Available online www.ijpras.com

International Journal of Pharmaceutical Research & Allied Sciences, 2016, 5(1): 21-33

Review Article

ISSN : 2277-3657
CODEN(USA) : IJPRPM

Aloe Vera: A Systematic Review of its Industrial and Ethno-Medicinal Efficacy

Amit Pandey* **and Shweta Singh**

University School of Environment Management, Guru Gobind Singh Indraprastha University, New Delhi, India
**Email: pandeyamit43@yahoo.com*
Subject: Pharmacognosy

ABSTRACT

Aloe vera belongs to the family Xanthorrhoeaceae (APG III System, 2009) commonly known as Ghrit Kumari, is the oldest medicinal plant ever known and the most applied medicinal plant worldwide. Aloe Vera is used for vigor, wellness and medicinal purposes since rigvedic times. Health benefits of aloe vera include its application in wound healing, treating burns, minimizing frost bite damage, protection against skin damage from x-rays, lung cancer, intestinal problems, Increasing High Density Lipoprotein (HDL), reducing Low Density Lipoprotein (LDL), reducing blood sugar in diabetics, fighting Acquired Immuno Deficiency Syndrome (AIDS), allergies and improving immune system. Phyto-chemistry of aloe vera gel has revealed the presence of more than 200 bioactive chemicals. Aloe Vera gel is extracted from its leaves and appropriate processing techniques are needed for stabilization as well as preparation of the end products. Aloe Vera Gel contains important ingredients including 19 of the 20 amino acids needed by the human body and seven of the eight essential ones that just cannot be made. In industries Aloe Vera is also used to extract liver tonic. The present research article is an effort towards the industrial and ethno-botanical properties of Aloe Vera.

Keywords: Aloe-Vera, ethno-botany, commercial uses, bioactive chemicals

---

1. Introduction

The semi-tropical plant, Aloe Vera, has a long and illustrious history dating from biblical times. It has been mentioned throughout recorded history and given a high ranking as an all-purpose herbal plant. Aloe's thick, tapered, spiny leaves grow from a short stalk near ground level. It is not a cactus, but a member of the tree lily family, know as *Aloe barbadensis*. Aloe is related to other members of the Lily family such as the onion, garlic and turnip families. Aloe's relationship to the lily family is evident from the tubular yellow flowers produced annually in the spring that resemble those of the Easter lily. There are over 550 species of aloe grown around the world (World Checklist of Selected Plant Families, Royal Botanic Garden Kew, 2013). However, only two species are grown today commercially, with *Aloe barbadensis* Miller and *Aloe aborescens* Miller being the most popular. The Aloe plant is grown in warm tropical areas and cannot survive freezing temperatures. In the United States, most of the Aloe is grown in the Rio Grande Valley of South Texas, Florida and Southern California. Internationally, Aloe can be found in Mexico, the Pacific Rim countries, India, South America, Central America, the Caribbean, Australia and Africa. The leaves of the Aloe plant grow from the base in the rosette pattern. Mature plants can grow as tall as 2 and a half inches to 4 feet with the average being around 28 to 36 inches in length. Each plant usually has 12-16 leaves that, when mature, may weigh up to three pounds. The plants can be harvested every 6 to 8 weeks by removing 3 to 4 leaves per plant. The original commercial use of the Aloe plant was in the production of a latex substance called Aloin, a yellow sap used for many years as a laxative ingredient. This product became synonymous with the name "Aloe" and recorded in the trade, technical and government literature during the early 20th century.

This terminology created much confusion later when Aloe's other main ingredient, Aloe Gel, a clear colorless semi-solid gel, was stabilized and marketed. This Aloe Vera Gel, beginning in the 50's, has gained respect as a commodity used as a base for nutritional drinks, as a moisturizer, and a healing agent in cosmetics and OTC drugs. Chemical analysis has revealed that this clear gel contains amino acids, minerals, vitamins, enzymes, proteins, polysaccharides and biological stimulators. Public interest in Aloe has grown quickly, and now there is a considerable amount of research into the various components of Aloe to find out more about their properties and to characterize these components so that more specific research can provide clues to the "magic" that is attributed to Aloe Vera.

This "magic" concept brought the industry under the Federal Food and Drug Administration's microscope in the late 70's and early 80's. The claims made to the consumer about uses and effectiveness of Aloe was exaggerated. Aloe Vera Gel, like most natural juices, both fruit and vegetable, is an unstable product when extracted and is subject to discoloration and spoilage from contamination by microorganisms. The great success of Aloe as a commodity for use in nutritional foods and cosmetics is due to the proper stabilizing procedures that enable processors to store and ship the Aloe Gel without fear of spoilage throughout the market places of the world. Research conducted around the world leaves little doubt that certain biochemical properties of Aloe will be proven facts. Such attributes as moisturizing and penetrating properties are known, but the attributes such as its healing abilities and analgesic action to bacterial activity has not been clearly defined and documented through properly controlled scientific research and testing. Today, the Aloe industry has established high ethical standards for businesses and their Aloe products. Through the International Aloe Science Council, the industry has solidified its dedication to providing the world with the highest quality Aloe. The wide acceptance of Aloe by society in so many consumer products suggests that the IASC is moving in the proper direction. The image of Aloe has never been higher. The IASC has a dedicated group of professionals committed to the further growth, research and marketing of quality Aloe Vera Gel and Aloe products made from this Gel. This is because the IASC knows the future of Aloe is full of promise for those willing to make the necessary effort (1996-2002 The International Aloe Science Council).

Aloe was originated in tropical Africa and it is now cultivated in warm climatic areas of Asia, Europe and America [(38)]. Presently, the use of aloe vera has gained popularity because of herbal movement initiated by naturopaths, yog gurus, alternative medicine promoters and holistic healers. The industry size for aloe raw material is estimated to be about $125 million dollars. The volume of the industry for finished products containing aloe vera is alleged to be around $110 billion dollars [(3)]. A recent market analysis report indicates that in 2008 Americans have spent almost 40 billion dollars on functional foods, drinks and supplements for the improvement of their appearance as well as to provide energy and added nutrition to handle health issues such as hypercholesterolemia and diabetes. Aloe vera products are among the popular ones for these applications. Today, the aloe vera industry is flourishing and the gel is used in many products such as fresh gel, juice and other formulations for health, medicinal and cosmetic purpose [(24)]. However, the fast expanding aloe vera industry urgently needs reliable testing protocols to assess the quality and quantity of bioactive chemicals present in the final products [(11)]. The product claims must be tested by intensive clinical trials, verified and certified by the Government regulatory authorities to built consumer confidence and safety of the aloe vera products. This is a hardy perennial tropical plant that can be cultivated in drought prone areas and is one of the crops whose potential is yet to be exploited, despite being identified as 'a new plant resource with the most promising prospects in the world'. In India, it is scattered in the wild, along the coast of southern India.

2. Botany of Aloe Vera

Aloe vera is a spiky cactus like xerophytes. It is a clump forming perennial plant with thick fibrous root which produces large basal leaves, usually 12–16 per plant, weighing up to 1.5 kg when mature. The plant matures when it is about 4 years old and has a life span of about 12 years. The leaves are up to 0.5 m long and 8–10 cm across at the base, tapering to a point, with saw-like teeth along their margins. In a transverse section, the plant shows a slightly concave appearance on the adaxial surface and distinctly convex appearance on the lower abaxial surface [(33)]. The leaves are covered with thick cuticle, beneath which epidermis and mesophyll are present. Later is differentiated in upper chlorenchyma and lower parenchyma, as the rosette mature, successive leaves have fewer whitish spots and grey-greenish in color [(23)]. The plant can be harvested every 6–8 weeks by removing 3–4 leaves per plant. Red, yellow, purple or pale stripped flowers are present most of the year growing in a long raceme at the top of the flower stalk which originates from the centre of the basal leaves. The flower stalk grows up to 1.5 m in height. The fruit is a triangular capsule containing numerous seeds. The plant is practically disease free, occasionally black spots may occur on upper surface because of fungal infection or soft rottening may damage whole plant. The causal organism for soft rottening is a bacterium. Frost is another enemy of aloe vera plant and it cannot survive in frost conditions [(33)]. Smoking in field during frost nights is one measure practiced by farmers to protect the plantation from frost.

There are over 550 species of aloe grown world over. However, only two species are grown commercially i.e. *Aloe barbadensis* Miller (Aloe vera) and *Aloe aborescens* Miller. There are at least two other species that have medicinal

properties namely *Aloe perry* baker and *Aloe ferox*. Most aloe vera plants are non toxic but a few are extremely poisonous containing a hemlock like substance [9]. Aloe variegate is a dwarf species which is only a few centimeter in diameter and is a popular house plant.

3. Ethno-botany of Aloe Vera

In Ayurveda, *Aloe* is known as Kumari or "Young Girl", because aloe is believed to bring back youthful energy and femininity. *Aloe* is used as a tonic for the female reproductive system. *Aloe* is said to have alliterative, tonic, rejuvenating, purgative, and vulnerary actions in Ayurveda. *Aloe* is also believed to tone all three of the Ayurveda constitutions, Vatta, Pitta and Kapha. It is used in traditional Indian medicine for constipation, colic, skin diseases, worm infestations and infections. *Aloe* is internally used as laxative, antihelminthic, haemorrhoid treatment, and uterine stimulant (menstrual regulator). It is used topically, often in combination with liquorice root, to treat eczema or psoriasis. People in Tamil Nadu, India often prepare a curry using *A. vera* which is taken along with Indian bread (nan bread) or rice [30, 37].

4. Phytochemistry of Aloe Vera

There are as many as 200 different types of molecules in aloe vera [21]. The aloe vera leaf gel contains about 98% water [11]. The total solid content of aloe vera gel is 0.66% and soluble solids are 0.56% with some seasonal fluctuation. On dry matter basis aloe gel consists of polysaccharides (55%), sugars (17%), minerals (16%), proteins (7%), lipids (4%) and phenolic compounds (1%) (Fig. 3). The aloe vera gel contains many vitamins including the important antioxidant vitamins A, C and E. Vitamin B1 (thiamine), niacin, Vitamin B2 (riboflavin), choline and folic acid are also present [48]. Some authors also suggested the presence of vitamins B12 (cyanocobalamin) in trace amounts which is normally available in animal source [18, 9]. Carbohydrates are derived from mucilage layer of the plant under the rind, surrounding the inner parenchyma or gel. They comprise both mono and polysaccharides. The most important are the long chain polysaccharides, comprising glucose and mannose, known as the glucomannans [β (1, 4) - linked acetylated mannan]. Xylose, rhamnose, galactose and arabinose are also present in trace amounts along with lupeol (a triterpenoid), cholesterol, campesterol and β-sitosterol. Structural studies on aloe vera gel polysaccharides have shown that the gel is composed of at least four different partially acetylated glucomannans, being linear polymers with no branching and having 1,4 glycosidic linkages with glucose and mannose in the ratio of 1:2:8. The viscosity of gel reduces upon hydrolysis of these sugars. When taken orally some of the sugars bind to receptor sites that line the gut and form a barrier, possibly helping to prevent 'leaky gut syndrome'[8].

Fig. 1 *Aloe barbadensis*

Fig. 2. *Aloe arborescens*

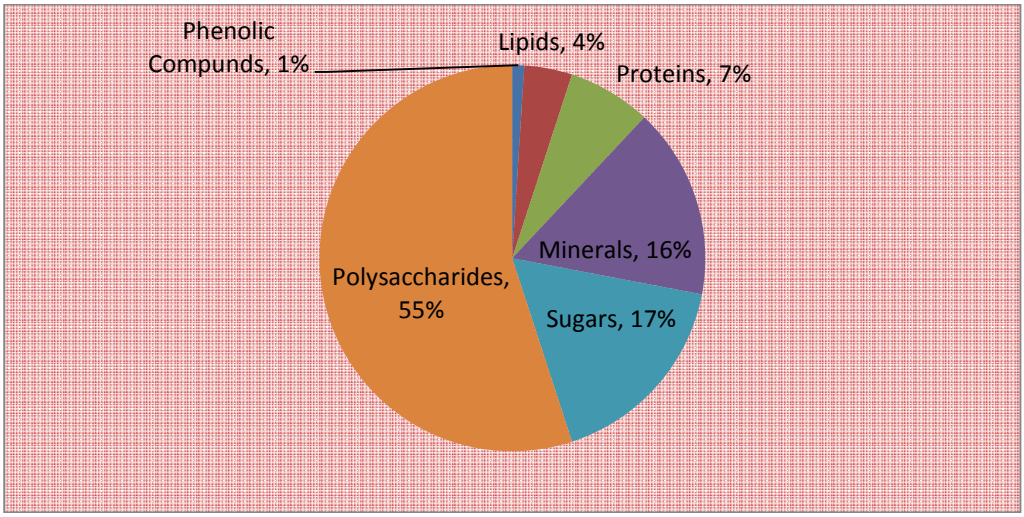

Fig. 3. Chemical composition of aloe vera gel (on dry weight basis) (Luta and McAnalley 2005)

Other reports suggest the presence of glucose and a polyuronide consisting of a high molecular weight glucose mannose polyose and hexouronic acid [31, 60] reported the presence of uronic acid, which gives galacturonic acid and oligosaccharides upon fermentative hydrolysis. It is reported that at least six enzymes are present in the aloe vera gel including bradykinase, cellulase, carboxypeptidase, catalase, amylase and oxidase[55]. The carboxypeptidase inactivates bradykinase at site ofwound or cut in body and produces pain relieving and anti-inflammatory effect. During the inflammatory process, bradykinase produces pain associated with vasodilatation[72]. The gel also contains glutothionperoxidase as well as several isozymes of superoxide dismutase. It has also been reported that potassium and chloride concentration appeared to be excessive in aloe vera juice in comparison to most plant products whereas the sodium content was found lesser in quantity [83]. Calcium, magnesium, copper, zinc, chromium and iron were also found in the aloe products. Magnesium lactate inhibits histidine decarboxylase and prevents the formation of histamine from the amino acid histidine [72]. Histamine is released in many allergic reactions and causes intense itching and pain. The prevention of its formation may explain the anti-allergic effects of aloe vera gel. Anthraquinones are the phenolic compounds present in the sap or yellow exudates of leaf or aloe vera latex. Aloe latex contains a series of glycosides known as anthraquinones, the most prominent being aloin A and aloin B [80]. The bitter aloes (dried yellow exudates) consists of free anthraquinones and their derivatives i.e. barbloin-IO-(1151-anhydroglucosyl)-aloeemodin- 9-anthrone, isobarbloin, anthrone–C- glycosides and chromones. These compounds exerts a powerful purgative effects when ingested in large amounts but when low in concentration, they appear to aid absorption from the gut and are potent antimicrobial [75] and powerful analgesic agents. Isolation and structure determinations of these chromones from the aloe vera leaves were also studied and these compounds were identified to be 8-C-glycosyl-7-O methyl-(S) aloesol, isoaloeresin D and aloeresin E [65].

Table 1. Novel components of aloe vera along with their health benefits

Chemical component	Health benefits
Acemannan	Accelerate wound healing; modulate immune system, Antineoplastic and antiviral effect.
Alprogen	Anti-allergic
C-glycosyl chromone	Anti-inflammatory
Bradykinase	Anti-inflammatory
Magnesium lactate	Anti-inflammatory
Salicylic acid	Analgesic, anti-inflammatory

(71, 61)

5. Processing of Aloe Vera

Aloe vera gel derived from the leaf pulp of the plant has become a big industry worldwide due to its application in the food industry. It is utilized in functional foods especially for the preparation of health drinks with no laxative effects. It is also used in other food products including milk, ice cream, confectionery, etc. Aloe vera gel is also used as flavoring component and preservative in some foods [17]. Thus, a simple and efficient processing technique needs to be developed especially for the aloe beverage industry to improve product quality and safety by preserving the bioactive chemicals naturally present in the intact aloe vera leaf [23].

Recently, a glycoprotein with anti-allergic properties, called alprogen was isolated from aloe gel. In addition, a novel anti-inflammatory compounds, C-glycosyl chromones, has also been isolated from aloe gel [43]. Saponins are the soapy substances, form 3% of the gel and are general cleansers, having antiseptic properties [39]. The sterols

include comperterol, β- sitosterol and lupeol [18]. Salicylic acid is an aspirin like compound possessing pain relieving properties (Table 1). About 20 out of 22 amino acids and seven of the eight essential amino acids required by human body are also present in aloe vera gel. Aloe vera juice was evaluated for antioxidant potential and the study showed significant presence of antioxidant in aloe extracts. A 3 years old plant extract exhibits the strongest free radical scavenging activity of 72.19%, which is significantly higher than that of BHT having 70.52% and α-tocopherol with 65.65% [41]. It is suggested that growth stage in aloe plant plays a vital role in the composition and antioxidant activity [41]. Aloe vera juice also has antibacterial properties against Gram- positive bacteria [1]. Antiviral and antifungal properties of aloe vera has been reported in detail [4].

Table.2: Summary of the phytochemicals of Aloe vera pulp and exudate

Class	Compounds
Anthraquinones/anthrones	Aloe-emodin, aloetic-acid, anthranol, aloin A and B (or collectively known as barbaloin), isobarbaloin, emodin, ester of cinnamic acid
Carbohydrates	Pure mannan, acetylated mannan, acetylated glucomannan, glucogalactomannan, galactan, galactogalacturan, arabinogalactan, galactoglucoarabinomannan, pectic substance, xylan, cellulose
Chromones	8-C-glucosyl-(2′-O-cinnamoyl)-7-O-methylaloediol A, 8-C-glucosyl-(S)-aloesol, 8-C-glucosyl-7-O-methyl-(S)-aloesol, 8-C-glucosyl-7-Omethylaloediol, 8-C-glucosyl-noreugenin, isoaloeresin D, isorabaichromone, neoaloesin A
Enzymes	Alkaline phosphatase, amylase, carboxypeptidase, catalase, cyclooxidase, cyclooxygenase, lipase, oxidase, phosphoenol, pyruvate carboxylase, superoxide dismutase
Minerals	Calcium, chlorine, chromium, copper, iron, magnesium, manganese, potassium, phosphorous, sodium, zinc
Lipids and miscellaneous organic compounds	Arachidonic acid, γ-linolenic acid, steroids (campestrol, cholesterol, β-sitosterol), triglicerides, triterpenoid, gibberillin, lignins, potassium sorbate, salicylic acid, uric acid
Amino acids	Alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, hydroxyproline, isoleucine, leucine, lysine, methionine, phenylalanine, proline, threonine, tyrosine, valine
Proteins	Lectins, lectin-like substance
Saccharides	Mannose, glucose, L-rhamnose, aldopentose
Vitamins	B1, B2, B6, C, β-carotene, choline, folic acid, α-tocopherol

(59, 20, 26, 15)

Fig.4. *Aloe barbadensis* processing to extract liver tonic, Indian Medicines Pharmaceutical Corporation Ltd. (IMPCL), Almora, Uttarakhand.

Fig.5. Initial preparation to extract liver tonic from Aloe Vera. IMPCL

Fig. 6. Machinery used to prepare liver tonic, IMPCL

Fig. 7. Extracted Liver tonic from Aloe Vera, IMPCL

The production process of aloe vera juice involves crushing, grinding or pressing of the entire leaf of the aloe vera plant to produce a liquid, followed by various steps of filtrations and stabilization (preserving the biological integrity of active ingredient to exert the reported physiological effect upon ingestion or topical application). The resulting juice is then incorporated in or mixed with other preparations or agents to produce a pharmaceutical, cosmetic or food product. In food industry, aloe vera has been utilized as a source of functional food drinks and other beverages including tea. The amount of aloe vera that finds its application in pharmaceutical industry is also substantial as evident by availability of topical ointments, gel preparations, tablets and capsules [23]. Unfortunately, because of improper processing procedures many of these so called aloe products contain very little or virtually no active ingredients namely, mucopolysaccharides. In view of known wide spectrum of biological activities possessed by the leaves of aloe vera plant and its wide spread use, it has become imperative that the leaf must be processed with the aim of retaining essential bioactive components up to maximum possible limit or as much as contained in fresh leaf. *Aloe barbadensis* has found great importance in the extraction of liver tonic which has been efficacious for people (Fig. 4-7). The general steps involved in the processing of aloe vera are explained in the following paragraphs.

5.1. Reception of raw material: The aloe vera leaves after harvesting must be transported in refrigerated vans from field to the processing plant. The leaves should be sound, undamaged, mold free and mature (3–4 years) in order to keep all the active ingredients in full concentration [48]. One important factor affecting the composition of final product is the handling of the leaves after its harvesting because the decomposition of the gel matrix starts just after its cutting due to natural enzymatic reactions and the activity of bacteria normally present on the leaves. It can adversely affect the quality of the end product. Thus, the freshly removed leaves are refrigerated within 6 h or the leaves are directly fed to processing plant on the farm itself. Filleting In this process green rind of leaf is removed to extract the parenchymatous tissue called the gel fillet [33]. It is reported that the aloe gel extracted from the leaf had greater stability than the gel left in the leaf. In order to avoid the loss of biological activity filleting operation must be completed within 36 hrs of harvesting the leaves [63]. The presence of anthraquinones is an important factor leading to non enzymatic browning in aloe products [36]. Homogenization and enzymatic treatment it includes crushing or grinding of gel fillet at room temperature (25 °C) in commercial high speed grinder. The crushing or grinding should be completed within 10–20 min in order to avoid the enzymatic browning. Enzymatic treatment of aloe vera gel for a long duration prior to processing is detrimental to polysaccharides [32, 82, 84]. It has been reported that the enzyme treatment at 50 °C and within 20 min did not cause loss of biological activity of polysaccharide in aloe vera gel [54].

5.2. Filtration and deareation: Fibrous material is removed by this step. This operation influences the stability of aloe vera juice. Poor filtration results in sedimentation of aloe juice on storage. The unpasteurized aloe juice is fortified with vitamin C and citric acid to avoid browning reactions, improve flavor and stabilize the juice [22, 44, 46, 78]. Aim of deareation is to prevent oxidation of ascorbic acid which eventually improves the flavors of aloe vera juice [14].

5.3. Hot processing and flash cooling: In hot processing, sterilization is achieved by treating the aloe liquid with the activated carbon at high temperature [13]. This step may affect the taste, appearance and the biological activity of aloe gel products. Biological activity of aloe vera gel essentially remains intact when gel is heated at 65 °C for a period less than 15 min. Extended periods or higher temperatures greatly reduce activity levels. After heat treatment, the juice is flash cooled to 5 °C or below within 15 s to preserve biological activity.

High temperature short time treatment (at 85–95 °C for 1–2 min) is an effective method to avoid the off flavor and the loss of biological activity of aloe vera gel. Physicochemical modification promoted by heat treatment at different temperature range from 30 to 80 °C on acemannan was evaluated by [7]. Heating promotes significant changes in the molecular weight of the bioactive polysaccharide increasing from 45 KDa in fresh aloe to 75 KDa for samples dehydrated at 70 and 80 °C. The physicochemical alterations of the main type of polysaccharide may have important implications on the physiological activities attributed to the aloe vera plant.

5.4. Cold processing: In the cold processing technique, the entire processing steps are accomplished without the application of the heat. The use of enzymes, like glucose oxidase and catalase to inhibit the growth of aerobic organisms within aloe vera gel and thereby sterilizing it has been reported [19]. Other sterilization steps reported in the cold processing include exposing the gel to ultraviolet light followed by micron filtration [52].

5.5. Addition of preservatives and stabilizers: In all the processing techniques, preservation can be achieved by the addition of chemical preservatives and other additives. The use in synergismhas been reported by some researchers [13, 56]. Stabilizing agent is added in aloe products to prevent sedimentation of juice upon storage. In an investigation [85] the aloe vera gel was mixed with sulphited polysaccharides isolated from the red microalgae, guar gum and xantham gum. Rheological studies indicated interaction of aloe vera gel with algal polysaccharides and xantham gum which is depicted by increased apparent viscosities, yield points and in some cases hysteresis but these interactions were not observed with guar gum. These desirable properties did not deteriorate during storage. It was, therefore, proposed that algal polysaccharides or xantham gum could stabilize the network structure of fresh aloe vera polysaccharide.

5.6. Storage: Aloe vera juice is packed in amber colored glass bottles to avoid the effect of light on the sensitive bioactive agents. Relative humidity and temperature are two most important environmental parameters that affect product quality. These two parameters can also affect the amount of the volatile substance of the juice absorbed by the packaging material [38] and consequently affect the shelf life of the product [66].

6. Aloe juice and its food applications

6.1. Traditional method of aloe juice processing: In this method lower one inch of the leaf base, the tapering point (2–4 in.) of the leaf top, the short sharp spines located along the leaf margin as well as the top and bottom rind are removed with sharp knife along with the rind parts to which some mucilage remains attached. The fillet and the mucilage are collected from the aloe leaf for further processing. The highest concentrations of the potentially beneficial aloe constituents are found in mucilage as this layer represent the place of synthesis of the beneficial constituents. The material of the mucilage layer, subsequent to their synthesis, is distributed to the storage cells (cellulose-reinforced hexagons) of the fillet [63]. The aloe vera gel fillet is washed with deionized water and transferred to the pulper. The pulper is fitted with refrigerated system that keeps the temperature of the extracted juice lower to prevent decomposition. The aloe vera juice is conveyed to a holding tank and kept for 24 h to decant. Holding tank is also refrigerated for preserving the bioactivity of sensitive molecules of aloe vera.

6.2. Whole leaf processing method: The process was developed in 1980's in USA and undergone continuous improvement by contribution of different workers [40, 53, 19]. The procedure employs cold treatment to ensure product rich in bioactive compounds. In this process the base and tip of leaf are removed. The leaf is cut into sections and ground into particulate slurry in a Fiz Mill (Model D6 Make Arnold equipment company, Ohio) to produce a soup like consistency. The material is then treated with cellulase enzyme which breaks down the hexagonal structure of the fillet and releasing the cell constituents. The rind particles are removed by means of a series of coarse screening filters or passage through a juice press. This liquid is then pumped into large stainless steel sanitized holding tank. Once the tank is filled, it is hooked up to a depulping extractor. This machine removes the large pieces of pulp and rind which are generated by initial grinding process. Now the aloe liquid is passed through a series of filters that removes the aloin and aloe emodin as well as any microscopic traces of leaves, sand or other particles. A press filter is used for this purpose. The press filter's carbon coated plates absorb the aloin and aloe emodin. Aloe liquid is continually passed through the filter press until the aloin and aloe emodin are removed. The filtered product is then placed in a second holding tank and passed through a press filter containing five micron filter paper. The aloe liquid is now ready for stabilization. This process can produce aloe vera juice containing three times more bio-active

constituents than traditional hand filleted process [63]. The aloe vera juice finds wide application in food products like production of ready to serve drink, health drink, soft drink, laxative drink, aloe vera lemon juice, sherbet, aloe sports drink with electrolyte, diet drink with soluble fiber, hangover drink with B vitamin, amino acids and acetaminophen, healthy vegetable juice mix, tropical fruit juice with aloe vera, aloe vera yoghurts, aloe vera mix for whiskey and white bread, cucumber juice with aloe vera [23, 34, 33, 2, 36, 74] (Table 3). [83] prepared a health beverage from fresh aloe vera leaves.

The leaves were washed, pulped, sterilized and filtered, then mixed with different concentrations of Dangshen, Maidong juices and Chinese herbs. Effects of processing conditions e.g. temperature, pH, sucrose, vitamin C and citric acid on the stability of color and gelatinoids in aloe vera juice were studied and it was concluded that the stability was negatively affected by increasing sucrose and citric acid concentrations while vitamin C and sodium chloride at low concentrations improved the stability. [21] prepared vinegar from aloe vera juice using *Acetobactor sp*. [50] made aloe vera yoghurt with lactic acid bacteria (single or mixed strains of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*) and compared it with yoghurt prepared using dried skim milk and it was found that quality retention of aloe vera yoghurt at 5 °C for 15 days was better than the milk yoghurt.

7. Aloe concentrate and its food applications

The aloe juice can be concentrated under vacuum without the loss of biological activity. The concentration operation must be conducted under 125 mm Hg vacuum at temperature below 50 °C and must not exceed 2 min as higher vacuum and temperature will cause loss of effectiveness of bioactive constituents [63]. Concentration is carried out to get aloe vera concentrate of desired consistency to suit various food applications i.e. squash, jam and jellies. The concentrate of aloe can also be mixed with tea, water or juice.

8. Aloe powder and its food applications

In dehydration method the pure intact aloe vera gel fillets are first washed to remove traces of aloin. Then the fillets are placed into a humidity chamber where desired level of relative humidity and temperature are maintained [63]. Here hot air is passed over the fillets to dry them. This material is then ground to powder and packed [63]. Qmatrix drying is a novel proprietary method of dehydration of aloe vera enabling the dehydration of aloe while maintaining its integrity with respect to flavor, colour and bioactivity. It is comparable to freeze drying in quality aspects but without the high operational cost. In freeze drying, gel fillet is lyophilized at −88 °C and 0.01 mm Hg pressure for 65 h to get dried gel fillet. Later is then ground to get aloe powder with moisture content below 4%. Peng et al 1991, prepared freeze dried powder from ultra-filtration and reverse osmosis of concentrated aloe vera gel [62]. Franz 1989, prepared aloe vera leaf powder by cutting leaves in small pieces, blending in a mixer and drying them in a tray drier at 50 °C for 12 h [27]. The dried material is then ground into powder in a mixer grinder. Aloe vera powder can be used in curd, lassi, ice-creams, etc. Aloe powder has also been used in the preparation of yoghurts [49, 69].

***9.* Commodity use of Aloe vera**

The leaves of Aloe are eaten as vegetable. Pickle made by small pieces of leaf pod is a common preparation in western Rajasthan [67]. The immature flower stalk that are completely free from bitter content, are also used for vegetable purpose. Fresh fleshy leaf pod is a part of green salad and helpful in treatment of indigestion and constipation. Sharma and Goel 2002 standardized the recipes of various Aloe product viz., vegetable, pickles, laddo, jam, squash, biscuits and churna by using sensory evaluation technique [71]. Saroj and Purohit (2004) standardized the recipe for preparation of some culinary products from sweet type Aloe (*Aloe barbadensis*) [68]. It helps to cure diabetes, ulcer, heart disease [16]. Now a day's *Aloe vera* juice is available in the market to enhance immune response against various diseases. Besides juice, *Aloe vera* leaf powder is also being used by food processing industries in preparation of yoghurt and other food products [86]. The gel is most commonly used part of the plant which has been processed and used in different products. Today, the industry is flourishing and gel is being used as fresh gel juice [5]. It has also been suggested that bio-fuels could be obtained from *Aloe vera* seeds [73]. It is common practice for cosmetic companies to add sap or other derivatives from *Aloe vera* to products such as makeup items, tissue papers, moisturizers, soaps, sunscreens, incense, shaving cream, and shampoos [64]. Traditionally, Aloe is extensively used for medicinal purpose particularly for urine related problems, pimples and ulcers. Aloin and its gel are used as skin tonic and have a cooling and moisturizing affects so it is used in preparation of creams, lotions, shampoos and allied products [75]. Aloe contents of different market products are about 20% (sunburn treatments, creams and ointments), 95% (juices), 50% (beverages), 10% (drinks), and 5-10% (capsules).

10. Commercial Production

Use of aloe gel and preparations containing it has become widespread and consequently a large industry has developed, mostly in Texas and Florida. One of the earliest producers was Carrington Laboratories (http: www.carringtonlabs.com: about.html) which used the expertise of staff from Texas A. and M. University and grows its plants in Costa Rica. Among a range of products the preparation named Acemannan or Carrisyn™ was much

studied. An associated firm, Mannatech ™ Incorporated (http: www.mannatechinc. com.) produced a similar mannose-based mucopolysaccharide from *A.* 6*era*, marketed as Manapol® by a Carrington subsidiary, Caraloe (http: www.aloevera.com.) backed by HPLC validation. Dr Madis Laboratories of New Jersey is another firm that was early in the field, supplying both the fresh gel and derived products. In view of the many claims made by aloe producers and the variable results achieved, the International Aloe Science Council (http: www2.iasc.org.iasc.articles.html) was set up in 1981 by the Trade to try to establish standards. One major supporter of the Council is Aloecorp (http: www.aloecorp.com:aloecorp.htm) with estates in Texas and Mexico. They support a wide range of research activities and supply products in the form of the gel either in the raw form, concentrated or freeze or spray-dried. Another well established (1973) firm is Terry Laboratories (http: www terrylabs.com:index.htm) who are major suppliers of gel to many multinational companies and are major supporters of aloe research and quality control. Dr Madis Laboratories Inc.offers the gel either as a purified extract or in a number of formulations. AloeVera Company UK (Forever Living Products) (http: www.aloevera.co.uk:home.htm) are active in selling the gel and derived products by franchise, using aloes grown in Texas. Many firms concentrate the gel by either mild air drying or freeze drying. Examples are Concentrated Aloe Corporation (http: www.geocities.com:Heartland: Ridge: 1396: concentrated–aloe: lisa.html), CRH International Inc (http: www.aloealoe.com. raw.html) and Valley Aloe Vera Inc (http: www.quikpage.com.valleyaloe). This is by no means a complete list, there are many other producers, large and small, some of which have pages on World Wide Web. An information site 'The *Aloe* v*era* studies organization' (http: www.aloe-vera.org.) gives some interesting hints, although its botany is a little quaint. A similar site has been set up by 'Miracle of Aloe' (http: www.miracleofaloe.com. internal.htm) and another by 'Triputic Laboratories' (http: www.primenet.comp hidden. hayward.html). Although these informative sites make very positive, often triumphalist statements in favor of the efficacy of aloe gel for a variety of ills, they do not make the extravagant claims which are a feature of some promotional literature, even if their scientific descriptions are sometimes a little garbled.

11. Safety aspects of Aloe Vera products

Scientific community is divided into two groups regarding safety of aloe vera products. One group advocates that the aloe vera is quite safe for human consumption. While the other group warns to use it with caution and utmost care to avoid contamination of aloin from the yellow exudates, as aloin is reported as DNA damaging and causes cancer [(47)]. On the contrary scientists have reported that anthroquinones present in aloe vera leaf, including aloin, are beneficial in a number of ways when used in small quantity, though the small quantity is not well defined [(76)]. It is reported that aloe vera gel is safe for external use, allergies are rare and adverse reactions with other medications have not been reported. Aloe should not be used internally during pregnancy, lactation or childhood and by persons suffering from abdominal pain, appendicitis or intestinal obstruction [(45)]. A case of disseminated dermatitis has been reported following application of aloe vera gel to a patient with stasis dermatitis. Several patients who applied aloe vera gel topically following dermabrasion reported burning sensation and development of dermatitis on the face [(42)]. Because of possible contamination by anthraquinones, oral aloe gel may cause symptoms of abdominal cramps and diarrhoea. There have also been several reports of aloe vera gel lowering plasma glucose in laboratory animal and in human [(29)]. Use of aloe vera is reportedly associated with occurrence of Henoch- Schonlein purpura (HSP) a systemic vasculitis that occurs most often in children who are rarely exposed to drugs or other environmental factors. Acute hepatitis could be linked to ingestion of Aloe barbdensis compounds. An acute bullous allergic reaction and urticaria have also been reported to result from the use of aloe vera gel [(57)]. Studies in mice revealed no acute toxicity in therapeutic doses but in high doses a decreased central nervous system (CNS) activity was noticed [(70)]. In chronic treatment decrease in red cell count and significant sperm damage was noticed [(70)]. However, no systematic investigation exists in humans on the effect of high doses of aloe vera for longer periods on red cell count and sperm damage [(81)].

CONCLUSION

The literature covered by the previous review [(33)] contained many case reports and more or less anecdotal accounts of the healing powers of *A.* v*era* gel, especially for skin lesions but extended by some to a host of other complaints [(10)]. Laboratory studies indicated that there was indeed in vitro activity present but the relevance to in vivo activity was not always clear. Since then much more experimental work has been carried out and a picture of biological activity properties is emerging. One feature that is becoming clear is that the systems undergoing healing contain several interacting factors, each of which may be affected by more than one component of the raw gel. It may be that some of the inconsistencies reported are caused by unknown variation in any of these factors.

It certainly seems that one feature, immune-stimulation, is frequently appearing as a major contributory factor. This is associated with the presence in the gel of polysaccharides. These substances occur in all plants, often as storage carbohydrates such as starch or insulin or structural carbohydrates such as cellulose while others have a more limited distribution. Many of these specialized polysaccharides of unknown function in the plant have been found to be

physiologically active in animals and subjects for new therapies [27, 77, 54]. Mucopolysaccharides also occur in saliva and it is fascinating to speculate if the supposed therapeutic powers of dogs, licking wounds, are due to these substances. In *Aloe* an acetylated glucomannan was found to be biologically active, so much so that it was named acemannan (Carrysin™). If the presence of acetyl groups is necessary for activity, one wonders if this is because they cover a number of hydrophilic hydroxyl groups and thus make the molecule more able to cross hydrophobic barriers in the cell. It may also be that some of these ester bonds are particularly labile, accounting for differences of reported efficacy of different preparations. No investigations appear to have been made into this or into the possibility of using other residues to cover hydroxyl groups, except for methylation, described in an American patent [24] and this were to confer stability to the polymer chain. It should also be noted however that active glycoproteins have also been demonstrated in aloe gel and may well play some part in therapeutic activity, either immunologically as lectins or as proteases such as anti-bradykinins.

There seems to be ever-decreasing doubt that aloe gel has genuine therapeutic properties, certainly for healing of skin lesions and perhaps for many other conditions. It is also clear that the subject is by no means closed and much needs to be discovered, both as to the active ingredients and their biological effects. These ingredients, acting alone or in concert, include at least polysaccharides, glycoproteins, perhaps prostaglandins, small molecules such as magnesium lactate, infiltrating exudate phenolics and even, simplest of all, water.

Acknowledgements
The authors of the research paper would like to place on record their heartfelt gratitude to University School of Environment Management, Guru Gobind Singh Indraprastha University for their immense support and cooperation throughout our endeavors in writing this review article. We also want to thank the editor of the research journal for scrutinizing the research article in very professional and scientific way which has added more value to our efforts for this review paper.

REFERENCES

[1] Alemdar S, Agaoglu S (2009) Investigations of in-vitro antimicrobial activity of aloe vera juice. J Anim Vet Adv 8(1):99–102
[2] Ang NU, Intaphan P, Saengo E (1996) Development of orange aloe vera jam. Proceeding of the 13th Rajamangala institute of technology annual conference: Food science and home economics Lampang (Thailand), pp 39–45
[3] Anonymous (2006) For Aloe vera as semi finish products like gel, powder and finish products like aloe vera drink or fizzy tablets. Technology transfer and project management network, Ensymm consulting of biotechnology. http://www.ensymm.com/pdf/ ensymmProjectstudyAloeVeraproduction.pdf. Accessed on 5 October 2010
[4] Anonymous (2008) Aloe vera: History, science and medicinal uses. http://www.healingaloe.com Accessed 5 October 2010
[5] Anonymous: (2004). *Aloe vera*. The ancient plant remedy for today's stressful life style. http:// wholeleaf.com (17.05.2005).
[6] Anonymous: (2006), For Aloe vera as semi finish products like gel, powder and finish products like aloe vera drink or fizzy tablets. Technology transfer and project management network, Ensymm consulting of biotechnology. http://www.ensymm.com/pdf/ ensymmProjectstudyAloeVeraproduction.pdf. Accessed on 5 October 2010
[7] Antoni FG, Pablo S, Susana S, Carmen R (2003) Effect of heat treatment and dehydration on bioactive polysaccharide acemannan and cell wall polymers from Aloe barbdensis miller. Carbohydr Polym 51:397–405
[8] Atherton P (1997) Aloe vera: myth or medicine. http://www. positivehealth.com Accessed 28 December 2010
[9] Atherton P (1998) First aid plant. Chem Brit 34:33–36
[10] Bloomfield F: (1985). Miracle Plants: Aloe Vera. Century, London.
[11] Bozzi A, Perrin C, Austin S, Arce Vera F (2007) Quality and authenticity of commercial aloe vera gel powders. Food Chem 103(1):22–30
[12] Bradley PR (1992) British herbal compendium. British Herbal Medicine Association
[13] Cerqveira L, McKnight LS, Rodriguez S, Turner CE (1999) Bifurcated method to process aloe whole leaf. US Patent 5 925 357
[14] Chan HT, Cavaletto CG (1986) Effects of deareation and storage temperature on quality of aseptically packaged guava puree. J Food Sci 51:165–168
[15] Choi S, Chung MH (2003) A review on the relationship between Aloe vera components and their biological effects. Semin Integr Med 1:53–62
[16] Choo C: (2003). Vital vera. Asia Pacific Food Ind. 15:36-37.
[17] Christaki EV, Florou-Paneri PC (2010) Aloe vera: a plant for many uses. J Food Agric Environ 8(2):245–249
[18] Coats BC (1979) Hypollergenic stabilized aloe vera gel. US Patent number 4 178 172

[19] Coats BC (1994) Methods of processing stabilized aloe vera gel obtained from the whole aloe vera leaf. US Patent 5 356 811
[20] Dagne E, Bisrat D, Viljoen A, Van Wyk BE (2000) Chemistry of aloe species. Curr Org Chem 4:1055–1078
[21] Davis RH (1997) Aloe vera- A scientific approach. Vantage Press Inc, New York, pp 290–306 Do-Sang L, Ryu II, Kap-Sang L, Yang-See S, Seung-Ho C (1999) Optimisation in the preparation of aloe vinegar by Acetobactor sp. and inhibitory effect against lipase activity. Hanguk Nongwhahak Hoechi 42:105–110
[22] Eison-Perchonok MH, Downes TW (1982) Kinetics of ascorbic acid oxidation as a function of dissolved oxygen concentration and temperature. J Food Sci 47:765–773
[23] Eshun K, He Q (2004) Aloe vera: a valuable ingredient for the food, pharmaceutical and cosmetic industries: a review. Crit Rev Food Sci Nutr 44:91–96
[24] Farkas, A., 1967. Methylated polysaccharide and method of making. US Patent 3,360,510.
[25] Farnsworth NR, Fong HHS,Mahady GB (1999) Aloe vera gel. In:WHO monographs on selected medicinal plants Vol 1. Malta pp 43–49
[26] Femenia A, Sanchez ES, Simal S, Rosello C (1999) Compositional features of polysaccharides from Aloe vera (Aloe barbadensis Miller) plant tissues. Carbohydr Polym 39:109–117
[27] Franz G: (1989). Polysaccharides in pharmacy: current applications and future concepts. Planta Medica 55, 493–497.
[28] Gautam S, Awasthi P (2007) Nutrient composition and physiochemical characteristics of Aloe vera (Aloe barbadensis) powder. J Food Sci Technol 44(2):224–225
[29] Ghannam N, Kingston M, Al-Meshaal IA, Tariq M, Parman NS, Woodhouse N (1986) The antidiabetic activity of aloe: preliminary clinical and experimental observation. Horm Res 24 (4):288–294
[30] Ghazanfer SA (1994). Handbook of Arabian Medicinal Plants. Boca Rato: CRC Press. P 263.
[31] Gjestad G (1971) Chemical studies of aloe vera juice. Adv Front Plant Sci 28:110–112
[32] Gowda D, Neelisiddaiah B, Anjaneyalo Y (1980) Structural studies of polysaccharides from Aloe saponaria and Aloe vanbalenni. Carbohydr Res 83:402–405
[33] Grindlay D, Reynolds T: (1986). The Aloe vera phenomenon: a review of the properties and modern uses of the leaf parenchyma gel. Journal of Ethnopharmacolgy 16, 117– 151.
[34] Hamman JH (2008) Composition and application of aloe vera leaf gel. Molecules 13:1599–1616
[35] Harding TBC (1979) Aloes of the world: a checklist, index and code. Excelsa 9:57–94
[36] Hastuti S (1999) Fresh beverage from aloe vera. Butetin Ilmiah Instiper (Indonesia) 6:39–45 He Q, Liu C, Zhang T (2002) Study on nonenzymatic browning of aloe products and its inhibition methods. Food Sci (Chenses) 23 (10):53–56
[37] Heber D (2007). Physicians' Desk Reference for Herbal Medicines. Thomson Health Care, Montvale. 4th Ed. Pp. 515-518.
[38] Hernadez RJ, Giacin JR (1998) Factors affecting permeation, sorption andmigration process in package-products system. In: Food storage stability. CRC Press, Boca Raton, Florida USA, pp 269–329
[39] Hirat T, Suga T (1983) The efficiency of aloe plants, chemical constituents and biological activities. Cosmetics and Toiletries 98:105–108
[40] Homcare Iberica SA (1983) Stabilization of a clear gel from aloe vera leaves. Span ES 502 307. Patent of Introduction
[41] Hu Y, Xu J, Hu Q (2003) Evaluation of antioxidant potential of aloe vera (Aloe barbdensis Miller) extracts. J Agric Food Chem 51 (26):7788–7791
[42] Hunter D, Frumkin A (1991) Adverse reaction to Vit E and aloe vera preparations after dermabration and chemical peel. Cutis 47 (3):193–195
[43] Hutter J, Salman M (1996) Anti-inflammatory C-glucosyl chromone from Aloe barbadensis. J Nat Prod 59(5):541–543
[44] Kacem B, Mathews RF, Grandall PG, Cornell JA (1987) Nonenzymatic browning in aseptic packaged orange drinks: effects of amino acids, dearation and anaerobic storage. J Food Sci 52:1665–1667
[45] Kemper KJ, Chiou V (1999) Aloe vera. Longwood herbal task and The Center for Holistic Pediatric Education and Research http:// www.longwoodherbal.org/aloe/aloe.pdf. Accessed 4 October 2010
[46] Kennedy FC, Rivera ZS, Loyd LL, Warner FP, Jumel K (1992) Lascorbic acid stability in aseptically processed orange juice in tetra brick cartons and the effect of oxygen. Food Chem 45:327–331
[47] Lachenmeier K, Kuepper U, Musshoff F, MadeaB RH, Lachenmeier DW (2005) Quality control of aloe vera beverages. Electronic J Environ Agric Food Chem 4(4):1033–1042
[48] Lawless J, Allen J (2000) Aloe vera- Natural wonder care. Harper Collins Publishers, Hammersmith, pp 5–12
[49] Lee EH, Choi SD (1994) Studies on the manufacture of aloe yoghurt. J Agric Technol Res Institute Chinju University (Korea Republic) 7:55–59
[50] Lee J, Hand-Yoon YH (1997) Characteristics of aloe vera suspended liquid yoghurt inoculated with Lactobacillus Casei YIT 9018. Korean J Animal Sci 39:93–100

[51] Luta G, McAnalley BH (2005) Aloe vera: chemical composition and methods used to determine its presence in commercial products. GlycoSci Nutr 6(4):1–12
[52] Maret RH (1975) Process for preparing extract of aloe vera. US Patent 3 878 197
[53] Maughan RG (1984) Methods to increase colour fastness of stabilized aloe vera. US Patent 4 465 629
[54] McAuliffe JC., Hindsgaul O: (1997). Carbohydrate drugs-an ongoing challenge. Chemistry and Industry, 170–174.
[55] Meadows TP (1980) Aloe as a humectant in new skin preparation. Cosmet Toiletries 95(11):51–56
[56] Moor ED, McAnalley BH (1995) A drink containing mucilaginous polysaccharides and its preparations. US Patent 5 443 830
[57] Morrow DM, Rappaport MJ, Strick RA (1980) Hypersensitivity to aloe. Arch Dermatol 116:106–1065
[58] Newton LE (1979) In defense of the name aloe vera. Cactus Succul J GB 41:29–30
[59] Ni Y, Tizard IR (2004) Analytical methodology: The gel-analysis of aloe pulp and its derivatives. In: Reynolds T (ed) Aloes the genus aloe. CRC, Boca Raton, pp 111–126
[60] Ovadova RG, Lapchich VF, Ovodov YS (1975) Polysaccharides in Aloe arboresens. Khimija Prirodykh Soedinenii 11:3–5
[61] Peng SY, Norman J, Curtin G, Corrier D, Mc Daniel HR, Busbee D (1991) Decreased mortality of Norman murine sarcoma in mice treated with the immunomodulator, Acemannan. Mol Biother 3:79–87
[62] Qian H (2002) Study on the technology of aloe gel freeze dried powder. Food Fermentation Industry 28:49–52
[63] Ramachandra CT, Srinivasa Rao P (2008) Processing of aloe vera leaf gel: a review. Am J Agril Biol Sci 3(2):502–510 Robert HD (1997) Aloe vera: a scientific approach. Vantage Press Inc, New York
[64] Reynolds T: (2004). Aloes: The Genus Aloe. CRC Press: Boca Raton.
[65] Saccu D, Bogoni P, Procida G (2001) Aloe exudate: characterization by reversed phase HPLC and headspace GC–MS. J Agric Food Chem 49(10):4526–4530
[66] Sadler GD, Braddock RJ (1990) Oxygen permealibity of low density polyethylene as a function of lomonene absorption: an approach to modeling flavour (Scalping). J Food Sci 55:587–590
[67] Saroj PL, Dhandar DG, Singh RS: (2004). Indian Aloe.Central Institute for Arid Horticulture, Bikaner. pp. 6-10.
[68] Saroj PL, Purohit CK: (2004). Indian Aloe: an alternative food with nutritional value, SAIC News Letter. January – March, 2004. 5 & 7.
[69] Seoshin Y, Lee KS, Lee JS, Lee CH (1995) Preparation of yoghurt added with Aloe vera and its quality characteristics. J Korean Soc Food Nutr 24:254–260
[70] Shah AH, Qureshi S, Tariq M, Ageel AM (1989) Toxicity studies on six plants used in the traditional Arab system of medicine. Phytother Res 3:25–29
[71] Sharma R, 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, NIM, Hyderabad.
[72] Shelton M (1991) Aloe vera, its chemical and therapeutic properties. Int J Dermatol 30:679–683 Sims P, Ruth M, Zinmerman ER (1971) Effect of aloe vera on Herpes simplex and Herpes virus (strains Zoster). Aloe vera of American Archive 1:239–240
[73] Shukla S: (2008). *Aloe vera* has biodiesl potential, reveals, MSU study. expressindia.com. http://www.expressindia.com/latest-news/Aloe-Vera-has-biodiesel-potential-reveals-MSU-study/324861/ (21.06.08).
[74] Singh A, Singh AK (2009) Optimization of processing variables for the preparation of herbal bread using Aloe vera gel. J Food Sci Technol 46(4):335–338
[75] Singh BM, Srivastava VK, Kidwai MA, Gupta S: (1995). Aloe (*Aloe barbadensis* Mill.), Psoralea and Mucuna. Advances in Horti. 1:513- 25.
[76] Sydiskis RJ, Owen DG, Lohr JL, Rosler KHA, Blomster RN (1991) Inactivation of enveloped viruses by anthraquinones extracted from plants. Antimicrob Agents Chemother 35(12):2463 2466
[77] Tizard I., Busbee D., Maxwell B., Kemp MC: (1994). Effects of Acemannan, a complex carbohydrate, on wound healing in young and aged rats. Wounds 6, 201–209.
[78] Tramell DJ, Dalsis DE, Malone CT (1986) Effect of oxygen on taste, ascorbic acid loss and browning for HTST pasteurized, single strength orange juice. J Food Sci 51:1021–1023
[79] Tucker AO, Duke JA, Foster S (1989) Botanical nomenclature of medicinal plants. In: Cracker LE, Simon JE (eds) Herbs, spices, and medicinal plants, vol 4. AR Oryx Press, Phoenix, pp 169– 242
[80] Tyler V (1994) Herbs of choice. In: The therapeutic use of phyto medicine. Binghamton Pharmaceutical Products Press, New York, pp 131–135
[81] Vogler BK, Ernst E (1999) Aloe vera: a systematic review of its clinical effectiveness. Br J Gen Pract 49:823–828
[82] Waller GR, Mangiafica S, Ritchey CR (1978) A chemical investigation of Aloe barbedensis Miller. Proc Okla Acad Sci 58:69–76

[83] Wang YT (1993) Bases of aloe certification. Aloe Today 27–29 Wei L, Chuncheng Y, Huafeng Z, Rugang Y (2004) Preparation of aloe-herbs health beverage. Food Sci China 25:207–209
[84] Yagi A, Shibata S, Nishioka I, Iwarde S, Ishida Y (1982) Cardiac stimulant action of constituents of Aloe saponaria. J Pharm Sci 71:739–741
[85] Yaron A, Cohen E, Arad SM (1992) Stabilization of aloe vera gel by interaction with sulfated polysaccharides from micro algae and with xantham gum. J Agric Food Chem 40:1316–1320
[86] Yong Seoshin, Kap Sang Lee, Jung Sung Lee, Chert Ho Lee: (1995). Preparation of yoghurt added with *Aloe vera* and its quality characteristics. J. Korean Soc. Food Nut. 24:254-260.