

Senna alexandrina Mill. (Senna): Traditional knowledge and Improved Production Technology

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ABSTRACT

Cassia species are used enormously to treat many diseases in the Indian traditional system of medicines. About 45 *Cassia* species are found in India, out of which *Senna alexandrina* Mill. is a medicinally important species. The traditionally use parts of *Senna alexandrina* are the leaves and immature pods which mainly contain sennoside-A and sennoside-B. Sennosides A and B are purgative, antibacterial, and antioxidant compounds isolated from *Senna* leaves and immature pods. *Senna* is in high demand in the international market due to its potential use in many medicines. Cultivation of *Senna* does not require much expense on irrigation, manuring, pesticides, protection and other pre-and post-harvesting care. The leaves are shipped from the branches and dried in the shade for 10-15 days till the moisture content reaches 8 to 10%. After shade dried and sorted the leaf and pods as per the leaf size into five different grades, viz., Prime numbers. Other important by-products are *Senna* stem and *Senna* powder. *Senna* crop offers an avenue for vertical integration and can be developed into a rural-based cottage industry starting from cultivation, grading, extraction and export.

Keywords: *Cassia*, cultivation, laxative, traditional, uses

INTRODUCTION

Cassia Linn. (*Senna*) is a medicinal shrub that belongs to the Fabaceae family and is mainly cultivated in tropical counties. *Senna alexandrina* Mill. known under the trade name Tirunelveli *Senna* or Indian *Senna* is a globally recognized natural laxative drug recommended in Ayurveda, Siddha, Unani, Yoga, Naturopathy, and

Homeopathy in India as well as in the pharmacopeias of the United Kingdom, Germany, United States, and other countries. India is the largest exporter of leaves, pods and total sennosides to the world market (Rs. 45 million). Nearly 75 percent of Senna produced in India is exported to around 55 countries, but the UK, West Germany and France buy in bulk quantities (Bown, 1995; Farooqui and Khan, 1993; Maiti and Kumar, 2000). Tirunelveli place in the southern Indian state of Tamil Nadu is where Senna was first introduced to India in the mid-eighteenth century and is extensively cultivated, processed and exported to various countries under the brand name "Tirunelveli Senna." Its occurrence in the wild in the Indian state of Gujarat indicates that it has become naturalized over the past approximately 250 years since its introduction (Goraya et al., 2017). Three states in India (Tamil Nadu, Rajasthan, and Gujarat) now produce the majority of all Senna in global trade Lal et al., 1998). The crop is grown as rainfed and irrigated in Maharashtra, Gujarat, Rajasthan, Karnataka, Andhra Pradesh, Telangana, Tripura and Tamil Nadu. The yield is well suited to drylands as it is drought tolerant and can be cultivated throughout the year (Kumar and Jnanasha, 2017; Jananasha et al., 2018). The significant importers of Senna are the USA, European Countries, Japan & Australia. Senna is an excellent foreign exchange earner (Maiti and Kumar, 2001; Reddy et al., 2015). According to the "The Plant List" (TPL, 2013), about 1854 names of various species are recorded for the genus *Cassia*, and among these, some of the accepted species are *Cassia abbreviate* Oliv., *Cassia absus* Linn., *Cassia alata* Linn., *Cassia auriculata* Linn., *Cassia biflora* Linn., *Cassia didymobotrya* (Fresen.) H. S. Irwin & Barneby, *Cassia fistula* Linn.,

Cassia glauca Lam., *Cassia grandis* Linn. F., *Cassia garrettiana* Craib, *Cassia hirsute* Linn., *Cassia italica* (Mill.) Lam. ex F.W., *Cassia javanica* Linn., *Cassia laevigata* Wild., *Cassia Mimosoides* Linn., *Cassia Multijuga* Rich., *Cassia nigricans* Vahl., *Cassia nodosa* Buch. Ham. Ex Roxb., *Cassia obtusifolia* Linn., *Cassia occidentalis* Linn., *Cassia podocarpa* Guill & Perr., *Cassia renigera* Wall. Ex Benth., *Cassia reticulata* Willd., *Cassia roxburghii* DC., *Cassia siamea* Lam., *Cassia sieberiana* DC., *Cassia septemtrionalis* Viv., *Cassia sophera* Linn., *Cassia spectabilis* DC., *Cassia tomentosa* Linn. F., *Cassia tora* Linn., *Cassia uniflora* Mill., and *Senna alexandrina* Mill. (Syn. *Cassia acutifolia* Delile, *Cassia angustifolia* Vahl, *Cassia Senna* L., *Senna angustifolia* (Vahl) Batka) are found in tropical and sub-tropical countries (Kumar et al. 2022). The use of some *Senna* species in the herbal preparations without the active pharmacological principles reduces the efficacy of the *Senna* herbal formulations. The leaves and pods of *Senna alexandrina* are used as stimulant laxatives, the laxative activity being attributed mainly to sennoside A and B and the amount of free hydroxyanthraquinones present (Rastogi and Mehrotra (1990); The Wealth of India).

This chapter's main aim and objective are to summarize various aspects of *Senna alexandrina* Mill. plant regarding their geographical distribution, morphology, production technology, phytochemistry, Traditional uses, trade, marketing, export and value addition was discussed and provided a scientific article for future work.

TRADITIONAL USES AND MEDICINAL PROPERTIES

The World Health Organization (WHO) Traditional Medicine Strategy 2014-2023 calls for improving the use of traditional medicines in

developing nations by 20 percent by 2020. In the 9th century, famous Christian Arab physician, Mesue the Elder, brought Senna leaves native of Africa to treat the constipation of the Caliph Harun al-Rashid (Khan, 2020). The name of the plant can be traced to two words: ‘sena’ (Arabic) and ‘cassia’ (Hebrew), which refers to its peelable bark. Known as Swarnapatri in the Sanskrit language (Ramchander et. al., 2017), *Cassia angustifolia* is documented as ‘pitta shodhaka’ i.e., removes the pitta dosha from body and ‘vata anulomaka’ i.e., removes vata through the anal route (The Ayurvedic Pharmacopoeia of India, Part I, Volume I, 2001). Before modern medicines were introduced, herbal remedies exclusively managed the treatment and management of various diseases (Le et al., 2021; Nille et al., 2021). World Health Organization (WHO) states that roughly 80% of the populations around the globe who reside in the extensive rural areas in the underdeveloped and developing nations still depend largely on medicinal plant species and their products. *Senna alexandrina* is a medicinal plant traditionally used mainly in India and other countries and has colossal potential for purgative properties. Pharmaceutical companies usually use leaves and immature pods (Leng, 1986; Lemli, 1988; Yamasaki, et al., 2010). In India, several household preparations such as decoction, powder, syrup, infusion, and confection are made with leaves of Senna (Atal et al., 1992; Le et al., 2021; Nille et al., 2021). Its leaves and pods are used in various traditional medicine systems to treat constipation, splenic-legally, hepatomegaly, dyspepsia, loss of appetite, jaundice, malaria, vomiting, anemia, skin rash, urticaria and are employed as a brisk and safe purgative that increases the peristaltic movement of the colon (Atal et al., 1992;

Akshay et al., 2019; Anon., 166; Aldakan et al., 1995; Le et al., 2021; Nille et al., 2021) (plate 1). Senna is used by some tribal communities for hair in the same way that henna is applied. The difference is that the Senna does not dye hair like henna. Senna makes hair thick and glossy and improves scalp health. In India, Senna is used in several household preparations such as decoction, powder, syrup, infection etc. In Kerala, Parambikulam tribal communities use the roots of Senna for joint pains (Le et al., 2021; Nille et al., 2021). In Europe, the leaves are preferred as an ingredient in herbal tea (Atal et al., 1992; Farooqui and Khan, 1993; Maiti and Kumar, 2000).

Senna is a popular drug in various traditional systems of medicine including Unani, Ayurvedic, Homeopathic, Siddha, Chinese etc. Some of the well-known compounds made by using Senna are PanchSakaara Churna, Shtshakaar Churna and Yashtyaadi Churna (Ayurvedic); Safoof-e-Mulaiyia, Majoon-e-Senaai, Itrifal Ustukhudus (Unani); and Nilaavarrai Choornam (Siddha) (Ramchander et. al., 2017). Popular Ayurvedic formulations using Senna are: Sarivadyasava (for the treatment of diabetes, skin diseases, and gout); Ayulax (for the treatment of distention of the abdomen and constipation); Kultab (for the treatment of piles and hemorrhoids); Pylend (for the treatment of constipation and piles); and Raktansoo (blood purifier). The leaves of the plant are used in several ailments such as constipation, indigestion, loss of appetite, anaemia, malaria, jaundice, splenomegaly, hepatomegaly. Purgation therapy termed as 'Virechna' has been advised in Ayurveda in cases of, jaundice, splenomegaly, hepatomegaly so as to remove excess pitt from the body (Ramchander et. al., 2017). Similar therapeutic effects have also

been seen in the pods of the plant, although it shows a gentler effect (Tripathi, 1999).

Senna alexandrina plant exhibits pharmacological activities at large scales such as anticancer, anti-inflammatory, antimicrobial, antioxidant, hyperglycemic, antimutagenic, Hepatoprotective and antivirals (Hemen and Lalita, 2012; Joshi et al., 2012; Le et al., 2021; Oshio et al., 1978). The Senna leaves compound Sennoside A, B, C, and D has been widely used as laxative drugs and health care products for weight loss (Le et al., 2021; Nille et al., 2021). In recent years, it has been found that sennosides also have other pharmacological effects, including antibacterial, antiviral, anti-amoebic and anti-neurodegenerative effects (Al-Ghamdi et al., 2020; Lemli, 1988; Yamasaki et al., 2010).

CHEMICAL CONSTITUENTS

The plant's active constituents are the anthranoids present in the leaf as dianthrone (75-80%) and as anthrones (20-25%). The number of anthranoids of the emodin and aloe-emodin types are generally higher in the leaves than in the immature pods. Leaves of *C. angustifolia* also afford a significant hepatoprotective action (Le et al., 2021; Nille et al., 2021). Various anthraquinones and their glycosides are reported from different parts of *C. angustifolia*. Mehta and Laddha (2009) had an estimated amount of anthraquinone glycoside in the leaves and pods of this plant. The leaves and pods of *C. angustifolia* contain not less than 2.5% anthraquinone glycosides, mainly sennosides A and B, dianthrone glucosides derived from rhein and aloe-emodin. This makes the leaf an essential source of rhein, which is currently subject of interest because of its antiviral, antitumor and antioxidant

properties. Rhein also serves as starting compound for the synthesis of diacerein, which has anti-inflammatory effects and is helpful in osteoarthritis (Le et al., 2021). Aqueous extracts of the leaves of *C. angustifolia* are used as laxative and remedy for scabies and itching. The sennoside A, B, C and D (Plate & table 1)) were also reported in the plant and found to inhibit bovine serum monoamine oxidase activity. El-Gengaihi et al. (1975) reported that the percentage of anthraquinone glycosides in Senna decreases with the increase in area and age of leaves and immature pods, the decrease being sharp at maturity.

PLANT DESCRIPTION AND DISTRIBUTION

Senna is a small, erect perennial shrub of 40–120 cm in height. This plant has pinnate leaves having pale green, narrow, acute, lanceolate, and glabrous leaflets. Senna plants usually commence flowering 60-70 days after seed sowing. Flowers are brilliant yellow colored, showy and arranged on a 30-45 cm long axillary or subterminal racemes. The pods are nearly 4–7 cm long, containing 5–7 obovate and dark brown smooth seeds (Tripathi, 1999). The pods are pale green in the beginning and change to greenish-brown and dark brown on maturity and after drying. The plants shed their leaves with the onset of cold weather in north India. Senna is predominantly a self-pollinated crop but the percentage of outcrossing is fairly large and pollination is done by beetles (Gupta et al., 1995; Rastogi and Mehrotra, 1990).

Table 1: Molecular formula and Molecular weight of Chemical constituents of *Senna alexandrina*

Name of the Compound	Molecular Formula	Molecular Weight
Sennoside A	C ₄₂ H ₃₈ O ₂₀	862.75
Sennoside B	C ₄₂ H ₃₈ O ₂₀	862.75

Sennoside C	$C_{42}H_{38}O_{20}$	862.75
Sennoside D	$C_{42}H_{38}O_{20}$	862.75

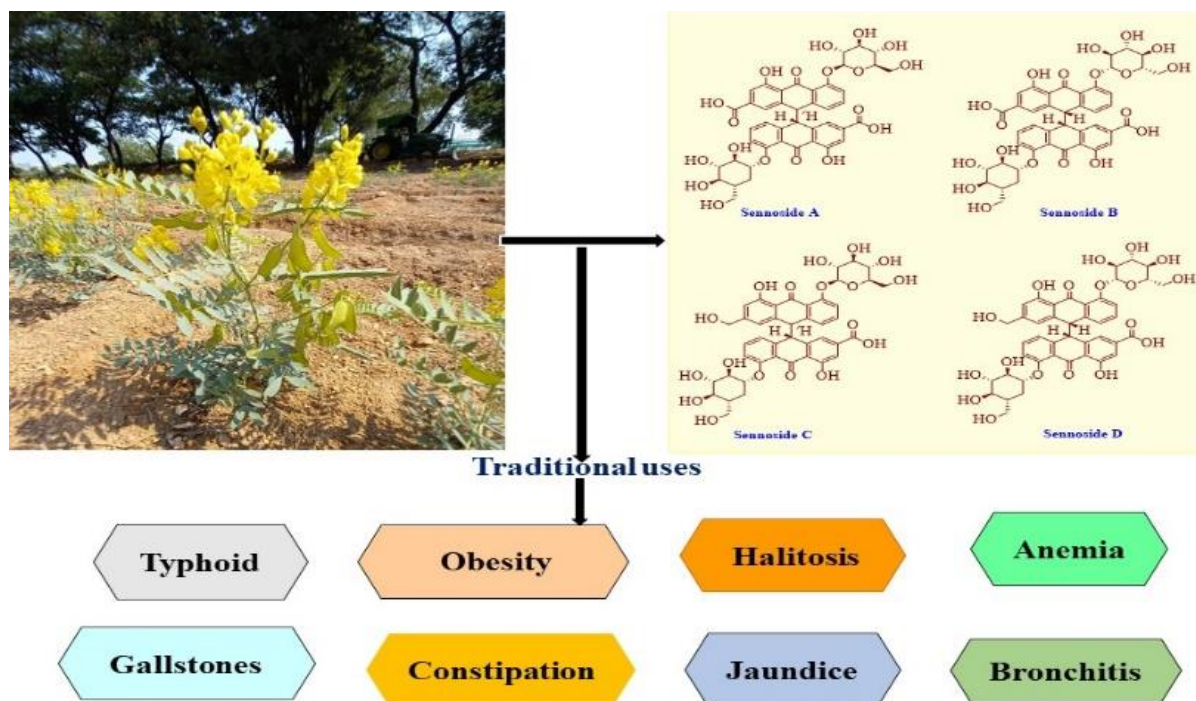


Plate 1: Pharmacologically active compounds anthraquinone glycosides of *Senna alexandrina*

Senna was introduced into European medicine by the Arabs in the 9th or 10th century. Its laxative properties were already known at that time. There are *Cassia* primary sources of the Senna drug components namely, *Senna alexandrina* Mill. (Syn. *Cassia acutifolia* Delile, *Cassia angustifolia* Vahl, *Cassia Senna* L., *Senna angustifolia* (Vahl) Batka) commonly called Alexandrian Senna, Tinnevely Senna, Senna, Bombay Senna, Medicinal Senna, Indian Senna is indigenous to Somalia, Southern Arabia, Part of Sindh now in Pakistan and the Kutch area of Gujrat. Senna is cultivated on a small scale in Sudan and Egypt (Rastogi and Mehrotra, 1990). It is widely grown in dry areas of Arabian countries for medicinal uses, for treating constipation. In India, Senna is grown in the states of Tamil Nadu,

Andhra Pradesh, Rajasthan, Gujrat, Maharashtra, Telangana, Karnataka, West Bengal, Tripura, some parts of Uttar Pradesh and Madhya Pradesh. The Senna belt of Tamil Nadu consists of three important districts, Tirunelveli, Tuticorin and Virudhunagar. In Rajasthan, its cultivation has been extended to the districts of Barmer, Jaisalmer, Bikaner, Nagaur, Pali, Jodhpur, Churu, Sikar, Jalore and Sri Ganganagar (Jananesha and Kumar, 2019; Maiti and Kumar, 2000). The dry climate of Jodhpur, Barmer, Jaisalmer, Bikaner and Nagaur districts of Rajasthan is the most suitable for Senna globally. The senna plant is found in a wild state in certain coastal parts of Gujarat in the Bhuj region of India. Senna is being cultivated in the Deccan plateau of the semi-arid region in Kurnool, Anantapur and Chittoor districts of Andhra Pradesh and Some farmers of Telangana state grow it as a cash crop in Mahbubnagar and Ranga Reddy districts (Jananesha and Kumar, 2019). About 75 percent of the production of Senna is produced in India, which is currently exported to Germany, France, the USA, Australia, and Southeast Asia (Pandey, 1971; Maiti and Kumar, 2001). Cultivating area of *Senna alexandrina* (Senna) in India is given in Table 2;

Table 2: Cultivating area of *Senna alexandrina* (Senna) in India

States	Districts	Area under cultivation (ha)	Productivity (Kg/ha)	Total Production in tons
Tamil Nadu	Tirunelveli (Palayamkottai, Mannargudi and Nanguneri); Tuticorin (Sathagulem, Natikulem, Kovilpani, Srivaikuntam, Ottapidiram); Virudhunagar (Srivallipunur, Sivakasi, Sattur and	6100	1435	8753

	Aruppukotai); Madurai, Ramnathpuram, Thoothukudi			
Rajasthan	Barmer, Jaisalmer, Bikaner, Nagaur, Pali, Jodhpur, Churu, Sikar, Jalore and Sri Ganganagar	800	1585	1268
Gujarat	Katch (Bhuj region) and Bhavnagar	4872	1650	8039
Andhra Pradesh and Telangana	Kurnool, Anantapur, Chittoor, Mahbubnagar and Ranga Reddy	17.54	2000	35.09

(Sources: Maiti and Kumar, 2000; NAAS, 2016; Sastry et al., 2010)

TAXONOMICAL POSITION

Senna (*Senna alexandrina* Mill. $2n = 28$) is a drought-tolerant annual medicinal shrub. Senna belonged to the Fabaceae or Leguminosae, also called the bean, pea, or legume family is the prominent family of the genus *Cassia* and the third-largest family of flowering plants on earth (Jadi et al., 2019). The Fabaceae family comprises many shrubs, trees, and other herbaceous useful plants, primarily differentiated by their stipulate, flower, compound leaves, and fruit (legumes). Traditionally, various species of the family Fabaceae are used to cure different ailments. *Senna alexandrina* Mill. is commonly known as Alexandrian Senna, Tinnevelly Senna, Senna, Bombay Senna, Medicinal Senna, Indian Senna in English; Sana ka pat, Sonamukhi, Sanay in Hindi; Svarnapatri in Sanskrit; Nela tangedu in Telugu; Sunnamukhi, Connamukk in Malayalam; Nelavarika sonamukhi in Kannada and Nilavarai, Nelavakai in Tamil (Khan, 2020; Rastogi and Mehrotra, 1990). This shrub is widely spread in India, covering its southern, western, and central dry zones and also in Sri Lanka. The taxonomical classification is given in table3.

Table 3: Taxonomic classification of *Senna alexandrina* Mill

Kingdom: Plantae	Class: Magnoliopsida
Subkingdom: Viridiplantae	Order: Fabales
Super division: Viridiplantae	Family: Fabaceae
Division: Tracheophyta	Genus: Senna Mill.
Subdivision: Spermatophytina	Species: <i>Senna alexandrina</i> Mill.

SPECIES AND VARIETY

Cassia Linn. (Senna), is a large genus belonging to the family Caesalpinaceae consisting of approximately 500 species as herbs, shrubs, and trees and are largely scattered all over Asia, including India, Pakistan, Sri Lanka, Thailand, Nepal, Mauritius, China, East Africa, South Africa, America, Mexico, West Indies, and Brazil. *Cassia* species are used enormously to treat many diseases in the traditional system of medicines. Some species are widely distributed throughout the world, especially in tropical countries and are abundantly available in India (Hemen and Lalita, 2012; Tripathi, 1999) About 45 species are found in India, of which few have been introduced for ornament. The *Cassia* species are a good source of mucilage, flavonoids, anthraquinones and polysaccharides. Earlier some literature and botanist suggested that the Alexandrian Senna (*Cassia acutifolia*) is different from its Indian counterpart, Tinnevelly Senna (*Cassia angustifolia* Vahl). These were believed to be different species as they showed some distinct morphological features and different naphthalene glycosides (hydroxymusicin in Alexandrian Senna; and Tinnevellin glucoside in Tinnevelly Senna (Franz, 1993; Hemen and Lalita, 2012; Khurm et al., 2021). However, the chromosome number

is same, i.e., 28 in both Alexandrian Senna, Tinnevelly Senna, Senna, Bombay Senna, Medicinal Senna, Indian Senna.

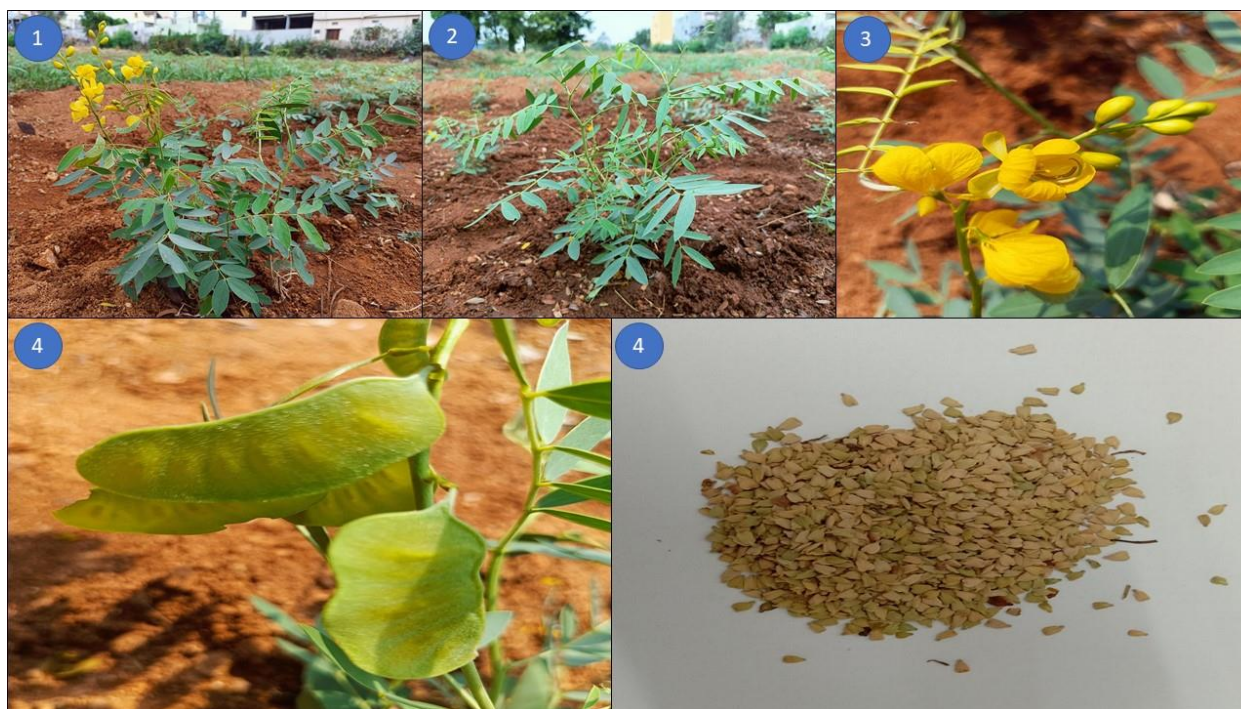


Plate 2: A Close view of *Senna alexandrina* species: 1) Full blooming and fruiting stage; 2); Leaves in harvesting stage; 3) Close up view of flowers; and 4) Pods in seed formation stage; 5) Seeds

Recently, *Senna alexandrina* Mill. (Syn. *Cassia acutifolia* Delile, *Cassia angustifolia* Vahl, *Cassia Senna* L., *Senna angustifolia* (Vahl) Batka) are considered synonyms and the accepted scientific name is *Senna alexandrina* Mill. according to World Flora Online (<http://www.worldfloraonline.org/taxon/wfo-0000164723>. Accessed on: 09 Sep 2021). In this chapter, some species will be summarized in table 4.

Table 4: summarized important cassia species and their reported medicinal properties in India

Species Name	Popular Name	Part (s) used	Habit	Distribution	Medicinal Uses	References
<i>Cassia abbreviate</i> Oliv.	Sjambok pod or Long-tail cassia	Roots, Leaves, Pods, Stem bark	Deciduous Tree, 6-8 m tall, Ornamental, Wild	India, Mozambique, Tanzania	Diarrhea, constipation, malaria, wounds, snakebite, dysentery, syphilis, Malaria, cough, epilepsy, Eye infections, Stomach ache, malaria	Ribeiro et al. (2010) and Mongalo et al. (2013)
<i>Cassia absus</i> Linn.	Jameejaz, Chaksu seeds	Seeds, Leaves, Roots	An annual plant, 30-60 cm height	India, Morocco, Gold Coast	Skin infections General types of Cancer, Tumors, wound healing, Constipation	Ahmad et al. (2018); The Wealth of India (1992)
<i>Cassia alata</i> Linn.	Ringworm Senna, Winged Senna	Leaves, Root	Shrub stands 3-4 m, leaves 50-80 cm long.	Mexico, India, Somalia, Philippines	Diabetes mellitus type 2, Laxative, Uterus disorders	Singh et al. (2012); The Wealth of India (1992)
<i>Cassia auriculata</i> Linn.	Tanner's cassia	Whole plants	Evergreen shrubby tree 2-4 m in height	India, Sri Lanka, Burma, Pakistan,	Chronic fever, diabetes, antihelminthic, Leucorrhoea, white discharge, Purgative	Kainsa et al. (2012); Rastogi and Mehrotra (1990)
<i>Cassia biflora</i> Linn.	Desert cassia	Leaves, Flower	Deciduous to semi-deciduous shrub, up to 1.8-2.4 m tall	Tropical America, India	Snakebite, dysentery, syphilis, Malaria, cough	Rastogi and Mehrotra (1990)
<i>Cassia didymobotrya</i> (Fresen.) H. S. Irwin & Barneby	Candelabra Tree	Leaves, Stems, Roots	Deciduous Shrub, small tree, 3.5 m height	East and Central Africa, Ethiopia, Namibia, Zimbabwe, Mozambique, India	Laxative, antifungal, antibacterial infections, anti-hypertension, gynaecologic	Nagappan (2012) and Tropical Plant database

					al diseases	
<i>Cassia fistula</i> Linn.	Amaltas, Indian Labernum, Riding Pipe	Leaves, Pods, Seeds	Tree 20 m heigh, Pods are indehiscent and terete with 40–60 cm length	India, Papua New Guinea, Tanzania, Thailand, Ghana	Malaria, blood poisoning, dysentery, skin diseases, liver tonic, laxative, Purgative, Backward fever, tonic, wounds purification, ulcers, purgative	Agrawal et al. (2012); Burkill (1994); Rastogi and Mehrotra (1990)
<i>Cassia glauca</i> Lam.	Scrambled Egg Bush	Leaves, Bark	An evergreen shrub that grows about 3 m high with ovate, pointed leaflet	India, Tropical Asia	Blennorrhagia, diabetes	Mazumder et al. (2009)
<i>Cassia grandis</i> Linn. F.	Coral shower, Apple blossom cassia, pink shower, Liquorice tree	Leaves, bark	Medium Sized tree up to 2.-30 m tall	Brazil, India, Malaysia, Ivory, Coast, Congo	Lumbago, laxative, ringworms	Grubben (2004)
<i>Cassia garrettiana</i> Craib	Samaesarn	Heartwood	Small tree up to 10 m height	Thailand	Cathartic, blood tonic, constipation, leukemia, nematodes	Yuenyongswad et al. (2014)
<i>Cassia hirsute</i> Linn.	Hairy Senna, Stinking cassia	Seeds, Leaves	Perennial shrub, 0.5-3 m tall	India (hilly tracts of South India), Bangladesh	Protect teeth and gums from cavities and Plaque, stomach troubles, dysentery, abscesses, rheumatism	Biswas et al. (2012), Le et al. (2021); Nille et al. (2021)
<i>Cassia italica</i> (Mill.) Lam. ex F.W.	Port Royal Senna, Italian Senna, or Senegal Senna	Seed	Small perennial shrub, with 3- 12 cm long leaves	India, South Africa, Somalia, Sudan, Benin, Namibia	Stomach problems, laxative, purgative, constipation, skin diseases, gout	Ahangarpour and Oroojan (2010)

<i>Cassia javanica</i> Linn.	Apple blossom, Javanese cassia	Whole plant	tree of medium-sized and about 3–20 m tall, leaves are 20–40 cm long	China, Malaysia, Cambodia, Pakistan, India, United States, and Thailand	Construction, furniture and cabinet making	Rastogi and Mehrotra (1990); Wart and Wong (2000)
<i>Cassia laevigata</i> Wild.	Laburnum, Hill cassia	Leaves, Seed, bark	Small shrub up to 2-3 m in height	Mexico, India	Seeds are sometimes used as a substitute for coffee, purgative	The Wealth of India
<i>Cassia Mimosoides</i> Linn.	Karagaim, Senegal	Leaves, Roots	Diffuse shrub up to 1.5-1.80 m in height	China, India	Ailments, such as diarrhea, dysentery and gastrointestinal problems	Global Plants database
<i>Cassia Multijuga</i> Rich.	Leafy cassia	Leaves, Flowers	Medium size tree, 10-15 m tall	South America, India	They grow in ornamental and cultivated areas for green manuring, shade, and as a hedge plant	Rastogi and Mehrotra (1990); Singh (1981)
<i>Cassia nigricans</i> Vahl.	Diola	Leaves, Roots	Woody annual undershrub or herb with 1.22–1.52 m height	Tropical Africa, Arabia, and India	Fevers (fumigation), sore throat, ulcer, Gastrointestinal diseases, Purgative, vermifuge	Rastogi and Mehrotra (1990); The Wealth of India (1992)
<i>Cassia nodosa</i> Buch. Ham. Ex Roxb.	Pink Mohur, Pink and White Shower	Leaves, Flower	Medium-sized treed	India, Pakistan	Purgative, fever, skin diseases, tonic	Rastogi and Mehrotra (1990); The Wealth of India (1992)
<i>Cassia obtusifolia</i> Linn.	Sicklepods	Leaves, Seed, Root	Annual weed, hairless stem	China, Thailand, Nepal, India	Red and tearing eyes, headache and dizziness	The Wealth of India (1992)
<i>Cassia occidentalis</i> Linn.	Coffee Senna, Stink Weed, Rubbish Cassia	Leaves, Seeds, Roots	semi-woody, smooth, fetid herb or shrub and tall up to 0.8–2 m	India, Brazil, Gambia, Guinea, Koman, West Indies, Nigeria	Worms, Cutaneous diseases, asthma, wounds, swellings, constipation, purgative, diuretic	Rastogi and Mehrotra (1990); The Wealth of India (1992)

<i>Cassia podocarpa</i> Guill & Perr.	Senna	Leaves, Pods	Shrub up to 5 m tall	Senegal, Gambia, Nigeria	Wounds, swellings, Constipation, purgative, diuretic, headache	Global Plants database
<i>Cassia renigera</i> Wall. Ex Benth.	Burmese pink cassia	Leaves, Pods	Tropical tree, 10 m tall	China, Pakistan, India, United States, and Thailand	Construction, furniture, purgative and cabinet making	Rastogi and Mehrotra (1990); The Wealth of India (1992)
<i>Cassia reticulata</i> Willd.	Golden Lantern tree	Leaves, Flower	Small flowering tree, pale-green leaves	South America	Liver, Construction	Anchel (1949) and Messmer et al. (1968)
<i>Cassia roxburghii</i> DC.	Red Indian Laburnum, Ceylon Senna	Leaves, Pods	Known as Red Cassia, 15-20 m tall tree	The Indian subcontinent, Sri Lanka, North America, West Tropical Africa	Laxative, splenomegaly, hepatomegaly	Kirtikar & Basu, (1999); Nasir et al. (1972)
<i>Cassia siamea</i> Lam.	Siamese Cassia, Ironwood tree	Flower, Root, Bark	Medium-sized tree, 15-30 m tall, grey bark	South East Asia, Thailand, Africa, India, Sri Lanka, Myanmar, Thailand	antioxidant, stomach complaints, mild purgative, anti-tumour, chemopreventive	Nadembega et al., (2011); Rastogi and Mehrotra (1990)
<i>Cassia sieberiana</i> DC.	Drumstick tree,	Leaves, Pods, Roots	Medium-sized tree, 10-20 m tall	West and East Africa, Senegal, Sudan, and Uganda	Laxative, analgesic, antibiotic, anti-inflammatory, purgative	Archer et. al, (2019)
<i>Cassia septemtrionalis</i> Viv.	Smooth Senna	Leaves, Seed	Small shrub, 1-5 m tall, stem hairless	Java, Ethiopia, Madagascar, Guatemala, India	Unripe seeds, young shoots, and the leaves are cooked and eaten for laxative properties	Global Plants database
<i>Cassia sophera</i> Linn.	Pepper-leaved Senna, Senna sophera	The whole plant (Leaves, Pods, Seeds, Bark)	Shrub, 2-3 m height	India, Bangladesh, Western Africa, Koman	Expectorant, cough, Ringworms, syphilitic Sores Fevers, malaria, Urine problems, Bronchitis,	Kirtikar and Basu (1918)

					Diuretic, snake bite, Fever, Diabetes	
<i>Cassia spectabilis</i> DC.	Spectacular cassia, golden wonder tree	Leaves, Seed	Fast grown tree, 9 m height	Central America, India, West Indies, Colombia	Seeds are source of commercial gum, antifungal activity	Kapoor et al. (1998)
<i>Cassia tomentosa</i> Linn. F.	Glandular Senna, downy Senna	Leaves, pods	Perennial tall shrub, yellow flower	Tropical America, Asia, Australasia, India	Purgative, antioxidant and anti-infectious	Zhenbao et al. (2007)
<i>Cassia tora</i> Linn	Sickle Senna, wild Senna	Leaves and Seeds	Herbaceous annual foetid herb, 30–90 cm high	India, China, Nigeria	Laxative, cutaneous diseases, allergies, cardiac problems constipation, bronchitis, leprosy, Skin itching, cutaneous ailments	Perry and Metzger (1980)
<i>Cassia uniflora</i> Mill.	Single flowered Senna	Leaves, Seed	An erect annual, 1 m tall	South America, India	Anti-inflammatory, Analgesic, and Antiarthritic, Antioxidant, Antimicrobial and Antibacterial	Rastogi and Mehrotra (1990); The Wealth of India
<i>Senna alexandrina</i> Mill. (Syn. <i>Cassia acutifolia</i> Delile, <i>Cassia angustifolia</i> Vahl, <i>Cassia Senna</i> L., <i>Senna angustifolia</i> (Vahl) Batka)	Alexandrian Senna, Tinnevely Senna, Bombay Senna, Medicinal Senna, Indian Senna, Senna	Leaves, Pods	A variable, erect shrub growing to 100-120 cm in height, with four or five pairs of leaves	India, Sri Lanka, Sudan, Arabia, Libya	Constipation, indigestion, jaundice, malaria, splenomegaly, hepatomegaly, loss of appetite	Silva et al., (2008); Tripathi (1999); Rastogi and Mehrotra (1990); The Wealth of India

In India, four types of varieties are available for cultivation (Table5).
CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow

has developed an improved variety of Senna named CIM-Sona, which is very popular among farmers. CSIR-CIMAP Headquarters Lucknow and its associated research centers train the farmers regarding agro-technologies for Senna cultivation and their suitability for specific climatic zones and production technology and market availability through awareness programs.

Table 5: Developed improved varieties of Senna in India

Name of variety	Details of variety	Origin	Country
ALFT-2	This is a late-flowering variety. It is widely grown in Gujarat and Tamil Nadu. Its foliage yield is higher.	Anand Agricultural University, Anand, Gujarat,	India
CIM-Sona	Sharon plains of North India are suitable for this variety and are recommended for growing, yield potential 1.1 t dry leaf 0.4 t seed 3.51% Sennosides	CSIR-CIMAP, Lucknow, U. P.	India
KKM-1	Suitable for dry conditions in Tirunelveli and Tuticorin districts of Tamil Nadu.	Agriculture College and Research Institute, Killikulam, Tamil Nadu	India
Tinnevelly Senna	It is semi-spreading in nature. Prevalent in Tirunelveli and Ramanathapuram districts of Tamil Nadu are commonly exported from Tuticorin in T.N.	Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu	India

(Sources: NAAS, 2016; www.cimap.res.in)

CROP PRODUCTION TECHNOLOGY

In India, *Senna alexandrina* Mill. (Senna) is cultivated in Gujarat, Rajasthan, Andhra Pradesh, and Tamil Nadu states. The total annual production of Senna herbage is estimated to be around 7500 tonnes (Sastry et al., 2010, Maiti and Kumar, 2000). The leaves and pods of a few other species of *Cassia* also possess laxative properties similar to those of *C. angustifolin*, the most important being *Cassia acutifolia* or Alexandrian Senna. Alexandrian Senna grows in the wild in North

African countries, including Ethiopia and Sudan. In the Tirunelveli district, Tirunelveli, Palayamkottai, Mannargudi and Nanguneri are important taluks in which Senna is cultivated. In Virudhnagar district, Virudhnagat, Srivallipunur, Sivakasi, Sattur and Aruppukotai are important taluks. In the Tuticorin district, Sathagulem, Naticulem, Kovilpani, Srivaikuntam, Ottapidiram and Tuticorin are the important tasks where Senna is cultivated. Senna can grow any dryland soil. For a rainfed crop, the land is prepared after the first monsoon rains, and for an irrigated crop, in December, after the northeast monsoon (Kumar and Jnanesha, 2018; Maiti and Kumar, 2001; Sastry et al., 2010). In Tamil Nadu, two district seasons are recognized for Senna cultivation. The first starts with the onset of the southeast monsoon in September to October, which is rainfed, while the second is sown in mid-February to started March. Field preparation is done according to the sowing season. The ploughed twince or thrice, harrowed once or twince and then leveled for uniform germination of seeds. Fine tilth is not necessary. As the crop cannot survive in a situation of waterlogging, good drainage in the field is very important. It has been reported that the application of methyl parathion dust 5% (25kg/ha) at the last ploughing and levelling of land protects young plants from the attack of cutworms. The soil pH suited for cultivation is 7.0-8.5. But, the most suitable sandy loam to loam soils are more friable and well-drained. Senna is also cultivated successfully on black cotton soils (Jnanesha et al., 2018; Kumar et al., 2019; Rastogi and Mehrotra, 1990; The Wealth of India, 1992; Sastry et al., 2015). Senna is usually grown as a rain-fed dry crop and rarely as an irrigated crop in certain areas (Kumar and Jnanesha, 2017).

Season and sowing: Senna is mostly cultivated as a rain-fed crop. Under limited irrigation conditions, the land is ploughed twice during February-March. It is divided into beds for facilitating irrigation. Under rain-fed conditions, in black soils, the first crop of cotton or sorghum or coriander is grown, and Senna is sown as a second crop on residual moisture at the end of the rainy season from the end of September to November (Sastry et al., 2010; Tripathi, 1999). The Senna crop is propagated by seeds. Seed sowing is done by broadcasting method or drilling in lines which is 30cm apart but line sowing is an improved method over the broadcasting method (Kumar and Jnanesha, 2017). About 25 to 28 kg/ha of seed is required for rainfed conditions, whereas about 12 to 15 kg/ha is needed under irrigated conditions (Kumar and Jnanesha, 2017).

Crop management: The first weeding cum hoeing is done at 25-30 days of sowing, a second at 75-80 days, and a third at 110 days to keep the crop free from weeds. Mostly Senna is taken as a rainfed crop and grows well under moderate moisture and cannot tolerate heavy rains and more extended rainy periods and waterlogging but slight drizzling during the cropping period promotes crop growth and development (Kumar and Jnanesha, 2017). The continuous rain during the growth period can spoil the quality of leaves. Being a hardy crop, it grows well under water scarcity. Sunnyside content is decreased due to decreased cell sap concentration which may be due to increasing irrigation frequency or decreasing irrigation intervals (Farooqui and Khan, 1993; Maiti and Kumar, 2000; Nilofer et al., 2018).

In most cases, the crop is grown economically by utilizing the residual nutrients of the previous crop. However, application of FYM

at 10 tons per hectare at the time of land preparation, under irrigated conditions, fertilizers (N: P: K in the ratio 40:40:40 Kg/ha) are applied at the time of sowing. It is advisable to grow Senna using organic farming practices. Foliar application of micronutrients enhances overall growth, i.e., no. of branches, plant height, leaves, etc., and sennosides component contents. Organic farming with minimum insecticides and pesticides/fungicides is more beneficial and feasible for Senna cultivation. Low irrigation also promotes the formation of Senna pods and increases the sennoside content in the leaves and pods (Farooqui and Khan, 1993; Maiti and Kumar, 2000).

CROP PROTECTION

In northern and western India, this crop is reported to suffer from damping-off disease when grown in poorly drained soils. The best method of managing this disease is to improve drainage conditions by allowing proper slopes in the field. Seed treatment with Thiram at 3g per kg seeds is also beneficial (Tripathi, 1999; Jananesha et al., 2018). Leaf spot and leaf blight are the two occasionally most severe diseases of this crop. Cloudy and humid weather conditions are conducive for the spread of these diseases. In severe infestation, leaves start drying and falling, causing severe yield loss. Pods are also affected in an advanced stage of disease development. Two to three sprayings of Dithane M-45 at 0.15% at fortnightly intervals keep the diseases under check. Spraying of Bordeaux mixture, benomyl, captafol and copper oxychloride is recommended. The crop should be harvested 25-30 days after the spray of pesticides (Maiti and Kumar, 2001). Butterfly migrations have been well documented from Tamil Nadu, Gujarat, Maharashtra, Karnataka, Kerala, and Madhya Pradesh

(Evershed 1910; Palot et al., 2002; Kunte, 2005). However, none reported the origin of butterflies. Synchrony with host, and plant has been suggested as an important factor in the dynamics of many forest pests (Van Asch and Visser, 2007). Aphids (*Aphis craccivora*) both nymphs and adults occur in colonies on the undersurface of leaves and terminal shoots. Due to desapping, the leaves become curled and present a crinkling appearance. Honeydew secretion is not uncommon which often attracts sooty mold growth. Ants are invited by honeydew excretion. Pierid Butterfly (*Catopsilia pyranthe* and *Eurema hecabe*) caterpillars feed voraciously on leaves and growing shoots causing heavy defoliation. Pod Borer (*Etiella zinckenella*) boreholes could be seen on the pods as the larva bores into the green pods feeding the seeds. Occasional, severe damage to foliage has been observed due to white butterflies, which can be minimized by sowing the crop in March-April. The larvae of several caterpillars feed on the leaves and remain active from July-October. In nature, they are found to be heavily parasitized by *Trichogramma chilonis*. The release of *T. chilonis* at 150 thousand populations per hectare per week at the adult stage coinciding with the egg-laying of the pest is a very effective method of this pest management (Maiti and Kumar, 2000; Pandey, 1971).

HARVESTING METHOD AND YIELD

After 60 days of sowing Senna, 50% of the leaves can be plucked from the bottom because many plants have blue-green leaves in color. However, after 85-100 days of Senna sowing, the plant is ready for harvesting. About 90-100 days after sowing, fully grown bluish-colored leaves and golden yellow-colored immature pods are stripped

manually. A second harvest is taken 30-45 days after the first harvest (Maiti and Kumar, 2000). The leaves and pods are shade dried for 10-15 days before packing (Sastry et al., 2015). Senna crop is generally grown annually in almost all parts of India by uprooting the entire plant after the 3rd picking/plucking. Still, the crop can also be grown as a perennial crop for 2-3 years under favorable soil and climatic conditions. A good average crop of Senna can give 1500-1600 kg/ha of dry leaves and 500-700kg/ha of pods under irrigated and good agricultural practices. The yield under rainfed conditions is about 1000-1200 kg of leaves and 300-400 kg/ha of pods. A good Senna crop can yield 300-400 kg of seed per hectare (Maiti and Kumar, 2001).

POST-HARVEST MANAGEMENT AND PROCESSING

The leaves are shipped from the branches and dried in the shade for 10-15 days till the moisture content reaches 8-10% (Maiti and Kumar, 2001). The leaves are collected by the local traders and transported to the wholesale dealers and exporters in Tuticorin. Depending upon the quantum of trade, leaves are processed manually or mechanically, and then leaves are winnowed to remove dust and small stones. After that, these are passed through the sieve of different sizes to sort them into different grades (prime 1 to prime 5), from which prime 1, 2 and 3 are exported to the international market, whereas prime 4 and 5 remain for selling in the internal market (Plate 3 & 4). Grading is the only process for value addition in Senna leaves that will be exported in India and to different countries of the world, and the countries which import perform the value addition. Flavored Senna leaf, Senna tea, sennosides and Senna tablets can be excellent value-added products (Sastry et al., 2010; Sastry et al., 2015).

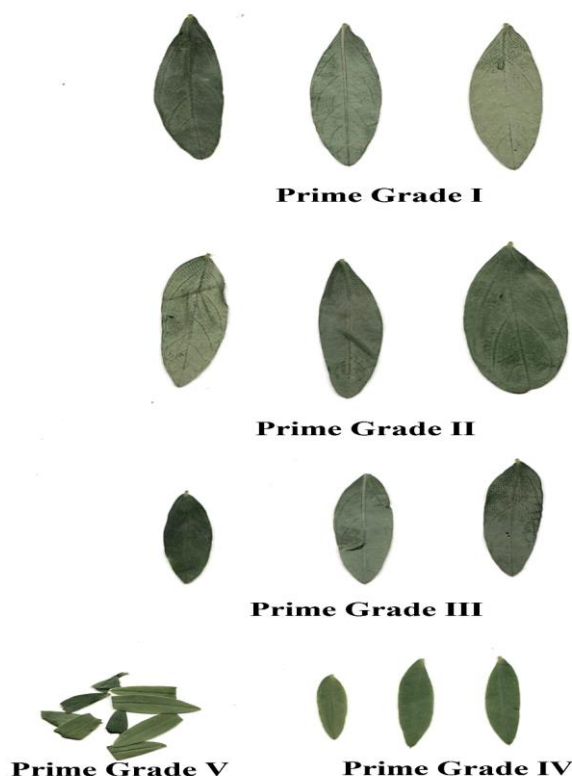


Plate 3: Plate of different grades of Senna leaves

The leaves are stripped from the branches and dried in the shade for 10-15 days up to 8-10 percent moisture content. The leaves are collected by local traders and transported to wholesale dealers and exporters in Tuticorin of Tamil Nadu.

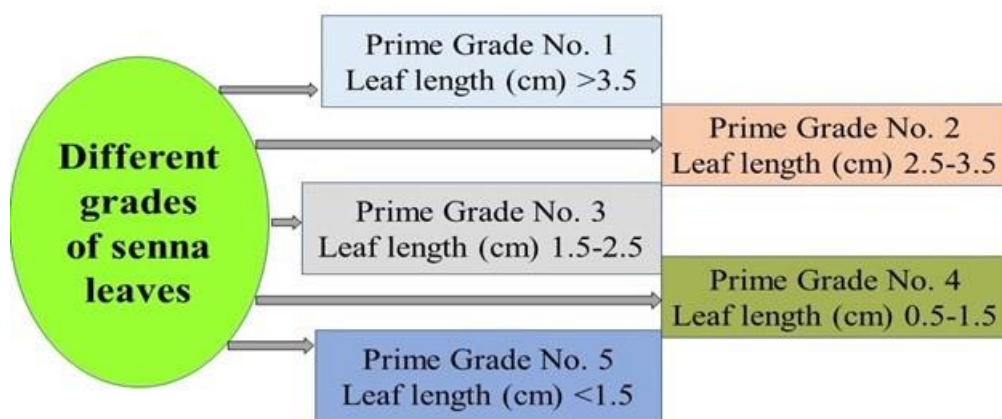


Plate 4: Different grades of Senna leaves

The leaves are processed manually or mechanically depending upon

the quantum of the trade. They are winnowed to remove dust and stones and then passed through sieves of different sizes to sort them into different grades (Sastry et al., 2010; Nilofer et al., 2001).

TRADE, MARKETING, AND EXPORT

The National Medicinal Plant Board (NMPB) New Delhi has identified 32 medicinal plants for promotion, and Senna is one of them. The Senna is the second largest earner of foreign exchange through exports. Indian Senna leaves and pods are valued as a good source of sennosides in international trade and the global market. India has an excellent opportunity to increase its production, value addition, trade and export earnings.

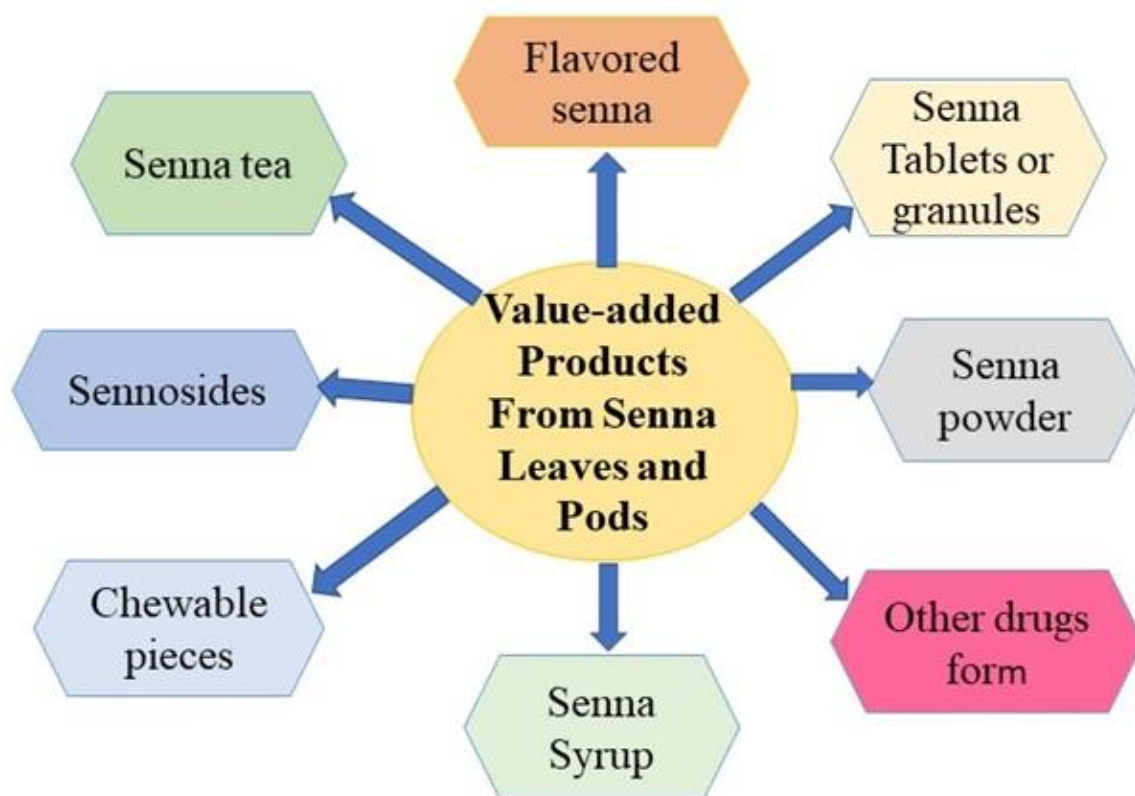


Plate 5: pharmaceutical products from Senna leaves and pods in markets

It is also imperative that India urgently develop processes and products before any other country can develop and patent them.

Sennosides (also known as Senna glycoside) are a medication used to treat constipation. Senna comes as a liquid, powder, granules, chewable pieces, tea bags and tablets to take by mouth (Le et al., 2021; Nille et al., 2021). It is maybe taken once or twice daily. All forms of Senna are intended to produce the same benefits. If you want quick-acting, immediate results, it is best to look for liquid extracts or powder blends for immediate consumption in the bloodstream. These forms will work faster, and users will realize the benefits far sooner than the other forms of Senna available for consumption (Khan, 2020; Le et al., 2021; Sastry et al., 2010; Nilofer et al., 2021; Nille et al., 2021). In India, Senna leaves and pods are presently the primary source of cultivated Senna (recorded in over 10,000 ha) directed to the world market. The export volume of 15,975 MT, valued at US\$ 10 million, was achieved in 2012-2013, which is increasing continuously. Over 80 % of the leaf produced in the country is exported without any value addition except grading. The importing countries are doing value addition (Sastry et al., 2010; Nilofer et al., 2021; Nille et al., 2021). Value addition should be India's primary objective to compete globally since the raw material is produced within the country. Some value-added products from Senna are presented in plate 2. The success of a cultivation enterprise depends on the marketability of the product (demand, quality, price, etc.), market access (marketing network, the role of middle merry farmer's access, etc.), and marketing ability (price negotiations, timely deliveries, etc.) of the producer. The Senna crop lacks extensive marketing networks making it necessary for the farmers to search for purchasers of their produce. Legally bound marketing tie-ups are rare, neither fool-proof nor farmer-friendly. It is

advisable to conduct a market survey before taking up cultivation of the Senna crop in a new location, where marketing facilities for the products from this crop are currently non-existent (Nilofer and Singh, 2018). Price fluctuations are not uncommon and depend on national and international supply-demand positions. Hence, the cropped area must be closely monitored so as not to exceed the demand. Good marketing practices (timely-regular-good quantity-unadulterated material supplies at competitive prices in attractive packaging) will sustain the demand for Indian produce in the international market (Farooqui and Khan, 1993; Sastry et al., 2010; Nilofer et al., 2021; NAAS, 2016; Nille et al., 2021; Tripathi, 1999). At present, the Senna area has reduced to 10000-12000 ha. in Tamil Nadu (India), whereas the area and production in Rajasthan are increasing, where it is grown as a rainfed perennial crop (4-5 years). The total area under Senna cultivation varied from 8000 to 11000 ha. Production of leaves varies from 10000-12000 tons per year depending upon the area, whereas a total of 6000-12000 tons of leaves and pods are produced, and about 80% of the production is exported, and earnings range from Rs. 35-36 crores/ annum. In the 2015-2016 agricultural year, India exported 15,952,830 kg (35,169,970 lbs) of Senna leaves and pods with a customs value of about \$14,530,000. In the subsequent agricultural year 2016-2017, India exported 12,744,070 kg (28,095,865 lbs) of Senna leaves and pods. More than 70% of India's export volume of Senna is imported by only ten countries: Vietnam, China, Japan, Germany, Poland, the United States, Egypt, Spain, Thailand, and Mexico (Nilofer and Singh, 2018). Domestic consumption of Senna leaves and pods by the Indian herbal drugs industry is estimated at 1,284,350 kg (2,831,507 lbs)

annually. Furthermore, India produces an estimated 180,000 kg (396,832 lbs) of sennosides (partially purified natural complex of anthraquinone glucosides obtained from Senna leaflets and pods) annually, of which about 140,000 kg (308,647 lbs) are exported (Sastry et al., 2010; Sastry et al., 2015; NAAS, 2016; Nilofer et al., 2001).

AGRO-ECONOMICS

An average yield of under Irrigated condition 1500-1600 kg leaves + 500-700 kg pods and Rainfed condition 1000-1200 kg leaves + 300-400 kg pods yield of Senna per ha, which dry leaves and pods estimated costs Rs. 40-45/kg. It can be sown twice a year during Rabi September-October and Kharif February-March. The crop matures within a 3-6 months period. As per some estimates, farmers can earn a gross profit of Rs. 76,000/- from a hectare of land, and the net profit is around Rs. 57,000/Ha.

Senna leaves and pods yield	:	Irrigated: 1500-1600 kg leaves + 400-500 kg pods Rainfed: 1000-1200 kg leaves + 300-400 kg pods
Market price ₹@	:	40-45/kg
Gross returns	:	72000-76000/-
Cost of cultivation	:	15000-20000/-
Net return (per ha)	:	56000-57000/-

FUTURE PROSPECTS

1. The medicinal uses of Senna are innumerable, and its value as a laxative crop is significant. The genetic up-gradation process in Senna cannot be ended until and unless it can meet the ever-increasing global demand for sennoside A and sennoside B. The genetic up-gradation process needs to be continued to develop varieties rich in sennoside A and sennoside B content. At

present, the indigenous Senna germplasm has a very narrow genetic base; we need to concentrate on broadening its genetic base through the intervention of the above strategies. The prospects of mutation breeding and Molecular markers have proved helpful in creating genetic variability, and the development of varieties rich in specific sennosides with high yield needs further efforts to enhance the total content.

2. The Senna is highly sensitive to varied environmental conditions. Although a few high-yielding varieties have been developed, the development of photoperiod insensitive, stable and adaptable types for different climatic conditions are still required.
3. The Senna crop is susceptible to caterpillar insects and other diseases caused by biological agents. The urgent need to development of multiple disease-resistant varieties is another major challenge in Senna. Very few studies have been done on this aspect, so further studies are required to develop resistant varieties in Senna against insects, pests, fungus, bacteria, etc., which cause severe damage to the crop.
4. Nowadays, the essential factor is to Reduce/minimize the gap between the producer and the buyer. So, there is an urgent need to develop cost-effective value-added products processes to export them instead of exporting crude drugs (leaves and pods).
5. The special cultivation program may be extended to ensure the supply of legitimate, authentic and specific seed material/varieties developed by different research laboratories for Senna commercial cultivation.

6. Successful pilots involving Senna cultivation, processing and marketing must be evolved, up-scaled and out-scaled. Successful contract-farming methodologies with buy-back assurance for small farmers need replication in different agro-climatic conditions.

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