Chapter 1

Introduction

Aloe vera is a tropical or subtropical plant characterized by lance-shaped leaves with jagged edges and sharp points. It has a history of use in folk medicine for skin and other disorders, which date back thousands of years (Morton, 1961). Today, the processing of Aloe vera gel (AVG), derived from the leaf pulp of the plant is widely used for manufacturing food products and beverages, pharmaceuticals and cosmetics because of its aromatic properties, bitter taste and pharmacological activities. It is also known as “lily of the desert”, the “plant of immortality” and the “medicinal plant”. The name was derived from the Arabic “alloeh” meaning "bitter", because of the bitter liquid found in the leaves.

1.1 Geographical origin and distribution

The geographical origin of Aloe vera is not known for sure, since it has been introduced and naturalized throughout most of the tropics and warmer regions of the world, including the West Indies and Bahamas, Southern USA, Mexico, Central America, Arabia, India and other parts of Asia. In India, the plant is found in Rajasthan and other dry belts. It also grows in Maharashtra, Gujarat and South India. The increasing demand, latest research findings and need of crop diversification have motivated traditional farmers in India to start commercial cultivation of *Aloe barbadensis* Miller on a large scale. Aloe vera production in India is estimated at about 100,000 tonnes and the annual consumption of aloe extract by the Indian pharmaceutical industries is 200 tonnes (Varindra, 2008). Ayurvedic pharmacies utilize only 1% of total production as its full potential has not been realized due to lack of research and requisite expertise.

1.2 Botany of Aloe vera

Reynolds (1966) described 314 species of Aloe in his classic monographs and now there are over 360 accepted species. Until recently, most sources placed Aloe in the Lily family (*Liliaceae*), but according to Reynolds (1985) it has now been designated its own family, known as *Aloaceae.* It is a clump-forming, perennial succulent with basal rosettes of tapering thick leaves. In young plants, the leaves appear at ground level, but the stem can grow up to 25 cm long in older plants. There may be 12–16

leaves per plant. The plant matures when it is about 4 years old and has a life span of about 12 years. When fully grown, the individual leaves can reach a height of 60–90 cm long and 5–10 cm across the base, tapering to a point with saw-like teeth along their margins (Fig. 1.1). A transverse section of the leaf reveals a slightly concave appearance on the adaxial surface, whereas the lower abaxial surface is markedly convex. There are broadly three distinct portions of the Aloe vera leaves: 1) yellow sap, mainly anthraquinones; 2) internal gel matrix or the 'fillet'; 3) the 'rind,' which consists of outer rinds, tips, bases and thorns (Mary and Frederick, 2006).

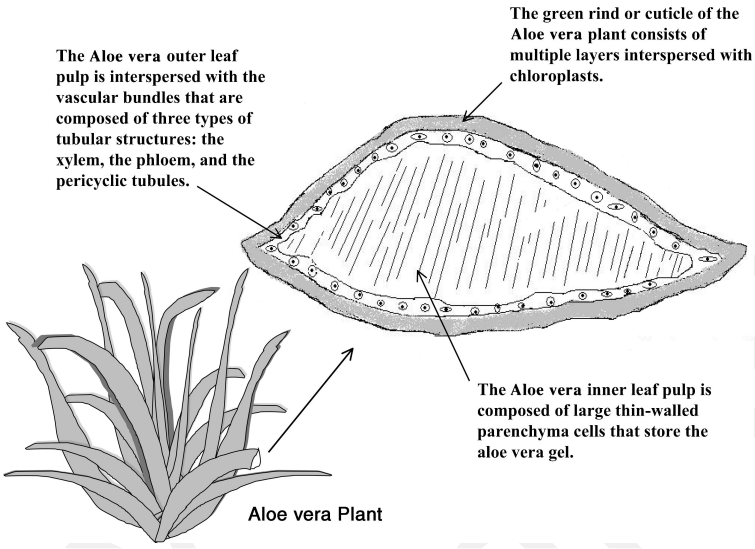

Fig. 1.1: Schematic representation of the Aloe vera plant and a cross section through an Aloe vera leaf (Source: Mary and Frederick, 2006)

1.3 Current market scenario and export potential

The current global turnover of raw Aloe vera leaves amount up to US $ 70-80 million, which is expected to grow at the rate of 35% in the next five years. Current global trade for processed derivatives and value added products is estimated at around US $ 1 billion and 25 billion, respectively. The USA supplies the major bulk of Aloe in world market having a share of 60-65%, whereas Latin American countries supply 20-25% and Australia, China and India together have market share of only 10% (Jyotsna, 2009). The price of dried Aloe in India ranges from Rs. 600-1000 per kg depending upon the "aloin" content and colour of the dried leaves. Owing to the increased preference to herbal cosmetics and health foods, the demand for Aloe vera is on the rise every year. Hence, it is definitely a crop highly suitable for growing in many parts of India.

1.4 Physical and chemical properties of Aloe vera

The physical and chemical composition of Aloe vera differs depending on the species, climate and growing conditions (Briggs, 1995). The main feature of the Aloe vera plant is its high water content, ranging from 99-99.5%. The remaining 0.5-1% solid material is reported to contain over 75 different potentially active compounds, including water and fat-soluble vitamins, minerals, enzymes, simple and complex polysaccharides, phenolic compounds and organic acids. In compositional studies on the structural components of the Aloe vera plant leaf portions, the rind is 20-30% and the pulp is 70-80% of the whole leaf weight. On a dry weight basis, the rind and pulp consists, respective percentages of lipids (2.7% and 4.2%) and that of proteins (6.3% and 7.3%) accounted for a minor fraction (Femenia *et al.,* 1999), soluble sugars (11.2% and 16.5%), primarily as glucose and the ash (13.5% and 15.4%), in particular calcium.

AVG is the clear jelly-like substance obtained from the Aloe vera leaf pulp. The mechanical extraction of gel gives a 70% yield with a water content of 99-99.5% (Femenia *et al.,* 1999). The gel of the field grown Aloe vera is reported to have a pH of 4.4-4.7 and total and soluble solids content of 0.56-0.66% (Wang and Strong, 1995). The reported ash content was relatively high in all fractions of the plant, but in particular in the gel, where it is accounted for 23.6% of the dry matter. Sodium, potassium, calcium and magnesium were the predominant minerals detected in all leaf fractions.

1.5 Uses and applications

The use of Aloe vera could be dated as far back as the biblical times. Historically, Aloe vera has been known as a traditional folklore medicine for the treatment of many diseases and sicknesses. It is a well-known anti-inflammatory and wound-healer, accelerating the rapid growth of epithelial tissue (Davis *et al.,* 1994), hence, used in the treatment of burns. It is suggested that lectin may be responsible for the therapeutic effect of the gel on burns (Yagi *et al.,* 1985). It can be used successfully in the general treatment of skin ulcers, including mouth ulcers, cold sores and leg ulcers. This is possibly due to the anti-virucidal effect of the Aloe vera gel at concentrations of about 80%.

Introduction

Blitz *et al.* (1963) reported the use of AVG internally taken to treat peptic ulcers and disturbances of the gastrointestinal tract. In the field of dentistry, Aloe vera has been used to treat a variety of dental conditions and has been found to relieve pain and accelerate healing after periodontal flap surgery. Recent studies indicate that Aloe vera can be used in the treatment of HIV-AIDS. This is attributed to the anti-viral and immuno-modulating properties. It is also found used in the treatment of cancer (Wolfgang, 1995) and has been demonstrated to have a positive effect on the inhibition of tumour growth.

The amount of AVG that finds its application in the pharmaceutical industry is significant as far as the manufacturing of topical ointments, gel preparations, tablets and capsules are concerned (Mortan, 1961). The AVG has found an extensive application in the cosmetic and toiletry industries where it is used as a base for the preparation of moisturizing creams, lotions, soaps, shampoos and facial cleansers. This is principally due to its valuable moisturizing emollient effect (Feil, 1980).

Aloe vera also finds its application in the food industry essentially in the formulation of health food drinks. It is used in the manufacture of yoghurt and other beverages, including tea. In food industry it is utilized as a source of functional food, especially for the preparation of health drinks, beverages and aloe based tea. It is commercialized as powdered concentrate for use in wide range of food products. It is presently used in health drinks, sport beverages, candies and chewing gums. A few examples of product formulations using Aloe vera for food and beverage are aloe soft drink (with electrolytes), diet drink with soluble fibre, hangover drink, tropical fruit juice, aloe ice cream, aloe based confectionery, aloe jelly, desserts with chunks of aloe, instant aloe tea granules, Aloe vera gums for sore or bleeding gums, Aloe vera candy, Aloe vera sorbet with citrus juice, Aloe vera fruit smoothies etc. (http://www.aloecorp.org).

1.6 Aloe vera gel extraction

The leaves of the Aloe vera plants have a relatively dense outer layer, rind or peel surrounding the relatively soft core that is filled within the AVG. A thin liquid layer of aloin is sandwiched between the gel containing core and outer peel is released when the peel is cut/broken or damaged. The aloin is undesirable yellowish coloured liquid extract which is considered as contaminant for the gel when used for internal

consumption. Among the undesirable characteristics of aloin are a bitter taste and cathartic action which renders the AVG unacceptable for human consumption. Crushing of entire Aloe vera leaves results in contamination of the gel with the aloin which produces a low grade extract. The bright yellowish colour of the aloin also discolours any Aloe vera containing product intended for external use that substantially reduces consumer acceptance.

Because of the contamination of the gel by aloin, gel extraction is mostly being done by hand trimming and filleting each leaf to remove all traces of aloin layer. This requires cutting away the peel from the core of the gel material and thereafter squeezing the fillet or core of the leaf in a conventional manner to extract the gel. This method produces the gel within permissible limits of contamination, but the operation is wasteful as a substantial core portion of each leaf containing gel may be severed and discarded. In addition, the process of filleting each leaf is time consuming, expensive and somewhat hazardous due to the sharp cutting knife employed.

Conventional mechanized processing equipment like Aloe vera leaf extractor, AVG separator, etc. removes valuable fluid material by very harsh pressing and grinding operations that masticate the rinds, which enclose the aloin layer. However, these conventional approaches are inapplicable to the Aloe vera because the fibrous rind of the Aloe vera contains toxic juices which must not be allowed to mix with the gel collected. Thus an appropriate mechanized extraction process must provide a rapid and efficient removal of the gel without excessive cutting or crushing of the rind.

The growing commercial importance of Aloe vera has resulted in a need for efficient means for extracting the gel from the leaves of the Aloe vera plants (Robert, 1997). Nevertheless, the aloe crop is still often processed by hand (Thomas, 1984). Mechanization of the extraction process must emphasize cleanliness with respect to the collected gel and provision for efficient disposal of the rind remaining after extraction.

1.7 Processing of Aloe vera gel

The potential use of Aloe vera products often involves various unit operations like, heating, dehydration and grinding. Processing may cause irreversible modifications to the polysaccharides affecting their original structure, which may promote changes in the physiological and pharmaceutical properties of constituents. Processing of AVG

derived from the leaf pulp of the plant has become a big industry worldwide due to its wider spread utilization and application in the pharmaceutical, cosmetic and food industry (Jyotsna, 2009). Generally, the production process of aloe products involves crushing, grinding or pressing of the entire leaf of the aloe plant to produce Aloe vera juice, followed by various steps of filtration and stabilization of the juice. The resulting solution is then incorporated in or mixed with other solutions or agents to produce a food, pharmaceutical or cosmetic product (Waller *et al.*, 2004).

Unfortunately, because of improper processing procedures, many of these so-called aloe products contain, very little or virtually no active ingredients, namely, mucopolysaccharides (Douglas and Reynolds, 1986). In view of the importance of biological activities possessed by the leaves of the Aloe vera, it is necessary that the leaf should be processed with the aim of retaining essential bioactive components. Presently spray-drying and freeze-drying technologies are commonly followed in aloe industries, which are time consuming and expensive (He *et al.*, 2002). The low-temperature dehydration has good potential to retain high level heat-stable components and sensory attributes than any other dehydration process. Desiccant dehumidified air drying has potential in obtaining good quality dehydrated AVG for food and pharmaceutical applications.

Keeping in view the importance of Aloe vera in food and pharmaceutical industries, the present study was undertaken with the following objectives.

1) To design and develop an Aloe vera gel (AVG) filleting machine for efficient gel filleting without aloin contamination.
2) To optimize the machine and leaf parameters for efficient gel filleting.
3) To study the effect of drying air parameters during desiccant dehumidified air drying on quality of dehydrated gel.
4) To study the moisture sorption behaviour of dehydrated AVG powder.
5) To study the storage characteristics of AVG powder and predict the safe storage conditions.