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# *AGAVE SISLANA:* A PLANT WITH HIGH CHEMICAL DIVERSITY AND MEDICINAL IMPORTANCE

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## ABSTRACT

*Agave* species has been used from an ancient era for the production of fiber and alcohol, however apart from the fibre, *Agave* species especially *A. sisalana* is rich in the phytoconstituents responsible for the potent medicinal activities. An attempt is made to emphasize the reported phytochemicals and therapeutic utilization of *Agave sisalana* plant with some of its other beneficial uses globally.

**KEY WORDS**: *Agave,* phytochemicals, medicinal properties

## INTRODUCTION

The genus Agave has been of great importance not only in economic context but also in social aspect. The genus *Agave* includes 210 species widespread in the tropical and subtropical regions of the world mainly in desert, dry and semiarid environments [1] or 166 valid species [2]. Middle America is the center of its greatest diversity use and cultivation [3,4]. *Agave sislana* Perrine ex Engelmann Family Agavaceae (Asparagaceae) also known as Sisal or Sisal Hemp is widely known for the production of fibre which is economically very important. It is also known by several other vernacular names like Ram bans (Indians), Garingboom (Africans), Ngwengwe (Angola:umbundu). Major edible part of Agave are flowers, leaves, stalks, basal rosettes, sap and root [5,6]. Agave is cultivated in large scale for fibre in Eastern Africa, Brazil, India and various countries in Asia. It was estimated that the Sisal was supplied about 70% of world's lying hard plant fibres, cultivation of *Agave* spp. is >500,000 ha [7-9]. Brazil is the largest producer and exporter country of sisal fibers. About 4% of the decortications of the sisal leaves produce fiber, and the remaining material (waste) is commonly discarded by sisal farms[10,11]. Sisal plant is generally constituted of Sisal fibre and Sisal waste however fibre is used widely. Sisal waste is mainly consists of water,

parenchymatous tissue, cellulose, fibers and several inorganic compounds and components related to primary and secondary metabolism. This waste material is rarely used, despite its indication for use as an organic fertilizer, a supplement in ruminant feed [10] and a raw material for the production of medicine. [12]

**Botanical Aspect**

Sisal is a perennial shrub to 2 m tall with rigid, sword-like leaves extending from basal rosette. Leaves are about 10 cm wide and up to 1.5 m long with sharp dark brown spine at end, grey-green in color. A branched inflorescence forms atop a flower stalk 7-9 m tall with yellowish-green flowers to 7 cm wide. This species is monocarpic (i.e. die after fruiting) and inflorescences form panicles of elliptic shape 5-6 m tall, with 10-20 lateral branches. Fruit an oblong capsule with black seeds. Plants usually sterile and die after blooming once. Small plantlets (bulbils) form in inflorescence that fall to ground after flowering and form new plants [13-15].


**Plant of *Agave sisalana***

**Plant of *Agave sisalana* with inflorescence**

**Introduction of species worldwide**

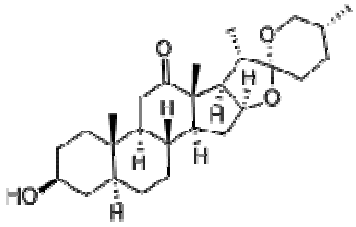
It is a monocotelydenous plant from Mexico, in the 19th century, the plants spreaded to countries in Africa like Tanzania and Kenya and Asian countries. Today it has covered some parts the tropics. *A. sisalana* is used as a rope; it has also been used for making cloths, wall coverings and carpets [16-18]. In the 19th century, the cultivation of *A. sisalana* spread to Brazil, Florida and the Caribbean Islands, and the countries in East Africa (i.e., Kenya, Tanzania, and Uganda) and Asia [19, 20]. In Florida, the first plants of *A. sisalana* were introduced at Indian Key in the year 1826 by Dr. Henry Perrine, to establish a plantation of this species [8]. In Brazil, the first commercial plantings of sisal were made in the late 1930s. In the 1960s the production of sisal in Brazil was accelerated and today Brazil is the major world producer of sisal fibres.[21] *A. sisalana* and other *Agave* species were introduced in Spain in the 1940s as ornamental and cultivated plants [22], and a recent study indicates that these species are spreading into new habitats, mainly on coastal sandy soils in the south-eastern end of the country.[23] The plant has a lifespan of about 7-10 years[19].The inflorescences of different *Agave* species are one of the largest in the plant kingdom, which may reach upto 10 meters above ground [24]. Few of the species of Agave are *Agave aboriginum, Agave abortiva, Agave abrupta, Agave acicularis, Agave acklinicola, Agave affinis, Agave albescens, Agave albomarginata, Agave alibertii, Agave aloides, Agave amaniensis, Agave americana, Agave angustifolia, Agave angustissima, Agave anomala, Agave antillarum, Agave arizonica, Agave arubensis, Agave aspera, Agave asperrima, Agave atrovirens, Agave atrovirens var. mirabilis, Agave attenuata, Agave aurea, Agave avellanidens, Agave bovicornuta, Agave bracteosa, Agave brauniana, Agave breedlovei, Agave brevipetala, Agave breviscapa, Agave brevispina, Agave brittonia, Agave bromeliaefolia, Agave brunnea, Agave bulbifera, Agave cantala, Agave caymanensis, Agave chiapensis, Agave corderoyi, Agave costaricana, Agave cucullata, Agave cundinamarcensis, Agave cupreata, Agave deserti, Agave donnell-smithii, Agave durangensis, Agave dussiana, Agave eggersiana, Agave falcata, Agave filifera, Agave fourcroydes, Agave geminiflora, Agave guadalajarana, Agave havardiana, Agave impressa, Agave jaiboli, Agave lechuguilla, Agave lophantha, Agave macroculmis, Agave mckelveyana, Agave neglecta, Agave palmeri, Agave parviflora, Agave ragusae, Agave rasconensis, Agave regia, Agave revoluta, Agave rhodacantha, Agave rigida, Agave roezliana, Agave rudis, Agave rupicola, Agave salmiana, Agave schottii, Agave scolymus, Agave simoni, Agave sisalana, Agave stricta, Agave stringens, Agave subinermis, Agave subsimplex, Agave subtilis, Agave subzonata, Agave*

*sullivani, Agave tequilana, Agave toumeyana, Agave tubulata, Agave utahensis, Agave victoriae-reginae, Agave vivipara, Agave weberi, Agave xylonacantha, Agave yuccaefolia, Agave zebra*[12, 25].

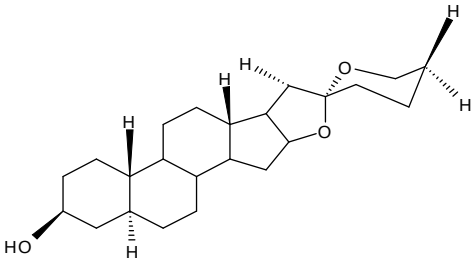
**Phytochemical studies in Agave**

The occurrence of steroidal saponins in Agave genus is well documented [26-29]. Sterols, steroidal sapogenins, steroidal alkaloids and alkaloidal amines were derived from A*gave sisalana,* and these substances derived from plant sources provide the starting material for steroid production. In China, licogenin and tigogenin from Agave species are used as industrial precursors for the partial synthesis of steroidal drugs [30]. Hecogenin, a saponin of *A. sisalana* [31], was transformed to cortisone [32], which defines the process of manufacturing of the cortisone from hecogenin. This has been found in the leaves of several other Agave spp. and is a possible source of the production of cortisone, but cultivars selected particularly for sisal fiber show reduced hecogenin. It has also been shown that hecogenin is most abundant (0.235%) in the leaves of the old plant. The major sapogenin hecogenin, dehydrohecogenin and tigogenin have been analysed by RP-HPLC further derivatization with benzoyl chloride [33]. Hecogenin and ticogenin have been isolated from the *A. sisalana* leaf juice [34]. Further three steroidal saponins, dognosides C, D and E were isolated and cherecterized from the dried fermented residues of leaf juice of *A. sisalana* [29]. In the continuing study on this plant two additional new major steroid saponin named dongnoside B and A has also been reported. Their structures were characterized respectively as tigogenin-3-O-α-L-rhamnopyranosyl-(1,4)-β-D-glucopyranosyl-(1,2)-[β-D-glucopyranosyl-(1,3)]-β-D-glucopyranosyl-(1,2)-[β-Dxylopyranosyl-(1,3)]-β-D-glucopyranosyl-(1,2)-[β-D-glucopyranosyl-(1,4)-β-D-galactopyranoside on the basis of chemical and physicochemical evidence. Chen et al., (2009) [35] isolated three known flavones and seven known homoisoflavonoids from the methanolic extract of the leaves. Three isolated flavonoids are 5,7-dihydroxyflavone [36], kaempferol 3-rutinoside-4'-glucoside[37] and kempferol 3-(2G-rhamnosylrutinoside) [38]. Seven homoisoflavonoids viz., 7-O-methylleucomol [39], 3'-deoxysappanone [40], (±)-3,9-dihydroeucomin [41], dihydro-bonducellin[42], 7-hydroxy-3-(4-hydroxybenzyl) chromane[43], 5,7-dihydroxy-3-(4'-methoxybenzyl)-4-chromanone [44] were isolated from methanolic extract of *A. sisalana*. Sapogenin steroid are mainly present in various species, mainly hecogenin, which is a raw material used for the synthesis of steroidal drugs. Sapogenins are aglycone portions of the saponin glycoside molecule used for the semisynthesis of medicinal steroids, as corticosteroids, sexual hormones and steroid diuretics

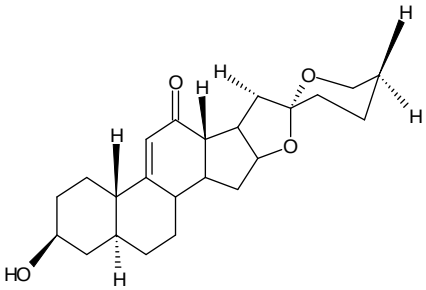
[45,46]. Marques et al., 2010[47] reported the structure of the heteroxylan isolated from sisal fibers has been characterized and its behavior during soda/AQ pulping and TCF/ECF bleaching has been studied.



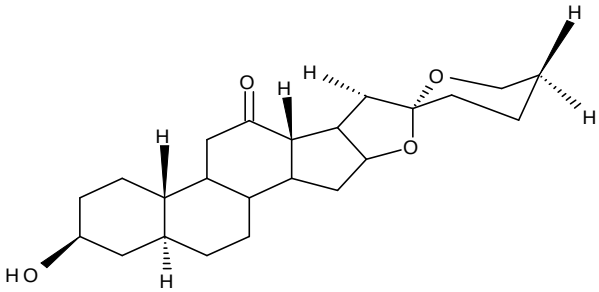
**Hecogenin**



**Tigogenin**



**Gloriogenin**



**Δ-9 dehydrohecogenin**

## ETHNOPHARMACOLOGICAL AND PHARMACOLOGICAL IMPORTANCE

### Immunomodulatory Activity

Important Flavonoids (+/-)-3,9-dihydroeucomine, dihydrobonducellin and 5,7, dihydroxy-3-(4'-hydroxybenzyl)-4-chromanone was found to show inhibitory effects on human peripheral blood mononuclear cell (PBMC) proliferation activated by PHA and all compounds significantly inhibited the production of interleukin IL-2 and IFN γ in activated (PBMC)[35].

### Anthelmintic Activities

Sisal juice showed more than 95% reduction in larval counts of the genus *Haemonchus* spp. in vitro and in vivo sisal juice reduced larvae of the 4$^{th}$ and 5$^{th}$ stages of *Haemonchous.* Oesophagostomum and Trichostrongylus in goats[48, 49]. Botura et al., 2011[11] found the aqueous extract from sisal waste showed low efficacy against parasitic-stage parasites. However, the extract was moderately effective against eggs and free-living stages of the parasite and did not cause any toxicity in the goats.

**Hepatoprotective activities**

Cerqueira et al., 2012 reported that hecogenin showed effect against the ethanol and indomethacin induced ulceration and described the mechanism as KATP channel-dependent, and suggested the participation of KATP channels in the gastroprotective effects of hecogenin.

**Anti-inflammatory and analgesic activities**

The less toxic hexanic fraction of *Agave sisalana* was evaluated for anti-inflammatory and analgesic activity by various animal models viz. Hot-plate test, Tail-flick test, Granuloma cotton pellet etc and it was observed that the isolated product was slightly better than the positive control. [50]

**Antimicrobial activity**

Animicrobial activity of *Agave sisalana is* reported by several workers against various gram positive, gram negative bacteria and fungus *Staphylococcus aureus, Salmonella typhi, Escherichia coli, Streptococcus pyogenes, Candida albicans, B. cereus, M. luteus, P. aureginosa, S. cholereasuis, C. albicans Shigella dysenteriae, Bacillus atrophaeus, Enterococcus faecalis, Pseudomonas aeruginosa, Candida albicans, Bacillusm stearothermophilus* [18,51,52, 53 ]. *Agave sisalana* was found tremendously potent antimicrobial agent against various species.

***Agave* as feedstock in biofuel**

In Australia the research on feasibility of *Agave* to be served as feedstock for biofuel production is on progress [54] as it is well known that *A. tequilana* is a good source of alcohol and can be served as a potential candidate for biofuel production.

**Other important use of Sisal**

Sisal fiber was used as a mini column for the estimation of copper in tobacco leaf sample[55], *Agave sisalana* is among the important plant used as toothbrush sticks by several people who cannot afford buying the commercial toothbrush and toothpaste[56].

**Ethnomedicinal importance**

Roots of *Agave sisalana* was found to be used orally for the treatment of blackleg by Zay people in Ethiopia[57]. Lightly heated pounded roots are used for the intercoastal pain and

nephralgia in west Africa. Its fibers are used as bandage in Kenya. It is also utilized to treat high blood pressure and various intestinal infections; the salted decoction of central bud is used for treatment of jaundice in Bahamas. It is also used for various veterinary practices as it is given in a combination with *M pyriflora* roots and Aloe sp. leaves for the treatment of fowl pox in Kenya.[58]

**Table 1 Reported medicinal properties of *different plant parts of Agave sisalana***

| Plant part used | Medicinal activity | Reference |
|---|---|---|
| Leaf juice | Intestinal stimulator and uterine musculatoe, hypotensive, abortifecient, skin diseases, pulmonary tuberculosis, syphilis and liver diseases | Debonath et al., 2010, El-Hilaly., 2003, Sharaf and Zahran., 1967. |
| Sap | Antiseptic, binding agent for various powder | Debonath et al., 2010, Chevallier, 1996 |
| Whole plant | Indigestion, flatulence, constipation, dysentery, jaundice | Bown, 1995 |
| Water of soaked fibre | Scalp disinfectant, tonic, hair fall | Lust, 1983 |
| Gum | Toothache | Duke and Ayensu, 1985 |
| Root | Diaphoratic, diuretic, syphyllis | Chopra et al., 1986, Bown, 1995 |

## CONCLUSION

It is concluded from the review that Agave is not only important for fibre but it is also very important for various other purposes especially for the medicinal purpose. The species is full of economical and cultural belief however the therapeutic activity based evaluation is still required. In India the Agave species is widely observed in the western Himalayan region however it is not properly established as it should be, the other interesting aspect was the production of biofuel and it is recommended that further studies and pilot projects should be take place for the establishment of *Agave sisalana* as a new energy source and for its medicinal applications.

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