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A Review on Ethnobotanical and Pharmacological Aspects of *Gossypium barbadense* L. (Cotton)- A Multidimensional Plant

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ABSTRACT

As an ancient medicinal plant, *Gossypium barbadense* has been used for medicinal, textile and edible purposes since ancient times to benefit humans. This plant belongs to the Malvaceae family originated from Mexico and Peru, and is commonly called 'Cotton'. Different parts of *G. barbadense* are used to treat colds, diarrhea, gout, and skin diseases, as well as ear, respiratory, reproductive and neurological problems in Africa, Brazil, and India. From roots and seeds, gossypol, 6-methoxygossypol, and 6,6′-dimethoxygossypol have been isolated, along with these phytochemicals some other compounds, such as triterpenoids and sesquiterpenoids, are known to be present in leaves. The extracts and essential oil of this plant displayed anti-microbial, anti-oxidant, and anti-ulcer activity. The seed oil of this plant is known among all unsaturated edible oils as 'Heart oil' due to its beneficial effects on the heart. The fiber is the longest with excellent quality, used by industries such as clothes and textiles like archival paper, tents, coffee filters, book binding and fishnets. The aim of this study is to validate the limited available data on this multidimensional plant, its phytoconstituents, and pharmacological aspects, and to stress the need of further research to identify new plant-based medicines and other products for full financial and environmental benefits.

Keywords: *Gossypium barbadense*, Pharmacological actions, Cotton, Seed oil, Fibre, Medicinal properties.

INTRODUCTION

The cotton genus Gossypium (Family Malvaceae) comprises about 50 species and a few new species continue to be discovered. The species in this genus are often shrubs or plants that resemble shrubs, and they are incredibly diverse in terms of morphology and adaptability. The leaves, roots, bark, and seeds of *Gossypium* species have been extensively researched for their therapeutic properties in addition to their economic relevance[1]. Cotton is the most important commercial crop for its fiber, oil, and other products in the world[2]. This plant is the largest natural fiber source in India. It is known as the backbone of the textile industry and also takes part in agriculture and the industrial economy, consuming 70% of the total fiber produced in the country[3]. *Gossypium* is known to consist of 19 species where, *G. hirsutum* L., *G. barbadense* L., *G. arboretum* L. and *G. herbaceum* L. exhibited pharmacological and medicinal importance[4].

G. barbadense L. is an everlasting shrub that matures up to 3 m in height, originating in southwest Ecuador and northwest Peru[2, 4]. Now, it is cultivated in countries as diverse as Australia, China, Egypt, India, Israel, Peru, Sudan, Tajikistan, the southwestern United States, Turkmenistan, and Uzbekistan[1]. It is also referred to as Gallini, Egyptian, staple length, and Sea Island cotton. Among Indian states, Punjab, Rajasthan, and Haryana are the three states with the highest productivity of *G. barbadense*[4]. This plant has a wide range of applications in the textile, agricultural, and pharmaceutical sectors[5]. This plant is recognized by Ayurveda as having the ability to control the ailments caused by the three essential energies of *Vata, Pitta*, and *Kapha*. The blooms have a lot of nectar, and the petals can help women produce more breast milk[4]. There is medicinal value to this plant in the field of reproductive health, including gynecological disorders, menstrual difficulties, female infertility, genital disorders, urinary disorders, as well as impotence. While numerous research has been carried out to support its therapeutic potential, none have been suggested for characterizing its pharmacological characteristics related to reproduction. This particular plant was chosen since it can be used to make food, clothing, and textiles as well as medication to treat a variety of illnesses.

This study elaborated on the multidimensional nature of the plant and its applications in different areas and to be very significant for the treatment of various deadly diseases. Further studies on the active ingredients and biological action of this plant are the major objective of research in the future aims of

our research groups.

METHODOLOGY

This review article was created by combining and evaluating existing studies on Ethnobotanical and Pharmacological Aspects of *G. barbadense* L. A literature search was conducted in August-October 2022, which included articles available in the last 31 years (1991-2022) using several data sources, including PUBMED, PubChem, Science Direct, and Google Scholar, and among others. Only published publications in English were chosen for performing search targets across several databases using a combination of key phrases including, *G. barbadense*, phytochemistry, pharmacological action, pharmacological terms such as anti-microbial, and antioxidant capabilities, etc. The literature search in this paper was limited to scientific publications included in the above-mentioned databases that may be available to the scientific community.

PLANT DESCRIPTION

G. barbadense is a multi-dimensional plant showed in Figure 1 and 5. It is approximately 3 meters tall, the plant is a shrub. The leaves are petiolate, ovate, oblong; flowers are terminal, solitary; capsule are glabrous, 3-7 cm long, oblong-ovoid[5]. *G. barbadense* (cotton) is commonly known as American pima, American-Egyptian, Barbados, Barbados tree, Brazilian, Cotton, Creole, Desi, Egyptian, Extra-long staple, Gallini, Kidney, Long-staple, Peru, Peruvian, Pima, Sea island-baumwolle, Sea island, Small cotton tree, Tree, Upland and West Indian cotton. Some of the vernacular names are also given in Figure 2.

ETHNOMEDICINAL AND THERAPEUTIC BENEFITS

The cotton plant is known to have many medicinal uses because of its several physiological effects and different constituents. While the main constituent of the cotton plant is gossypol. Approximately 10% of seeds contain gossypol, which is presently being investigated for its potential medical benefits. But in recent years, gossypol has attracted much attention due to its antifertility, antiparasitic, and anti-HIV properties. Gossypol and cyclopropenoid fatty acids (CPFAs) are the two cottonseed compounds that limit their use as a protein supplement in animal feed. Hence, these compounds are detoxified during digestion in the rumen of ruminants, where they are less affected. Cotton seeds are used in a limited amount as stock feed to avoid potential toxic effects Cotton seed is an expectorant, laxative, demulcent, and galactagogue and is used as a nervine tonic in headaches and brain affections, while a decoction of seeds is used to treat dysentery and intermittent fevers. Gossypol in large quantities can be antinutritional, toxic, and have adverse effects on human and animal health[2]. The seeds also possess the antifungal compound gossypol, which makes them less potent for insect damage[6]. Moreover, cotton is used in Ayurveda, Siddha, and Unani medicinal systems to treat a variety of disorders such as blood disorders, ear problems, colds, diarrhea, and gout, while snake bites and scorpion stings can be treated with infusions or mixtures of seeds and leaves and have also been used as a male contraceptive[2]. The Indians used cotton seeds to treat coughs, constipation, and gonorrhea. The leaves of *G. barbadense* are used in Suriname's traditional medicine to treat hypertension and irregular menstruation[6].

Its low irritating capacity makes processed cotton fiber an excellent choice for pharmaceutical and medical applications. Cotton fiber contains over 99% cellulose and is used more and more in pharmaceutical and medical applications. This tropical plant has hypertensive (reducing blood pressure) and antifungal effects. This is also one of the safest and most certain herbal abortifacients (substances that cause a pregnancy to end prematurely and abortion to occur). Other uses of this plant are as a menstrual blood medicine (menstrual stimulant) and in amenorrhea, dysmenorrhea, irregular and painful or heavy menstrual bleeding, to replace ergot (a fungus that produces certain alkaloids used in medicine), and to control hemorrhage (bleeding). Besides being an oxytocic and used to treat climacteric complaints and poor lactation, it also helps expel the placenta after delivery [2]. The various ethno-medicinal uses of the plant along with its description is listed in Table 1. Different parts of the plants have been used for the treatment of several diseases by the tribals. In the analysis shown graphically in Figure 3, it was found that leaves were most effective in treating diseases followed by seeds and flowers.

PHYTOCHEMICAL STUDIES

The medicinal value of a plant can be attributed to the presence of various active ingredients that are effective against various ailments. *G. barbadense* contains biochemical components such as triterpenoids and sesquiterpenoids. Sesquiterpenoids helps in the adaptation of plant according to the environment while the phytoalexins present in pigment glands of root and aerial parts plays important role against pathogens and herbivores[20]. "Gossypol", an essential oil composed of terpene aldehydes in an oily water-soluble matrix provides a constitutive and inducible defense against herbivory, it is also toxic to many insects and microbes[11]. 6-methoxygossypol and 6,6'-dimethoxygossypol are derivatives of gossypol that can be isolated from *Gossypium barbadense* (Sea Island cotton) using preparative chromatography[19]. In *G. barbadense* flowers and roots, there is more (+) gossypol, whereas the percentage of (-)-gossypol is greater in seeds[20].

PHARMACOLOGICAL ACTIONS

Pharmacological study of a plant provides a scientific reporting of its therapeutic property along with its benefits and side effects on the body. This also provides a support for the further formulation and use of the plant. Some of the reported pharmacological activities of the plant are detailed below and a pictorial representation is given in Figure 4.

Anti-malarial activity

According to this study, the aqueous extract (250, 500, and 1000 mg/kg) from *G. barbadense* leaves were evaluated for antimalarial activity against *Plasmodium berghei* using suppressive and curative albino mice model with positive control, chloroquine (5 mg/kg) revealed that aqueous extract (1000 mg/kg) significantly exhibited modest suppressive effects against *P. berghei* by 23.10% in mice when compared with chloroquine (100%). Moreover, extract at 500 and 1000 mg/kg enhanced the curative effects by 12.10±27.0 and 16.09±32.1 respectively till day 17 when compared with chloroquine[6].

Anti-microbial activity

The anti-microbial activity of juice from *G. barbadense* fruits (25 and 50% dilutions) against bacteria; *Staphylococcus saprophyticus*, *S. aureus*, *Escherichia coli*, *Haemophilus influenza*, *Pseudomonas aeruginosa* and *Proteus vulgaris* and fungal strain; *Candida albicans*,

finding that juice (*G. barbadense*) exhibited more than 25% growth inhibition of *S. aureus* and *S. saprophyticus* compared to positive control, streptomycin (100% inhibition) by using agar disc diffusion assay[22]. In a study, Ade, *et al*[4] demonstrated that aqueous and ethanolic extracts (0.1 ml) from *G. barbadense* leaf decoction exhibited anti-microbial activity against *Staphylococcus aureus* (responsible for skin infections), *Escherichia coli*, and *Escherichia coli* ATCC 25922 (responsible for gastrointestinal and urinary tract infections), *Pseudomonas aeruginosa* and *Klebsiella pneumoniae (*responsible for bronchial infections and pneumonia*)* and *Shigella sonnei* (responsible for diarrhoea*)* with zone of inhibition ranging from 7 to 11 mm, where highest effect was shown by aqueous extract against *S. aureus* (zone of inhibition 11 mm) by using nutrient agar well method. Likewise, Ikobi *et al*[23] reported that the methanolic extract (10, 20, and 30 mg/ml) from *G. barbadense* leaf showed antimicrobial effects against *S. aureus* and *P. aeruginosa* with zone of inhibition ranging from 12 to 16 mm while methanolic extract (20 and 30 mg/ml) displayed effects against *Proteus mirabilis* with inhibition zone 13 and 15 mm and *Shigella sonnei* with inhibition zone 15 and 17 mm, respectively compared with positive control, dettol (zone of inhibition 12 to 25 mm) by using agar well diffusion technique. Essein *et al*[9] stated moderate anti-microbial activity of essential oil from cotton (*G. barbadense*) leaf exhibited moderate anti-microbial activity *S. aureus*, *Gardinella* spp, and *E. coli* (UCH 2306 and NCTC 9001) with a zone of inhibition 18±0.5, 20±0.4, 15±0.5 and 18±0.3 mm, respectively when compared with gentamicin (zone of inhibition 30 ± 0.4 mm) by using agar well diffusion techniques.

Anti-mutagenic activity

The ethanolic extract (500 mg/kg) of *G. barbadense* was determined to avoid and repair mutagenic lesions caused by cyclophosphamide (CP) in male Swiss mice by using the micronucleus test finding that extract significantly elevated the number of micronucleated erythrocytes while extract did not show the ability to protect DNA from bone marrow cells against clastogenic agents[16].

Anti-oxidant activity

The methanolic extract from *G. barbadense* leaves exhibited DPPH scavenging effects with 50% inhibitory concentration (IC_{50}) value of 55.15±5.09 µg/ml compared with standard drug, ascorbic acid (35.23±0.21 µg/ml) while methanolic extract displayed significantly ($p<0.05$) lower absorbance compared with ascorbic acid using reducing power assay[4].

Anti-ulcer activity:

The aqueous extract (250 and 500 mg/kg) from *G. barbadense* leaves was evaluated for anti-ulcer activity on oxidative gastric ulceration induced by indomethacin in Wistar rats with positive control, esomeprazole (20 mg/kg), finding that extract as well as esomeprazole significantly ($p<0.05$) suppressed the ulcer index while enhanced the inhibition level towards ulceration when comparable with IND group. Moreover, extract (250 mg/kg) significantly ($p<0.05$) attenuated the gastric volume and pepsin activity but enhanced pH and mucin content when compared with IND group. Furthermore, extract and esomeprazole significantly ($p<0.01$) upregulated the levels of SOD, CAT, and GSH induced by IND in mice when compared with IND group. Similarly, extract significantly ($p<0.05$) showed an elevated level of MDA in mice when compared with IND group[24].

Membrane stabilizing effect:

The aqueous extract (0.25-2 mg/ml) from *G. barbadense* leaf markedly protected bovine serum erythrocytes with 90.81 and 80.56% at 2 mg/ml when compared with standard, ibuprofen (0.10 mg/ml) with 89.90 and 83.87%, respectively against hypotonic solution and heat-induced damages[24].

Wound healing activity

The methanolic extracts (10, 20, and 40 mg/ml) from the leaves of *G. barbadense* were investigated for wound healing activity using the excision wound model on healthy albino rats using Cicatrin® powder as a positive control finding that methanolic extract applied at 20 mg/ml was able to heal the wound by 91% in rats when compared with cicatrin® powder (80% healing of wound in rats)[23].

TOXICOLOGICAL STUDIES

The aqueous extracts (105.25, 21.21, 4.65, and 2.325 mg/ml) of cottonseed (*G. barbadense*) did not show any alterations in plasma follicle-stimulating hormone (FSH) and luteinizing hormone (LH) but reduced ($p<0.05$) plasma testosterone when compared with control between 2 and 8 hours with a recovery time of 168 hours following treatment. Moreover, the aqueous extract increased plasma creatinine by 2 h and recovered by 8 h. However, urea was increased up to 168 h. Furthermore, the aqueous extract significantly ($p<0.001$) enhanced the levels of AST and ALT when compared with the control. Histopathological analysis of the testicles showed early germ cell disarray, followed by increasing fibrosis (sperm cytoskeleton) by 24 hours. In contrast, by 168 hours recovery was evident[27]. In another study, the aqueous extract from the leaves of *G. barbadense* did not exhibit toxicity up to 2000 mg/kg when evaluated in albino mice[6].

EDIBLE USES

Seeds are pounded into flour and are added to baking products. Seed oil is used in salads, shortenings, packaged goods, and is made into margarine, potato chips, snack bars, cereals, mayonnaise, and pasta sauce[26]. Cottonseed oil is frequently used by humans for edible purpose along with other uses, therefore it has evolved into a fibre as well as oil crop. It has a high protein content in its seeds (20-25%). Cotton seeds have both a shell and a kernel. The hull is used to prepare fibre and linters. Carbohydrates, lecithin, minerals, oil, protein, sterols, vitamins and other nutrients are found in the kernel. Cottonseed oil is extracted from the kernel of its seed. Among the unsaturated oil of safflower, corn, soybean, rapeseed, and sunflower, cottonseed oil, is one best unsaturated edible oils and so sometimes called "heart oil. It also boasts a high level of antioxidants - tocopherols. It contains 65-70% unsaturated fatty acids, including 18-24% monounsaturated (oleic), 42-52% polyunsaturated (linoleic) and 26-35% saturated (palmitic and stearic), with a polyunsaturated to saturated fatty acid ratio of 2: 1. It's frequently used as a benchmark for judging the odour and flavour of other oils. Its flavour is pleasant. Seed oil is typically transparent and has a light golden colour, however the degree of colour varies depending on the amount of refining, as with other oils. Clear and colourless oils are not always superior, although they may have been refined more completely. It's great for stir-frying and frying because of its light, non-oily consistency and high smoke point[3]. The leaves are most likely edible[26].

INDUSTRIAL AND TEXTILE USES

A cotton plant's primary product is fibre - its qualities have been valued and analyzed for centuries. It's a multipurpose crop with a lot of economic potentials. Currently, the most commonly cultivated cotton species are *G. hirsutum* and *G. barbadense*, with *G. hirsutum* covering for 90% of world production. *G. barbadense* represents approximately 5% of world fibre production[11]. The fibre obtained from the seed floss of the *G. barbadense* plant is the longest of all the cotton varieties and is of excellent quality, and can be used to make twine ropes, clothes, rubber tires, fabrics, stuffing material for pillows and quilts, and cushion covers[16].

Lint from cotton is beneficially used in luxury fabrics, yarns, high-quality textiles, sewing thread, cordage, and fishing nets. The cotton fiber was harvested from the plant to make clothing. Cotton is also used for hygienic purposes. Most especially, the fibres are used to manufacture cotton wool, compresses, gauze bandages, tampons or sanitary towels, and cotton swabs. The cotton fibres used in this way are often impregnated with medications such as zinc, calamine, or antimicrobials. Cotton dressings are sometimes mixed with other fibers, such as viscose, which helps absorb exudates from wounds. After surgery, absorbent cotton gauze can be used to pack cavities such as the sinuses or throat. It can also be used to clean wounds or areas of the skin before surgery or to apply medications to the skin. Cotton bandages provide support to strains, sprains, splints, and varicose veins[2]. More than one million farmers and textile workers in India rely on cotton production for their livelihood[3].

According to recent research, this plant has the best fibre quality, with better fibre length, fineness, strength, tensile strength, and other characteristics than other cotton varieties [21]. This plant is the world's second-largest cotton plantation, with incomparable superiority for its highly desirable fibre properties[25].

Table 1: Medicinal Uses of *Gossypium barbadense*

S. No	Diseases	Parts used	Preparation	Country	References
1	Animal bites (Snake bite)	Seeds	Paste	India	[7]
2	Anorectal diseases (Tenesmus)	Leaves	-	India	[8]
3	Cardiac disorder (Palpitations)	Shoots	-	-	
4	Cuts	Leaves	-	West Africa	[10]
5	Dental and Gum ailments	Leaves	Infusion	West Africa	[10]
6	Dystocia	Leaves	Juice	West Africa	[10]
7	Diarrhea	Whole Plant	Powder	Nigeria, Brazil, China, India, Madagascar, Sri Lanka, Ecuador, Mali, Brazil Ethiopia, Cameroon, Suriname, Yemen	[12]
8	Ear disorders (Otitis)	Seed and Leaf sap	oil	Cameroon, Congo	[10]
9	Edema (Chronic inflammatory diseases)	Whole plant	-	-	[10]
10	Eye disorders (Eye infection and Conjunctivitis)	Leaves	Infusion and Juice	West Africa	[10]
11	Female fertility & Genital disorders (Vaginal infections, genitourinary inflammation, excess vaginal discharge and infections)	Leaves and flowers	-	-	[11][12]
12	Fungal infections	Whole plant	-	-	[4]
13	Gastro-intestinal disorders (Dysentry, Stomachache and constipation)	Seeds and Leaves	-	India and Cameroon	[7]
14	Hemorrhoid (Piles)	Leaves		India	[13]
15	Hepatitis	Flowers	Decoction	Amazon	[14]
16	Hypertension	Whole Plant			[4]
17	Hypochondria	Flowers		India	[15]
18	Jaundice	Leaves	Decoction	Cameroon	[10]
19	Menstrual problems (Menorrhagia)	Leaves		India	[7]
20	Musculoskeletal disorders (Convulsions)	Leaves along with *Pergularia daemiais*	Decoction	West Africa	[10]
21	Neurological disorder (Strokes)	Leaves	-	-	[16]
22	Pain (Body pain and Backache)	Leaves and seeds	Paste	India	[26]
23	Pediatric disorders (Colic)	Leaf infusion	Infusion	-	[14]
24	Pyrexia (Fever)	Roots and seeds	-	India	[17]

25	Respiratory disorders (Hicough, Cough and Cold and bronchitis)	Flowers and leaves	Juice, decoction and Infusion	-	[7][10]
26	Rheumatoid arthritis	Leaves	Infusion	West Africa	[10]
27	Skin disorder (Spots and freckles from skin, Skin diseases, Itching, Scabies, Abscesses and leprosy, sores and Acne)	Seeds, leaves and lint	Oil and Paste	India, Gabon, Congo, West Africa and Kenya	[7][10][18]
28	Urinary System disorder (Cystitis)	Roots and seeds	-	India	[17]
29	Venereal diseases (Gonorrhoea)	Leaves	Juice	Gabon	[10]
30	Vertigo	Leaves	Juice	West Africa	[10]
31	Wound dressing	Leaves and fibre	Infusion	West Africa	[10]

Figure 1: Handmade Painting of *Gossypium barbadense* [Photograph from Patanjali Herbal Museum]

Figure 2: Vernacular Names of *Gossypium barbadense*

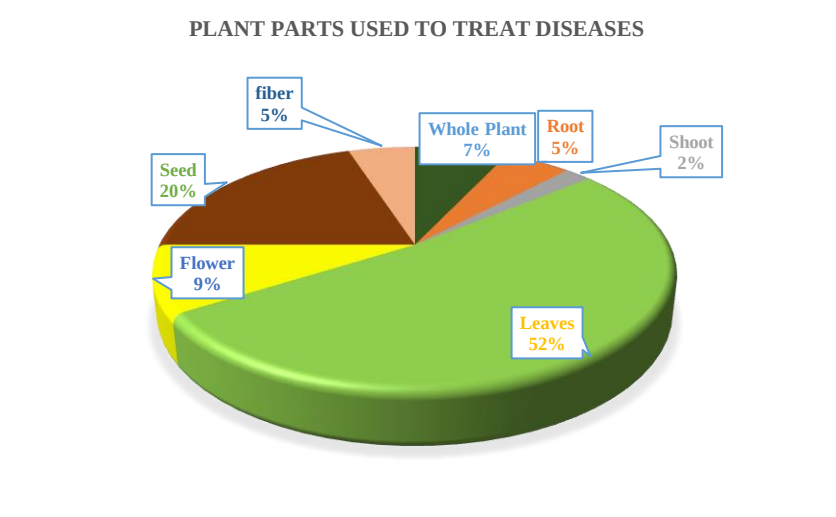

Figure 3: Plant parts used to treat diseases

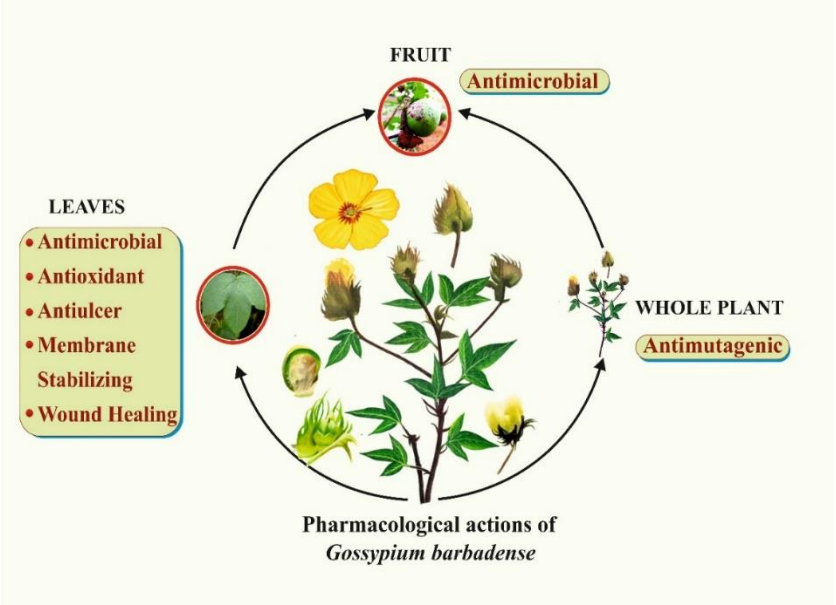

Figure 4: Pharmacological Actions from different parts of *G. barbadense*

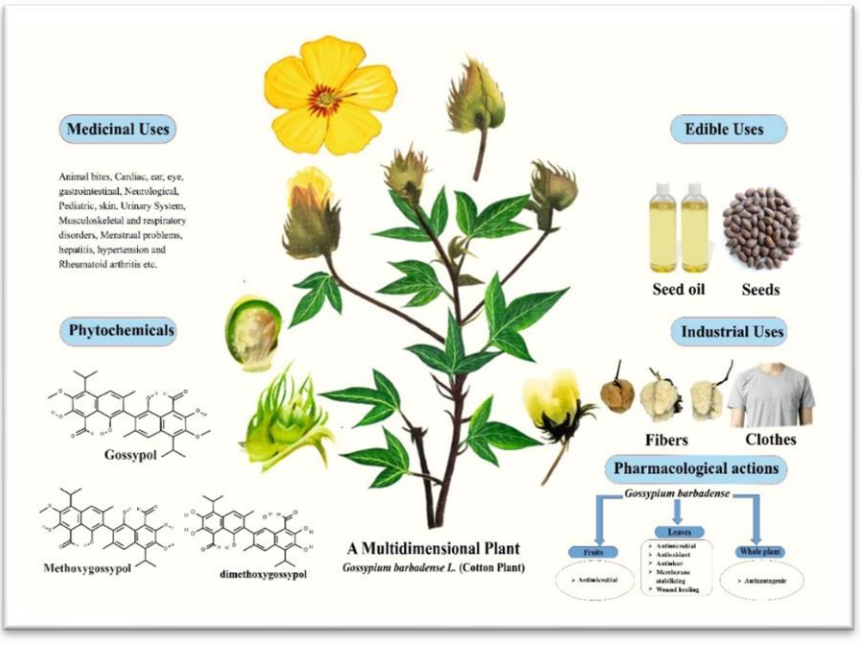

Figure 5: *Gossypium barbadense* L.-A Multidimensional Plant

CONCLUSION

The comprehensive information of medicinal or phytochemical aspects, biological activity, edible uses and industrial application of *G. barbadense* plant is first documented in the present review. This plant has been traditionally used for gynecological, skin, respiratory, urinary, gastrointestinal, musculoskeletal, inflammatory and infectious disorders around the world. All parts of this plant displayed therapeutic properties but leaves covers the majority of pharmacological activities. Several pharmacological actions are reported from the different parts of the plant but the active ingredients and mechanistic insights are still unexplored. This study elaborated the multidimensional nature of the plant and its applications in different areas. The plant seems to be very significant for the treatment of various deadly diseases. Further studies on the active ingredients and biological action on this plant is the major objective of research in the future aims of our research group.

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Conflict of Interests

None declared.

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