Preparation of Laddu

Flow Chart

Aloe leaf pad
 ↓
 Wash thoroughly
 ↓
 Peel after removing top and side portion
 ↓
 Cut into smaller pieces
 ↓
 Fry in *Ghee* / edible oil till it becomes brownish colour and mix well
 ↓
 Fry the flour (Wheat or Gram) in *Ghee* till it becomes brownish in colour
 ↓
 Mix all the materials (fried paste of Aloe + fried flour + dry fruits + gum+sugar or *bura*)
 ↓
 Prepare *Laddu* after mild cooling
 ↓
 Keep in tray preferably in single layer over night
 ↓
 Store in bigger mouth glass jar and close the lid

Ingredient

Aloe leaf pad	01 kg
Ghee/oil	250 ml
Wheat/gram flour	01 kg
Sugar/bura	01 kg
Dry fruits	As per need



11.2 Preparation of pickle

Flow Chart

Aloe leaf pad
 ↓
 Wash thoroughly
 ↓
 Remove side margins and cut into pieces
 ↓
 Keep cut pieces overnight by adding salt and little water
 ↓
 Completely drain-off water in order to avoid bitter taste
 ↓
 Add salt and turmeric powder and again keep for overnight
 ↓
 Fry spices in mustard oil (Fenugreek, fennel, nigella, chilli powder, coriander powder, hot spices)
 ↓
 Mix well with fried spices
 ↓
 Add mustard oil after warming by ensuring that the pieces must be dipped properly
 ↓
 Store in glass jar/earthen pots after cooling and subsequent capping
 ↓
 Keep until peculiar taste and softness develops

Ingredient

Aloe leaf pad	1 kg
Mustard oil	350 ml
Fenugreek	100 g
(partially broken)	
Fennel	50 g
Nigella	25 g
Turmeric powder	01 t s
Chilli powder	01 t s
Hot spices	01 t s
Salt	As per taste



12. Economics

Now a day, there is a high demand for raw materials of Aloe by different industries for preparation of variety of cosmetics, medicines and health care products. If properly managed, cultivation of Aloe may be a remunerative enterprise as cash crops. Though the initial establishment cost of Aloe cultivation on large scale is high, as more number of planting material (sucker) is required but it starts giving return from first year itself and continues for at least 5-6 years; thereafter replanting is required. It is also suggested that in order to minimize the high cost involvement in first year, the cultivation should be started on smaller holdings and one can harvest the suckers from the same field for further extension of area under Aloe cultivation in subsequent years. An account of cost of cultivation under irrigated hot arid ecosystem of north-western Rajasthan is given in table 3. The computation of economics has been made based on the cost of inputs and outputs prevailing in the locality. On an average, the net return of Rs.64620/ ha can be obtained per annum by selling leaf pad only (Fig 6). It is also interesting to mention that selling of suckers from the same field by using almost same amount of inputs can double the income.



Fig. 6. On-spot selling of Aloe leaf pad for vegetable purpose.

Table 3. Economics of Aloe cultivation in irrigated hot arid ecosystem of north-western Rajasthan.

A. Cost of cultivation	Years/Values (Rs.)				
	I	II	III	IV	V
1. Field preparation (leveling, ploughing, bunding etc.	2000	—	—	—	—
2. Planting- 27777 rooted suckers @ Rs 2/sucker Cost of planting- 15 man days	55555 900	—	—	—	—
3. Cost of manures and fertilizers- 2000 cft FYM, 100 kg Urea and 100 kg DAP first year and 50 kg Urea subsequent years Cost of application- 5 man days first year and 2 subsequent years	7300 300	200 120	200 120	200 120	200 120
4. Irrigation (by canal water)- Rs. 300/ha	300	300	300	300	300
5. Inter culture operations					
Twice-20 man days for weeding, cost of plant protection chemicals etc.	3400	3400	3400	3400	3400
6. Harvesting and processing- 15, 25, 35, 25 man days in consecutive years	900	1500	2100	1800	1500
7. Cost of harvesting of suckers 25, 35, 50, 40, 35 man days in consecutive years	1500	2100	3000	2400	2100
8. Interest on working capitals @ 12%.	8659	914	1094	986	914
Total	80814	8534	10214	9206	8534
B. Cost of output					
Leaf pad yield- 125, 250, 320, 215, 208q/ha from I to V Yr. respectively @ Rs. 4/kg	43200	100000	128000	86000	83200
No. of Suckers					
26550, 40360, 68108, 50810, 30680 from I to V Yr. respectively @ Rs. 2/sucker	53100	80720	136216	101620	61360
Total	96300	180720	264216	187620	144560
C. Net Return (B-A)	15486	172186	254002	178414	136026

Rates: Tractor/hr Rs. 100/-, Field labour/day Rs. 60/-, Irrigation by canal/ha/yr. Rs. 300/-, Urea Rs. 4/kg, Cost of FYM Rs. 300/100cft DAP Rs. 9/kg

13. References

- Anonymous (1959). *Wealth of India*. CSIR, New Delhi, Vol. I A. Pp. 191-193.
- Anonymous (1962). *Wealth of India*, Raw Materials. 6 CSIR, New Delhi, Pp. 439-444
- Anonymous (1996). *Encyclopedia of Medicinal Plants*. Pub. Darling Kindersley Ltd.. London. p.57.
- Anonymous (2002). *Aloe (Aloe vera) and its cultivation in India*, CIMAP, Lucknow, Pp. 1-15.
- Anonymous (2003). *Cultivation of Aloe vera*, NRC Medicinal and Aromatic Plants, Anand, Gujarat, Pp. 1-6.
- Bentley, R. and Trimen, H. (2000). *Medicinal Plants*. 4:228-306. Asiatic Publishing House, New Delhi 110092.
- Chandra, V. and Pandey, M.C. (1989). *Cultivation of Herbal Plants*. (3rd ed.) Indian Agriculture Research Institute, Pusa, New Delhi. Pp. 127-129.
- Chopra, I.C.; Abrol, B.K and Handa, K.L. (1982). *Medicinal plants of the arid zones*. Part I. Today and Tomorrow's Printers and Publishers, New Delhi. Pp. 18-19.
- Collins, C.E. and Collins, C. (1935). Roentgen dermatitis treated with fresh whole leaf of *Aloe vera*. *Am. J. Roentgenology and Radiation Therapy*, 33.
- Kirtikar, K.R. and Basu, B.D. (1989). *Indian Medicinal Plants*. Vol. IV (2nd ed.). Pub. Lalit Mohan Basu, Allahabad, India.
- Lushbaugh, C. and Hale, D. (1953). Experimental acute radiodermatitis following beta irradiation. V. Histopathological study of the mode of action of therapy with *Aloe vera*. *Cancer*, 6: 690-698.
- Nadkerni, K.M. (1976). *Indian Meteria Medica* Vol. I (3rd ed.). Pub. Bombay Popular Prakashan Private Limited. Pp. 73-74.
- Pareek, G.N. (1990). *Sudhanidhi Vanoshadhi Ratnakar*. Pub. Dhanvantri Office, Aligarh. Pp. 64 and 73.
- Pareek, O. P. and Inder Mohan (1995). Indian Aloe: Wealth from Thar Desert. *Indian Horticulture* (Oct. Dec., 1995). Pp. cover II and 29.
- Pareek, O. P.; Sharma, B. D.; Vishal Nath; Singh, R. S. and Bhargava, R. (1999). Effect of Nitrogen and Phosphorus fertilizers and organic manures on growth and yield of Indian Aloe (*A. barbadensis* Mill.). *Annals of Arid Zone*, 38(1): 85-86.

- Rowe, T.D., Lovell, B.K. and Parks, L.M. (1940). Further observations on the use of *Aloe vera* leaf in the treatment of third-degree x-ray reactions. *J. Am. Pharm. Assoc.*, 30: 266-269.
- Saroj, P.L.; Dhandar, D.G.; Sharma, B.D. and Bhargava, R. (2003). Evaluation of ber (*Ziziphus mauritiana* Lam.) based cropping systems for hot arid ecosystem of north-western Rajasthan. Paper presented in 6th Agricultural Science Congress at IISS, Bhopal, February 13-15, 2003.
- Saroj, P.L. and Purohit, C.K. (2004). Indian Aloe: an alternative food with nutritional value, *SAIC News Letter*, January-March, 2004 Pp. 5 & 7.
- Sharma, R. and Goel, M. (2002). Utilization of local plants guarpatha (*Aloe barbadensis*) by women residing in Bikaner city (Rajasthan). In. Proceeding of NSI, XXXIII Annual Meeting, December 1-2, 2002, NIN, Hyderabad.
- Sharma, S. and Pareek, Navita (2003) Nutritional composition of *Aloe vera* (Guarpatha)- a dryland product. Paper presented in IX Asian Congress of Nutrition, New Delhi, Feb. 23-27, 2003.
- Singh, B. M.; Srivastava, V. K.; Kidwai, M. A.; Gupta, V. and Gupta, R. (1995). Aloe, Psoralea and Mucuna. In: Advances of Horticulture (Eds. K. L. Chadha and R. Gupta). Malhotra Publishing House, New Delhi, Pp 513-517.
- Vishal Nath and Singh, R. S. (1999). Sushka Kshetra Mein Guarpatha Ki Kheti. *Krishi Vistar Samiksha*, 9(2): 24-27.
- Wright, C. (1936). *Aloe vera* in treatment of roentgen ulcers and telangiectagis. *J. Am. Medical. Assoc.*, 103: 1363-1364.

Some Aloe based products

Name of product	Type of product	Aloe content	Manufacturer
A. Ayurvedic			
Ghrit Kumari	Hair Oil	4.57%	B.K. Products, J.N. Lal Road, Under: Surya Chemical Works, Calcutta-700 001
Kumari Asav	Syrup	—	Shree Vaidyanath Ayurvedic Bhavan Pvt. Ltd., C-14, Industrial Area, Surajpur, Greater Noida-201 306, Gautambudh Nagar
Moiste	Cream	10%	AXION, 5 RS Road, Ambala-133 006
B. Homoeopathic			
Aloe	Liquid form	—	SBL India Pvt. Ltd. A-3, Site 4, Sahibabad, Gajiabad. Branch Office: 533, Sitapura Industrial Area, Jaipur.
C. Cosmetics			
Ayur Cleansing milk	Face wash	—	Ravi Enterprise New Delhi-110 008
Ayur Herbal all purpose cream	Cream	—	Three-N-Products (P) Ltd., H-301, Industrial Area, Bhiwadi (Rajasthan)
Fair and Lovely Cream	Cream	—	Mul Dentpro Pvt. Ltd., Plot No. 722, Somnath Road, Village-Dabhil, Daman-396 210
Emami naturally fair pearl	Soap	—	G & Y Soap Works 19, Khopoli Co-op. Industrial Estate, Khopoli-410 203
Eraser Ayurvedic Skin Cream	Cream	1%	Cherub Naturals Pvt. Ltd. G.S. Road, 15 th Miles Bamihat Ribhol, Meghalaya-793 101
NOMARKS	Cream	5%	Ozone Ayurvedies EPIP, Amingaon Guwahati-781 031
Boroplus	Cream	—	Emami Limited A-83, Piplic Industrial Estate, Mettupalayam, Pondicherry- 605 009
Fairness Cream	Cream	5%	The Himalayan Drug Company Makali, Bangalore-562 123
Fem Jula	Cream	Juice 50% w/w	Fem Care Pharma Ltd. D-55 MIDC, Ambad, Nasik-422 010

Some Indian industries dealing with Aloe products

Sl. No.	Manufactures	Type of product	Trade Name	Cost
1.	M/s INDICHEM Herbal Division 7, Shamroz Industrial Estate Ram Mandir Road Goregaon (West), Mumbai-400 104	Aloe Juice	Lilovera	Rs.80/200 ml
2.	M/s Om Datta Vashishtha J-32, Gangaram Vatika Dhoukhandi Road, Tilak Nagar New Delhi- 110 018	Aloe Juice	Eco-friendly product	Rs. 150/lit.
3.	M/s Sindhu Herbs SF No. 259/2, Palayakottai, Road Kangayam- 638 701 Ditt. Erode (Tamil Nadu)	Shampoo and Herbal Cosmetics	—	—
4.	M/s Femicare Ambad Industrial Estate Nasik-411 027 (Maharashtra)	Cosmetics	—	—
5.	M/s Sri Mohta Ayurvedic Rasayan Sala, Station Road Bikaner-334001 (Rajasthan)	Syrup	Kumaryasav	—

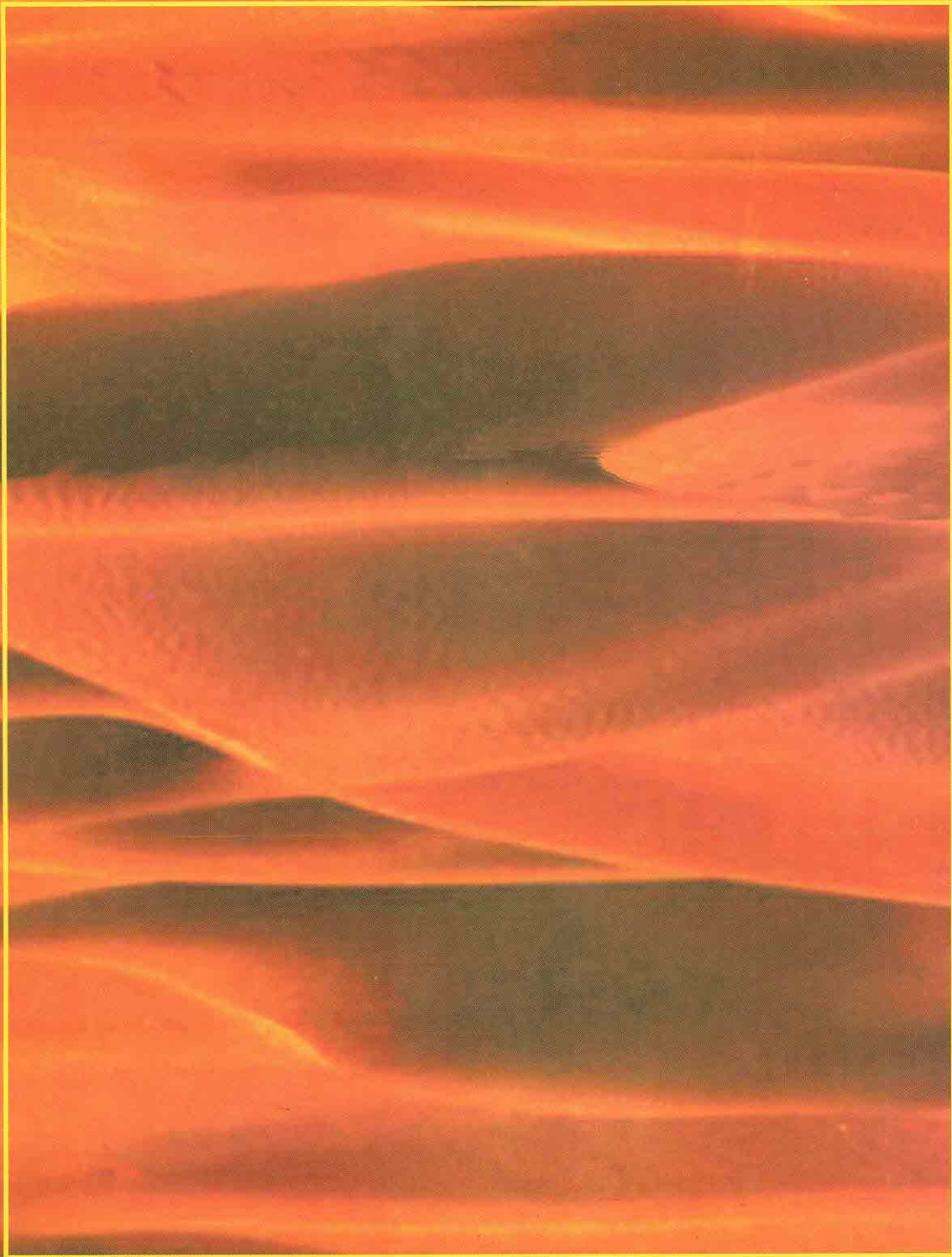
Acknowledgement

The authors are grateful to Dr. G. Kalloo, DDG (Hort.), and Dr. S.N. Pandey, ADG (Hort.) ICAR, New Delhi; Prof. R.K. Pathak, Director, CISH, Lucknow and Members of Peer Review team of NATP (Arid Ecosystem) for their inspiration to develop this document. The scientific support of published literatures and quoted works by different worker cited while compilation are sincerely acknowledged. We are also thankful to Dr. O.P. Pareek, Ex-Director, CIAH, Bikaner; Dr. B.B. Vashishtha, Director, NRC on Seed Spices, Ajmer; Dr. Atul Chandra and Inder Mohan, K.V.K., RAU, Bikaner; Dr. P.K. Yadava, Deptt. of Horticulture, RAU, Bikaner; Dr. O.P. Awasthi, Sr. Scientist (Hort.) and Smt. C. Umamaheswai, Scientist (Pathology), CIAH, Bikaner; Sh. C.K. Purohit, SRF, NATP (ASH), and Dr. Uday Vir Singh, CIAH, Bikaner; Sh. Gyan Prakash Rajpurohit, a progressive farmer, Bajju, Bikaner and all CIAH, Bikaner staff and Aloe growers of Bikaner region for their help and support in various ways while compilation and production of this valuable document

P.L. Saroj

D.G. Dhandar

R.S. Singh



Painted By: Rahul Pantora, Bkn. Ph. 2526852