Phytochemical and Ethnobotanical Effects of Aloe vera

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ABSTRACT

Aloe vera is part and parcel of the Liliaceae family. This is one of 250 Aloe Barbadensis species, scientifically known as Aloe Vera. Acemannane, one of the most bioactive polysaccharides of Aloe Vera, has effects of immunity modulation, anti-cancer, anti-oxidation, bone repair, neuroprotection and promotion of intestinal health. The mucilaginous gel in the pulp of aloe vera formed by the parenchymal cells has been used for a variety of curative applications since ancient times. Aloe vera is a nutraceutical product used mostly for decades. It is available in a range of health drinks and wellness beverages, in capsules/tablets and in gels & creams externally. This article includes the bioactive components, extraction and processing of aloe vera and the prospects of tissue engineering. This article highlights important uses as a nutraceutical, medicinal, and therapeutic food potential of A. vera constituents. Aloe vera nutraceutical gel scaffolds, such as acemannan, promote biomedical biomedical and polymeric tissue management. The presence of over 200 phytochemicals was revealed by Aloe vera gel. Aloe vera gel from its leaves is extracted and the stabilisation and preparation of the final products requires adequate processing techniques.

Keywords: *Aloe vera*, Bioactive compounds, Phytocomponents, Aloins

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INTRODUCTION

Aloe vera is a permanent green herb with light and bright yellow flowers found in North Africa, the Middle East of Asia, the South Mediterranean, and the Channel Islands. Aloe vera (Aloe barbadensis Miller, Xanthorrhoeaceae). Aloe vera is derived from the Arabic words "allaeh," which mean "brilliant bitter substances". While it is similar to garlic, asparagus and onions, aloe vera is a succulent plant that looks like a cactus (Surjushe, A et al., 2008). It has stemless leaves with circular leaf sheaths that are grayish to dark green in appearance and tiny white teeth on the margins .The leaves are made up of 3 layers: an inner gel, a yellow fluid, and a densecoating of 15-20 cells that makes up

the rind.Aloe leaves are being used for cosmetic and pharmaceutical applications and also in fresh foods for a long time but the scientific basis for such properties is unknown.Latex and gel are the two primary ingredients of aloe vera. The latex, also known as aloe juice or aloe sap, is a bitter yellow abscess that comes from the pericyclic tubules underneath the leaf's skin surface and makes up about 20-30% of the weight of the whole leaf.In comparison to older leaves the young leaves had larger latex component amounts.The colorless, tasteless gel on the other side is the pulp or mucilage from the plant's parenchymatous cells in the internal part of leaf. These days, it is well understood that the gel which accounts for roughly 70-80 percent of total mass of the leaf serves as plant's energy and water storage portion (Akinyele, B. O et al., 2007). Since exudates compounds can infiltrate gel during the gel preparation it's difficult to tell whether the biological effect may be due to the gel or the latex while the whole Aloe Vera leaf is used.

Aloe vera leaves' colorless mucilaginous gel has been commonly used in cosmetic and pharmaceutical purposes.For thousands of years, aloe vera is also used in traditional medicine for its medicinal potential, particularly on the skin.Furthermore Aloe vera has been shown to have antidiabetic, anticancer, antihyperlipidemicand antioxi-dantproperties.More than 75 different compounds are contained in aloe vera including minerals like zinc, copper, selenium, and calcium, enzymes like amylase, catalase, and peroxidase, vitamins vit. A, C, E, and B12, sugars monosac-charideslike mannose-6-phosphate and polysaccharides like glucomannans, hormones auxins and gibberellins, anthraquinonesaloin and emodin, fatty acids arelupeol and campesterol and others salicylic acid, lignin, and saponins.

Sources

1. Source of biology

Aloes are made from dried juice of the leaves of Aloe barbadensis Miller, also known as Curacao aloes (Aloe Vera).

• Aloe perryi baker.

• Socotrine aloes.

Aloe ferox Miller and Aloe africana Miller and Aloe spicata Baker, also known as Cape aloes, are plants of liliaceae. Aloe, Musabbar, and Lolesara are all synonyms of Aloe (they are in the past assigned to largely restricted family Liliacae) (in kannada).

2. Geographical source

Aloes is an eastern and southern African plant that is cultivated in the Cape Colony of Zanzibar and the Socotra Islands.Also it's grown on Caribbean islands in Europe, as well as in many parts of India, along with the North West Himalayan region.

Composition of *Aloe vera*

Aloe Vera is a tender, rich plant with water (99-99.5 percent). (99-99.5 percent). Solids are 0.5 percent to 1.0 percent , and comprise various active components such as fats, water-soluble minerals, vitamins, polysaccharides, organic acids, enzymes and phenolic compounds (Hamman, 2008). (Hamman, 2008). There are three layers in the leaf gel, latex, and rind (Figure 2).

Gel: Soft, clear, moist, slippery interior fabric with big parenchyma cells. It's like a mucilaginous transparent jelly. It includes water (99%), glucose, amino acid (89%), fat, sterol and vitamins (Ramachandra and Rao, 2008; Hammann, 2008; Benítez et al. 2015).

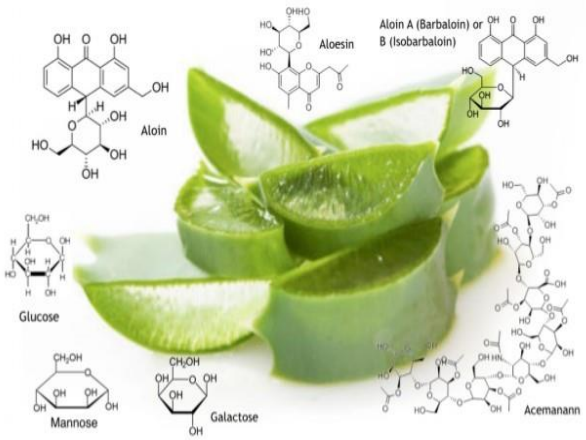

Figure 1: Structure of Aloevera

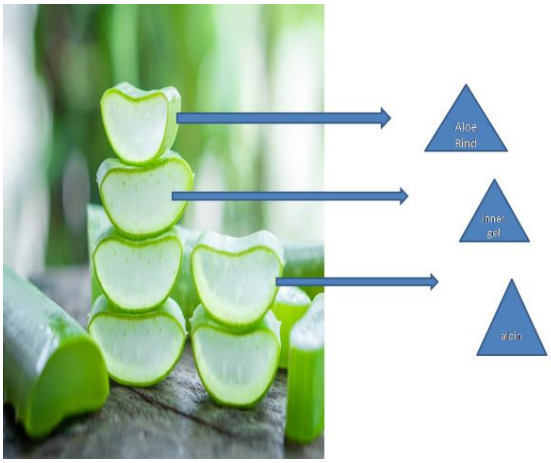

Figure 2:Compostion of Aloevera

Latex: Anthraquinone medium layer, saphir bitter yellow, glycosides (Hamman, 2008).

Rind: 15-20 cells in the thick outer layer protecting the matrix of gel and contributing to carbon and protein synthesis (Misir et al., 2014).

Rind and gel are the biggest part of the entire weight of the blade (20-30 percent and 70-80 percent , respectively).

Dry gel:

55% of the gel are polysaccharides, 17% of

it is sugar, 7% protein, 4% lipids, 16% minerals, 1% of the vitamins A, C, E and B1, B2 and B12, and 1% of the vitamins E. (Ahlawat and Khatkar, 2011; Ni et al., 2004; Radha and Laxmipriya, 2015).

Phytochemicals of *Aloe vera*

Aloe contains two classes of Aloins:

Nataloins: that produce nitric acid picric and oxalic acids, and don't give nitric acid red colours.

Barbaloins: Barbaloin acid roughening (C7H2N3O5), chrysammic acid (C7H2N2O6) and oxalic nitric acid. This second group can be composed of barbalins from aloes from barbados, reddened cold and barbalins from soothrins and sanzibar aloes, which are rotated with normal nitric acid only when heated and acid fuming in the cold. Shiny yellow scales of natural forms. Barbaloin is formed of yellow prismtic crystals (K. Nirala et al., 2020).

Processing of *Aloe vera*

Aloe vera was used as an ingredient in different formulations. The processing of Aloe Vera in different preparations is therefore necessary which can be easily integrated depending on the product nature(Ramachandra and Rao, 2008). Aloe vera is generally prepared in juice, concentrate and powder for different applications.

***Aloe vera* juice**

Unwanted components (leaves base, leaves top, conical dots and sleeping margins of the leaves) are removed traditionally, and the fillets have now been cleaned to prepare the juice. It is added to the pulper which extracts the juice when it is refreshed. The juice is kept at low temperatures, so that sensitive molecules do not lose the bioactivity (Ahlawat and Khatkar, 2011).

Table 1. various compounds present in *Aloe vera* gel:

Class	Compounds	References
Amino Acid	Cysteine, arginine, alanine, aspartum acid, glycines, histidines, sulphur, phenylalanines, prolins, threonine, serins and tyrosine, as well as valines and glycosins, leukines, lysin and methionines.	Nwaoguikpe et al., 2010
Anthraquinone	Anthrax, anthracin, anti-anthraxic acid, aloe-emodine, chrysophanic acid, emodine, etereal oil, cinnemonic acid ester, isobarbarbaloin, resistannol A&B, anthracine, barbaroin.	Kilic, 2005
Carbohydrates	Arabinous, cellulose, fructose, fumar, glucose, galactose, maltose, mannose, pectic, rhama, sucrose, uronic acid and xylosis. lignins and sugars	Bozzi et al., 2007
Chromones	A-7-Omethylaloediol A-8-Cglucosyl-(S)-alosol 8-C-glucosy-(2'-Ocinnamoyl) 8-C-glucosyl-7-oethyl(S) aloesol, 8- C-glucosyl-noreugenine 8-C, isoalosine D, isorabaichromone, and neoalosine A.	Hamman, 2008
Enzymes	Phosphoxidase alkaline, amylase, carboxypeptidase, catalase, cyclooxidase, cyclooxygenase, lipase, oxidose, peroxidase, carboxypylase phosphoenolpyruvate, and dismutase superoxide	Saeed et al., 2004
Hormones	Auxins and gibberllins	Samuelsson and Bohlin, 2004
Inorganic Compounds	Calcium, potassium, iron, phosphorous, manganese, sodium chromium, and zinc minerals are all minerals	Mohamed,2011; Nwaoguikpe et al., 2010
Miscellaneous	Organic compounds and lipids included and uric acid Triglycerides, Titerpenoid, Potassium Sorbate,	Femenia et al., 1999
Organic Acids	Sub-cutaneous, citric acid, pyruvine, sucinic acid, tartaric acid, fumaric acid, lactic Acid, malic acid, pyruvate.	Bozzi et al., 2007
Proteins	Lectins	Femenia et al., 1999
Sterols	Cholesterol, campesterol, lupeol and beta sitosterol	Kilic, 2005
Vitamins	Vitamin C, A, E, B1, B2, B9, B6 and choline	Mohamed, 2011

The base and tip of the leaf are removed and ground like a slurry that creates an alternating method for preparing a juice for the consistency of a soup. In order to release cell components, the cellulose enzyme is treated. A number of ground filters are then produced through the material to avoid impurity (e.g. rind particles). During the grinding process, the resulting liquid is removed through the debris extractor from the big pulp and rind parts. Finally, several filters pass aloin, emodine, leaf traces, sand and other particles across the material. This method contains three times more bioactive ingredients compared to conventional juice (Ramachandra and Rao, 2008).

Table 2: Ethnobotanical Effects and its Mechanisms:

Uses	Mechanism	References
Cosmetic uses	The three different plant preparations are Aloe vera latex, gel and Aloe veraentire cellulose gum that can work individually and combinabily with the biological components.There are not many new applications in the market for Aloe verain cosmetics at concentrations of 1% to 98% Alovera. Humidifiers, cleansers, sun lotions, dentures, oral laundries, creams and deodians, shampoos are just a few of its beauties and toiletries. Aloe based cosmetic substances do not have ananthraquinone Level of 50 ppm since this is too low for phototoxicity.	Boudreau et al., 2006. Grindlay, et al., 2005 Eshun, et al., 2004 Franz, et al., 2005
Healing wounds	Polysaccharides and the growth hormone gibberellins can decrease wrinkling by increasing collagen and elastin output.The fast healing ability of Aloe vera is determined by the presence of 10,000-20,000 mucopolysaccharidesper litre.Furthermore, Aloe vera's effects in scar tissue healing and scar prevention regarding skin injury are possibly due to the action of amino acids needed for new cell formation and the ability of its enzymes to promote cell regeneration in the deepest sections of the skin.	Talmadge, et al., 2004
Anti-inflammatory action and immunity activity	Salicylic acid, which is both analgesic and anti-inflammatory, prevents the formation of prostaglandins from arachidonic acid.As a result Aloe has been used to treat arthritis and joint issues. Aloe polysaccharides increase immune response.	Feily et al., 2009 Yu, et al 2009
Effects on skin exposure to UV and X-radiation	Though its precise function of aloe vera in the treatment of first and second degree burns is unknown, it appears to help. It's possible that lectin is to blame for the therapeutic impact.	Maenthaisong et al., 2007
Effects on ulcers:	Skin ulcers in particular, including mouth ulcers, herpes simplex and psoriasis, may be treated with aloe vera. This plant has been developed to help prevent gastric ulcers from developing.	Djeraba et al., 2000
Antidiabetic activities	Other synthetic components, such as vanadium, manganese and copper, as well as carbohydrates found in Aloe vera may have anti-diabetic properties. This plant has been related to lower blood sugar levels in diabetic patients and reducing blood lipid levels or cholesterol in hyperlipidaemic patients (roughly 30% less).	Geremias et al., 2006
Antioxidant activities	Antioxidant properties have been investigated. The operation of aloe vera was comparable to that of alpha-tocopherol. It has also been discovered that plant's development phase is crucial for these practices.	Miladi, S et al., 2008
Laxative effects	Aloe vera latex contains anthraquinones, which act as a sedative by increasing intestinal peristaltic movement.	Lee, et al., 2000

Antibacterial properties	Many studies have found that Aloe vera prevents the bacterial growth such as Streptococcus pyogenes, Shigellaflexneri, and Klebsiellasp, especially Gram-positive bacteria that cause food poisoning and diseases in humans and animals.	Alemdar, Set al., 2009 Feily, et al., 2009
Antifungal activity	While inhibitory effects towards Candida has been published, antifungal activity has received less attention. Because of its antifungal properties, aloe vera is used as a fish liquid fertilizer dry shampoo.	Sumbul, S et al., 2004
Antiviral and antitumor activity	These results may be due to directly or indirectly impacts directly due to anthraquinones and indirectly by immune response activation As a result, clinical studies are currently underway to gather definitive evidence of Aloe vera usein HIV/AIDS and cancer prevention.	Ikeno, et al., 2002
Age-related effects	On pathogen-free rats, aloe vera was studied, with positive results for age-related disorders.	(Takahashi et al., 2009)
Food uses	It's been used as aorigin of nutritional foods like yogurt and in the production of healthy beverages like tea. Botanical products are well-known for their use as a dietary supplement for health promotion and disease prevention. Aloe veracan be used as an active packaging to help preserve freshness and consistency of foods. The depletion of natural ingredients including complete polyphenol and citric acid was significantly delayed in table grapes covered with Aloe gel. Aloe vera does, in fact, inhibit the growth of microorganisms that cause food poisoning in man and livestock as well as foodborne diseases. Since aloe vera has no effect on the taste or appearance of food it appears to hold promise as a healthy, organic, and ecologically responsible compared to natural additives. The FDA has approved the internal use of gel as a nutritional supplement in the United States. The feed industry may use aloe vera as a sensory additive functional group flavor enhancer substances to improve the scent or palatability of feeding materials.	(Eshun, et ai., 2004.) (Serrano et al., 2006.)

The requirements for temperature and vacuum should be carefully adapted to avoid bioactive losses because the bioactive elements are sensitive to temperature and pressure (Ramachandra and Rao, 2008). The juice is concentrated to meet the desired coherence, which is ideal for different food uses such as jams, juices, jellies and squash.

***Aloe vera* powder**

The Aloe Vera fillets shall be washed, moistened and dried at the desired temperature in the fillets with hot air. Freezes have also been reported for drying and drying. Afterwards, the dried material is powdered and packaged. Aloe vera contains bioactional, temperature-sensitive compoun-ds that are harmful to traditional drying techniques. The bioactivity can remain inactive and time consuming through a freezing drying process. The efficient alternative to conventional and

freeze drying can be used by new microwave drying aid. This technique involves removing moisture from the product by using microwave heating and complete drying methods. The process is energy efficient, cost-effective and delivers quick operation and improved product quality (Khan et al., 2016).

Extraction of *Aloe vera* Gel and Powder

Exploitation and refining of gel and powder through aloe vera gel has become a large industry around the worldwide despite to developments in the food, medicine, and cosmetic industries. Fresh gel can be extracted from aloe vera leaves and prepared for later use. Extraction efficiency is determined by plants, growing conditions (e.g., temperature, volume of water, fertilization), harvest period, and extraction process. Extraction of aloe vera gel often includes several processing steps such as smashing, grinding, and pressing the whole leaf, or filleting to scrape the outer leaf and grinding the gel to obtain aloe juice, which is then accompanied by various filtering and stabilization steps Figure 3 and 4(Laux, Gouws et al. 2019).

The processing steps will modify the characteristics of polysaccharides by making structural modifications, which could result in certain changes in the proposed physiological and medicinal properties of these constituents. To increase product consistency and conserve and retain almost all of the bioactive chemical entities naturally present in the plant, a simple but effective extraction technique must be produced. Time, temperatures, and sterilization are also crucial in preserving the biological compounds of aloe vera(Chandegara and Varshney 2013).

Spray Drying and Freeze Drying

Aloe vera leaves begin to lose biological activity within six hour of room temperature harvest, and the majority of biological activities are totally lost after 24 hours. The extraction of gel from the leaves is supported by the addition of cellulose dissolution compounds, and aloe liquids frequently treat laxative aloine and anthraquinones with activated carbon for discoloration and removal.

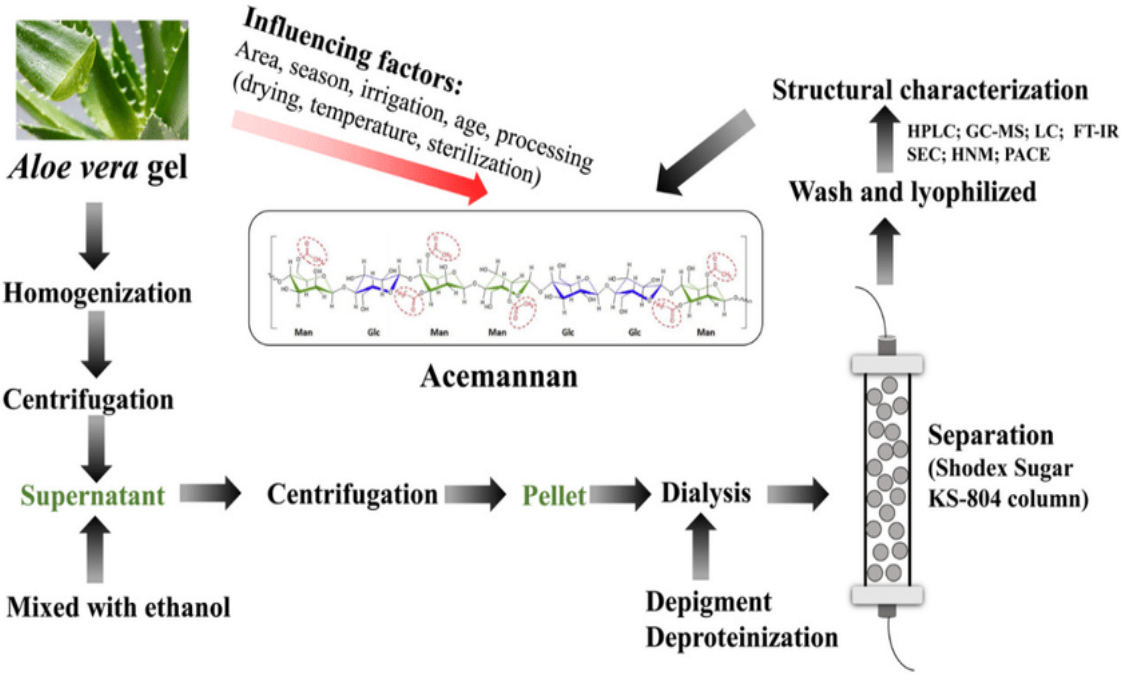

Figure 3: Extraction of *Aloe vera* Gel and Powder

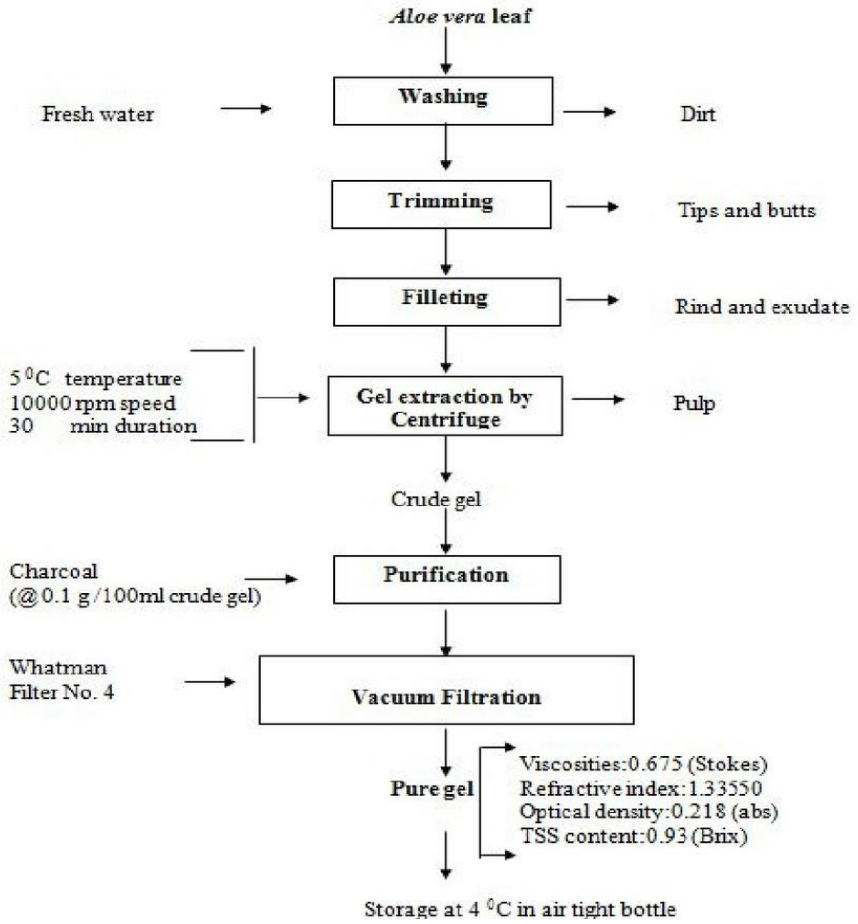

Figure 4: Extraction of *Aloe vera* Leaf

Centrifugal activity on aloe gel breaks that sugar chain which is encircled by gel molecules and leads to additional gel regeneration and gel freezing (Chandegara and Varshney 2014). Aloe vera gel is strengthened by concentrating it to reduce water content, dry it to make a firm powder and add preservatives and other components, including sodium benzoate and citric acid (Rahman, Carter et al. 2017). Due to its biochemical activities, Aloe Vera's nutritional effects. Even when concentrated under vacuum, the biological activities of the aloe vera gel can be maintained. The mercury vacuum of 125 mm, concentrations of below 50 C, and a period of two minutes shall be performed at this level (Sehgal, Winters et al. 2013). Spray drying and freeze drying are the most popular techniques for the production of aloe vera powder through gel. Although aloe vera powder is less dense, easier to treat and less vulnerable to long-term storage contamination, it is critical to maintain the biodiversity of the product (Minjares-Fuentes, Femenia et al. 2016).

Hot water extraction

Acemannan discovered that aloe gel, a polysaccharide consisting of (1,4)linked heavily acetylated mannoses, (1,4)linked glucose, and (1,6)linked galactose, is present in the internal leaf. Various techniques were used to extract bioactive components of aloe, including acemannan. the separation process, from which the crystal formula is obtained. Particularly, processing in hot water and ethanol is by far the most simple approach in the laboratory and is widely used in industry (Thunyakitpisal, Ruangpornvisuti et al. 2017). Cleaning, homogenization, isolation, and centrifugation of Aloe vera are all steps in the water extraction process.

For 12 hours, the supernatant was obtained and blended with absolute ethanol at a 1:3 ratio. The precipitate formed was gathered and spun down in a centrifuge. Dialysis was used to extract acemannan (Ali, Dwivedi et al. 2016).

Complications and precautions

Aloe vera is usually considered safe but some side effects and complications have occurred. Some side effects can be used for constipation therapy, like abdominal cramps, flatulence and grips (Mulay, 2014). The use of aloe vera may encourage bleeding during the operation; its use should therefore be stopped at least two weeks before the surgery is performed. Aloe vera can be used with furosemide or digoxin to lower the potassium level in the body and therefore not to use for these drug treatments, for irregular rhythms in the heart and for congestive cardiac failure. The loss of sodium can cause secondary hyperaldosteronism and loss of potassium can lead to fatigue, weak muscles, weight loss, mental illness or kidneys failure. The loss of potassium can lead to electrolytic imbalance (Mulay, 2014). Aloe vera skin and steroid creams can increase absorption (e.g. hydrocortisone with creams). Allergic effects like skin rashes can occur when aloe vera gel is applied to open or deep wounds, but can be used without injury in safety on the skin (Surjushe et al., 2008). A recently associated risk of tumour and colon cancer with anthraquinone and aloin present in aloe vera gel (Aldhous, 2011; Mulay, 2014). In cosmetic products with aloe vera the photooxidation input (especially aloe emodin) of anthraquinone not exceeding 50 ppm should be avoided (Boudreau, M. D. and Beland, F. A., 2006; Christaki and Florou-Paneri, 2010).

CONCLUSION

Due to its unique and appealing physiochemical and biological properties aloe vera has a promising future for tissue engineering applications. It has auxins and gibberellin hormones that can be used in wound healing and it also have anti-inflammatory actions. Saponins has cleansing and antiseptic properties. The information shared in this review update on aloevera might be fruitful for better understanding in the direction in search of plant origin drugs.

REFERENCES

Ahlawat, K.S., Khatkar, B.S., 2011. Processing, food applications and safety of aloe vera products: a review. Journal of food science and technology. 48(5), 525-533.

Akinyele, B. O. and Odiyi, A. C. 2007. Comparative study of the vegetative morphology and the existing taxonomic status of Aloe vera L. Journal of Plant Sciences 2:558-563.

Ali, K., Dwivedi, S., Azam, A., Saquib, Q., Al-Said, M. S., Alkhedhairy, A. A., & Musarrat, J. (2016). Aloe vera extract functionalized zinc oxide nanoparticles as nanoantibiotics against multi-drug resistant clinical bacterial isolates. *Journal of colloid and interface science*, *472*, 145-156.

Benítez, S., Achaerandio, I., Pujolà, M., Sepulcre, F., 2015. Aloe vera as an alternative to traditional edible coatings used in fresh-cut fruits: A case ofstudy with kiwifruitslices. LWT - Food Science and Technology. 61(1), 184-193

Boudreau, M. D. and Beland, F. A. 2006.An evaluation of the biological and toxicological properties of Aloe barbadensis (Miller), Aloe vera. J. Environ. Sci. Health. C Environ. Carcinog. Ecotoxicol. Rev. 24(1):103-154.

Chandegara, V. and A. Varshney (2013). "Aloe vera L. processing and products: A review." Int. J. Med. Aromat. Plants 3: 492-506.

Chandegara, V. and A. Varshney (2014). "Effect of centrifuge speed on gel extraction from aloe vera leaves." J. Food Process. Technol5: 1-6.

Choi, S. and Chung, M. H. 2003.A review of the relationship between Aloe vera components and their biological effects.Semin.in Integrative Medicine 1:53-62.

Eshun, K. and He, Q. 2004. Aloe vera: A valuable ingredient for the food, pharmaceutical and cosmetic industries, A review. Critical Reviews in Food Science and Nutrition 44:91-96.

Eshun, K. and He, Q. 2004. Aloe vera: A valuable ingredient for the food, pharmaceutical and cosmetic industries, A review. Critical Reviews in Food Science and Nutrition 44:91-96.

Eshun, K., He, Q., 2004. Aloe vera: A valuable ingredient for the food, pharmaceutical and cosmetic industries: A review. Critical reviews in food science and nutrition. 44(2), 91-96.

Feily, A. and Namazi, M. R. 2009. Aloe vera in dermatology: A brief review. G. Ital. Dermatol. Venereol. 144:85-91.

Franz Ch., Bauer, R., Carle, R., Tedesco, D., Tubaro, A. and ZitterlEglseer, K. 2005. Study of the assessment of plants/herbs, plant/herb extracts and their naturally or synthetically produced components as "additives" for use in animal production CFT/EFSA/FEEDAP/2005/

Geremias, R., Pedrosa, R. C., Locatelli, C., de Fávere, V. T., CouryPedrosa, R. and Laranjeira, N. C. M. 2006. Lipid lowering activity of hydrosoluble chitosan and association with Aloe vera L. and Brassica oleracea L. Phytotherapy Research 20:288-293.

Hamman, J., 2008. Composition and Applications of Aloe vera Leaf Gel. Molecules. 13(8), 1599- 1616

Ikeno, Y., Hubbard, G. B., Shuko, L., Byung, D. V. and Herlihy, J. T. 2002.The influence of long-term Aloe vera ingestion on age-related disease in male Fischer 344 rats.Phytotherapy Research 16:712-718.

Iwu, M.M., 2014. Handbook of African Medicinal Plants, 2nd ed. Taylor & Francis, NY, USA. Jain, N., Vijayaraghavan, R., Pant, S.C., Lomash, V., Ali, M., 2010. Aloe vera gel alleviates cardiotoxicity in streptozocin-induced diabetes in rats. J Pharm Pharmacol. 62, 115-123.

Khan, M.K.I., Ansar, M., Nazir, A., Maan, A.A., 2016. Sustainable dehydration of onion slices through novel microwave hydro-diffusion gravity technique. Innovative Food Science & Emerging Technologies. 33, 327-332.

Klein, A. D. and Penneys, N. S. 1988. Aloe vera. J. of the American Academy of Dermatology 18:714-720.

Laux, A., Gouws, C., & Hamman, J. H. (2019). Aloe vera gel and whole leaf extract: functional and versatile excipients for drug delivery?. *Expert opinion on drug delivery*, *16*(12), 1283-1285.

Lee, K. Y., Weintraub, S. T. and Yu, B. P. 2000.Isolation and identification of a phenolic antioxidant from Aloe barbadensis. Free Radical Biology and Medicine 28(2):261-265.

Lim, B. O., Seong, N. S., Choe, R. W., Kim, J. D., Lee, H. Y., Kim, S. Y., Yu, B. P., Jeon, T. I. and Park, D. K. 2003. Efficacy of dietary Aloe vera supplementation on hepatic cholesterol and oxidative status in aged rats. J. Nutr. Sci. Vitaminol. 49:292-296.

Liu, C., Cui, Y., Pi, F., Cheng, Y., Guo, Y., & Qian, H. (2019). Extraction, purification, structural characteristics, biological activities and pharmacological applications of acemannan, a polysaccharide from aloe vera: A review. *Molecules*, *24*(8), 1554.

Maan, A.A.; Nazir, A.; Khan, M.K.I.; Ahmad, T.; Zia, R.; Murid, M.; Abrar, M. The therapeutic properties and applications of Aloe vera: A review. J. Herb. Med. 2018, 12, 1–10.

Malik, I.; Zarnigar, H.N. Aloe vera-A Review of its Clinical Effectiveness. Int. Res. J. Phar. 2003, 4, 75–79.

Miladi, S. and Damak, M. 2008. In vitro antioxidant activities of Aloe vera leaf skin extracts. Journal de la SociétéChimique de Tunisie 10:101-109.

Minjares-Fuentes, R., et al. (2016). "Effect of different drying procedures on physicochemical properties and flow behavior of Aloe vera (Aloe barbadensis Miller) gel." LWT 74: 378-386.

Misir, J., Brishti, F.H., Hoque, M.M., 2014. Aloe vera gel as a Novel Edible Coating for Fresh Fruits: A Review. American Journal of Food Science and Technology. 2(3), 93-97.

Nirala, R. K. (2020). A review on Aloe vera and its traditional uses in India. Journal of Pharmacognosy and Phytochemistry, 9(5), 2571-2573.

Radha, M.H., Laxmipriya, N.P., 2015. Evaluation of biological properties and clinical effectiveness of Aloe vera: A systematic review. Journal of Traditional and Complementary Medicine. 5(1), 21-26.

Rahman, S., Carter, P., & Bhattarai, N. (2017). Aloe vera for tissue engineering applications. *Journal of functional biomaterials*, *8*(1), 6.

Rajendran, A., Narayanan, V. and Gnanavel, I. 2007. Study on the analysis of trace elements in Aloe vera and its biological importance J. of Applied Sciences Research 3:1467-1478.

Ramachandra, C.T., Rao, P.S., 2008. Processing of Aloe vera leaf gel: a review. American Journal of Agricultural and Biological Sciences. 3(2), 502-510.

Sehgal, I., Winters, W. D., Scott, M., David, A., Gillis, G., Stoufflet, T., ... & Kousoulas, K. (2013). Toxicologic assessment of a commercial decolorized whole leaf aloe vera juice, lily of the desert filtered whole leaf juice with aloesorb. *Journal of toxicology*, *2013*.

Serrano, M., Valverde, J. M., Guillén, F., Castillo, S., Martinez-Romero, D. and Valero, D. 2006. Use of Aloe vera gel coating preserves the functional properties of table grapes. J. Agric. Food Chem. 54:3882- 3886.

Sumbul, S., Ahmed, S. W. and Azhar, I. 2004.Antifungal activity of Allium, Aloe and Solannum species.Pharmaceutical Biology 42:491- 498.

Surjushe, A., Vasani, R. and Saple, D. G. 2008. Aloe vera: A short review. Indian Journal of Dermatology 53:163-166

Surjushe, A.; Vasani, R.; Saple, D.G. Aloe vera: A short review. Indian J. Dermatol. 2008, 53, 163–166.

Takahashi, M., Kitamoto, D., Asikin, Y., Takara, K. and Wada, Koji. 2009. Liposomes encapsulating Aloe vera leaf gel extracts significantly enhance proliferation and collagen synthesis in human skin cell lines. Journal of Oleo. Science 58:643-650.

Talmadge, J., Chavez, J., Jacobs, L., Munger, C., Chinnah, T., Chow, J. T., Williamson, D. and Yates, K. 2004. Fractionation of Aloe vera L. inner gel, purification and molecular profiling of activity. Int. Immunopharmacol. 4(14):1757-1773.

Thunyakitpisal, P., Ruangpornvisuti, V., Kengkwasing, P., Chokboribal, J., & Sangvanich, P. (2017). Acemannan increases NF-κB/DNA binding and IL-6/-8 expression by selectively binding Toll-like receptor-5 in human gingival fibroblasts. *Carbohydrate polymers*, *161*, 149-157.