The prospects and potential of the horticultural and pharmacological medicinal herb senna (Cassia angustifolia Vahl.): A review

R.K. Lal1, C.S. Chanotiya2 and A. Kumar1

Abstract
The dried leaves and pods of Cassia L., a member of the Caesalpinioideae subfamily of the Fabaceae family and the Cassiinae sub-tribe are called “senna drug”. The drug is known by the names Senna, Indian Senna, Tinnevelly Senna, and Cassia Senna in the Indian, British, and American pharmacopoeias. It appears to be native to North Africa. Sennoside A and B, anthraquinone glycosides responsible for the plant’s laxative effects, are found in the leaves, pods, and seeds, which are the plant’s most valuable parts. The plant grows as a perennial in the dry regions of Somalia, Ethiopia, Sudan, Egypt, Southern Arabia, and neighboring countries. Through the Medical School Salerno and the writings of Arab Physicians, it was first introduced into Europe in the twelfth century. Cassia acutifolia, or senna as it became known in English, is found in tropical North Africa’s Northern Sudan, Egypt’s Upper Nile, and some areas of Ethiopia. Sena alexandrina was born in Yemen, the Saudi province of Hadramgoun, and some areas of Sind (Pakistan). It is, however, common along the Gujarat coast, particularly in the Mundra coastal tract and Aigal near Bhuj in the Kutch area of India. The plant must have, at some stage, been transported from its native North Africa to India. It is believed that it was originally used in Tirunelveli, an area of Tamil Nadu, sometime around the middle of the eleventh century. The plant has become a native in India throughout the years. It is grown in semi-arid regions of Gujarat, Rajasthan, and Tamil Nadu (Thirunelveli, Ramanathapuram, Madurai, Salem, and Tineichirapalli). Sena alexandrina is a tiny, obuse-branched perennial shrub that grows to 60−75 cm. Large, compound, pinnate, 5−8-gugate, oval-lanceolate, plebrous, bluish-green to pale green, lamina 2.5−6 cm long, 7−8 mm broad, acutely apical leaves. It typically blooms after 65 to 70 days. Bright yellow, axillary (or subterminal), many erect racemes with membranous bracts have bright yellow flowers. Legumes are flat, 15−17 mm wide, with compressed, obovate, and cuneate seeds. Compared to Cassia angustifolia, Cassia acutifolia has smaller, thinner-consistency leaves and pods. Some taxonomists combined these two species into a single taxon called Cassia senna. Senna is taken orally as a tea, pill formulation, or powder encapsulated to relieve intestinal constipation. Senna has been the subject of several reviews; however, we focus on the most recent facts to be updated rather than previous review papers. Senna’s origin, botany and taxonomy, agriculture, genetic advancement, cytogenetics, mutation breeding, diseases and pests, pharmaceutical significance, microbiological activities, etc. were thoroughly reviewed. A brief review of available cytogenetics, genetic advancement, and agricultural technology was also addressed.

Introduction
Cassia angustifolia Vahl., also known as Senna, is a flowering plant species that belongs to the family Fabaceae. It is native to East Africa and the Arabian Peninsula but is now widely cultivated in many parts of the world, including India, Pakistan, and Sudan. This plant is a shrub or small tree that can grow up to 2−3 meters tall, with long, narrow leaves and yellow flowers. The leaves are compound, with 4−8 pairs of leaflets 1−3 cm long and 0.2−0.5 cm wide. The flowers are arranged in clusters at the end of the branches and are about 2 cm in diameter. The botanical species referred to as “senna” is employed today and in the past as stimulating laxatives in pharmacopoeia. There were roughly 330 Cassia species; about 300 of them had been assigned to the genus Senna due to evolutionary relationships, while about 30 were still classified as Cassia1: For instance, three related genera Senna Mill. (13 species), Chamaecrista Moench. (three species), and Cassia L. (seven species) were reclassified from 23 Sudanese Cassia species2. Regarding the Senna group and which species is a true Senna, the literature is rather ambiguous. Sena alexandrina Mill3, is the name of the plant that is referred to in the United States as “senna”. This is puzzling because Sena alexandrina is still widely referred to as Cassia angustifolia, Cassia acutifolia, and Cassia senna. The European Pharmacopoeia still regards C. angustifolia and C. senna as separate species, each with unique geographic origins, morphologies, quality and grade designations, and active principle contents4−9. As a result, the two species will be described in this article using their Latin pharmacopoeial and trade names10−15. Other varieties of senna that are used as medicines are not covered in this article, including American Senna (C.marilandica), which was once listed in the United States Pharmacopeia (USP)16−18. Senna, also known as Indian senna or Tinnevelly senna, has been used for medicinal purposes since ancient times and is now recognized by Indian, British, and American pharmacopeias19−21. The economic sections of the plant contain dianthrone glycosides (sennosides A, B, C, D, etc.), free anthraquinones (aloem-edomin, chrysophanol, rhein), and anthraquinone glycosides, as well as anthraquinone glycosides.
Sennod B, present in more significant amounts, provides laxative effects via two mechanisms: enhanced intestinal fluid transport and increased intestinal motility. The sennoside content varies between leaves and pods from 1.5% to 3.5%. The variation in herbal constituents may be due to harvest seasons, plant origins, drying processes, and developmental stages. Senna is used as a diuretic and a treatment for skin diseases, jaundice, and liver disorders. The leaves are collected when the plant is about two years old, and the pods are collected when they are ripe. After harvesting, the leaves and pods are dried in the sun and then stored in a cool, and dry place until they are ready for use. It is vital to use senna as directed, as excessive use can lead to abdominal cramps, electrolyte imbalances, and dependence. In addition to its medicinal benefits, senna is also used as a natural dye and in the production of paper. The plant is a good source of tannins used for tanning leather and in the production of ink. The pods are also used as a natural dye for fabrics, producing a yellowish-brown color. The plant is also used in traditional medicine for several other purposes, such as the treatment of diabetes and cancer. Aside from its medicinal uses, senna also has some ornamental value due to its attractive yellow flowers and feathery foliage. It is occasionally planted as an ornamental shrub in gardens or used in landscaping projects.

Overall, senna is a versatile plant that has many uses, including medicinal, industrial, and ornamental purposes. Its natural laxative properties make it a popular choice for treating constipation and promoting regular bowel movements. However, it is important to use it under the guidance of a healthcare professional to avoid any adverse effects.

Origin and dissemination of Senna

The plant (Cassia angustifolia) seems to be a native of North Africa. It grows wild as a perennial in the arid tract of Somalia, Ethiopia, Sudan, Egypt, Southern Arabia, Jordan, Iran, Qatar, Yemen, Sultanate of Oman, and the United Arab Emirates. It was initially introduced into Europe through the Medical School Salerno and the works of Arab Physicians. As it became known in English, Senna became The perfect reliable purge and the most popular cleanser today. Khan et al. discovered growing wild senna in the Arabian Peninsula, now known as Saudi Arabia. Senna alexandrina originated in Yemen, the Hadramaut province of Saudi Arabia, and Somali land. However, this species is naturalized in Gujarat (Mundra coastal tract and Aijal near Bhuj in Kutch region), India, and in Sind and North-West Pakistan. Over the period, the species naturalized in India and cultivated in semi-arid parts of Tamil Nadu, Ramanathapuram, Madurai, Salem, Tiruchirappalli, Karnataka, Rajasthan (Jodhpur, Jaisalmer, Barmer, and Jaisalpur) and Gujarat. Cassia angustifolia Delle is distributed in tropical North Africa in Ethiopia, Northern Sudan, Upper Nile, and Egypt.

Taxonomy

Senna belongs to the genus Cassia, subtribe Cassiinae, tribe Cassieae, subfamily Caesalpinioideae, family Fabaceae, order Fabales, subclass Rosidae, class Magnoliopsida, division Magnoliophyta, and kingdom Plantae. Taxonomic classification based on morphological traits is complex, and boundary shifting reported. The genus Cassia was originally treated as a large, widespread, diverse genus characterized by distinctive floral morphology, including species with enantio stylos, asymmetric flowers, and extra floral nectarines. It is a heterogeneous and sole representative of the subtribe Cassiinae.

Cytogenetics

Darlington and Wylie listed three basic chromosome numbers of x = 6, 7, and 8, and parenthetically a secondary basic number of x = 13. Irwin and Turner suggested a basic chromosome number for the genus Cassia x = 7. The other basic chromosome numbers (x = 6, x = 8) have been derived by aneuploid either through the loss or gain of one chromosome. Cumulative worldwide cytological data revealed that Cassia is a multibasic genus with x = 6, 7, 8, 10, 11, 13, and 15. However, all Indian species so far investigated show x = 6, 7, and 8. It is suggested that the species with x = 14, the most successful number in the genus, may be of polyploidy origin from x = 7. It is suggested that the basic number of chromosomes is x = 14 and 2n = 28. Indicated that the basic number of Cassia angustifolia is x = 14.

Genetic improvement

Senna contains 2n = 28 chromosomes. It is predominantly self-pollinated. Plants have a mechanism imposing self-fertiliza-
The horticultural and medicinal herb Senna

Table 1. Some medicinally important Cassia species found in India

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Botanical name</th>
<th>Place/origin</th>
<th>Place/origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cassia italica sub. species italica</td>
<td>Tenkukillum Asour</td>
<td>Tenkukillum Asour</td>
</tr>
<tr>
<td>2.</td>
<td>C. officinalis sub. species micrantha</td>
<td>Tenkukillum Asour</td>
<td>Tenkukillum Asour</td>
</tr>
<tr>
<td>3.</td>
<td>C. officinalis sub. species micrantha</td>
<td>Tenkukillum Asour</td>
<td>Tenkukillum Asour</td>
</tr>
<tr>
<td>4.</td>
<td>C. officinalis sub. species micrantha</td>
<td>Tenkukillum Asour</td>
<td>Tenkukillum Asour</td>
</tr>
<tr>
<td>5.</td>
<td>Cassia italica sub. species italica</td>
<td>Sanguluna (Tinnvely)</td>
<td>Sanguluna (Tinnvely)</td>
</tr>
<tr>
<td>6.</td>
<td>Cassia accidentialis</td>
<td>Sanguluna (Tinnvely)</td>
<td>Sanguluna (Tinnvely)</td>
</tr>
<tr>
<td>7.</td>
<td>Cassia accidentialis</td>
<td>Sanguluna (Tinnvely)</td>
<td>Sanguluna (Tinnvely)</td>
</tr>
<tr>
<td>8.</td>
<td>Cassia accidentialis</td>
<td>Valliloor Tirunelvello</td>
<td>Valliloor Tirunelvello</td>
</tr>
<tr>
<td>9.</td>
<td>Cassia accidentialis</td>
<td>Ramnathpurum</td>
<td>Ramnathpurum</td>
</tr>
<tr>
<td>10.</td>
<td>Cassia italica sub. species italica</td>
<td>Marimadmum</td>
<td>Marimadmum</td>
</tr>
<tr>
<td>11.</td>
<td>C. officinalis sub. species micrantha</td>
<td>Asoor</td>
<td>Asoor</td>
</tr>
<tr>
<td>12.</td>
<td>Cassia uniflora</td>
<td>Kaamthapanai</td>
<td>Kaamthapanai</td>
</tr>
<tr>
<td>13.</td>
<td>Cassia italica sub. species italica</td>
<td>Kaamthapanai</td>
<td>Kaamthapanai</td>
</tr>
<tr>
<td>14.</td>
<td>C. officinalis sub. species micrantha</td>
<td>Kaamthapanai</td>
<td>Kaamthapanai</td>
</tr>
<tr>
<td>15.</td>
<td>Cassia auriculata</td>
<td>Kaamthapanai</td>
<td>Kaamthapanai</td>
</tr>
<tr>
<td>16.</td>
<td>Cassia italica sub. species italica</td>
<td>Ramnathpurum</td>
<td>Ramnathpurum</td>
</tr>
<tr>
<td>17.</td>
<td>Cassia italica sub. species italica</td>
<td>Ramnathpurum</td>
<td>Ramnathpurum</td>
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<td>18.</td>
<td>Cassia uniflora</td>
<td>Ramnathpurum</td>
<td>Ramnathpurum</td>
</tr>
<tr>
<td>19.</td>
<td>Cassia uniflora</td>
<td>Ramnathpurum</td>
<td>Ramnathpurum</td>
</tr>
<tr>
<td>20.</td>
<td>Cassia nigrica</td>
<td>Ramnathpurum</td>
<td>Ramnathpurum</td>
</tr>
</tbody>
</table>

Table 2. Some species of Cassia having anthraquinone derivatives, their origin, and chromosome numbers

<table>
<thead>
<tr>
<th>Species</th>
<th>Place of origin</th>
<th>2n chromosome numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. alata Linn.</td>
<td>Cosmopoliton tropical</td>
<td>12, 24, 28</td>
</tr>
<tr>
<td>C. angustifolia</td>
<td>Africa tropical</td>
<td>14, 16, 28</td>
</tr>
<tr>
<td>C. auriculata Linn.</td>
<td>Indian orientalis</td>
<td>14, 28</td>
</tr>
<tr>
<td>C. fistula</td>
<td>India orientalis</td>
<td>16, 28</td>
</tr>
<tr>
<td>C. laevigata Wildl.</td>
<td>Cosmopoliton tropical</td>
<td>26, 28</td>
</tr>
<tr>
<td>C. obovata Collad.</td>
<td>Geront tropic</td>
<td>28</td>
</tr>
<tr>
<td>C. javanica Linn.</td>
<td>Malaya</td>
<td>28</td>
</tr>
<tr>
<td>C. mimosoides Linn.</td>
<td>Cosmopoliton tropical</td>
<td>16, 32</td>
</tr>
<tr>
<td>C. nodosa Buch-Ham. ex Roxb.</td>
<td>Asia tropical</td>
<td>24</td>
</tr>
<tr>
<td>C. occidentalis Linn.</td>
<td>Cosmopoliton tropical</td>
<td>26, 28</td>
</tr>
<tr>
<td>C. renigera Wall. ex Benth.</td>
<td>Burma</td>
<td>24</td>
</tr>
<tr>
<td>C. roxburghii D.C.</td>
<td>Indian orientalis</td>
<td>24, 28</td>
</tr>
<tr>
<td>C. siamea Lam.</td>
<td>Indian orientalis, Malaya</td>
<td>26, 28</td>
</tr>
<tr>
<td>C. sophera Linn.</td>
<td>Geront tropic</td>
<td>24, 28</td>
</tr>
<tr>
<td>C. tora Linn.</td>
<td>Cosmopoliton tropical</td>
<td>26, 28, 52</td>
</tr>
</tbody>
</table>

Table 3. Scientific classifications of Senna

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Plantae</th>
<th>Synonyms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clade</td>
<td>Tracheophytes</td>
<td>Cassia acutifolia Delile</td>
</tr>
<tr>
<td>Clade</td>
<td>Angiosperms</td>
<td>Cassia alexandrina (Garsault) Thell.</td>
</tr>
<tr>
<td>Clade</td>
<td>Eudicots</td>
<td>Cassia angustifolia M. Vahl</td>
</tr>
<tr>
<td>Clade</td>
<td>Rosids</td>
<td>Cassia lanceolata Collad</td>
</tr>
<tr>
<td>Species</td>
<td>Senna</td>
<td>Cassia latifolia Bisch</td>
</tr>
<tr>
<td>Species</td>
<td>S. alexandrina</td>
<td>Cassia senno L.</td>
</tr>
<tr>
<td>Genus</td>
<td>Senna</td>
<td>Cassia acutifolia (Delile)</td>
</tr>
<tr>
<td>Genus</td>
<td>Senna</td>
<td>Cassia alexandrina</td>
</tr>
<tr>
<td>Genus</td>
<td>Senna</td>
<td>Cassia angustifolia (Vahl)</td>
</tr>
</tbody>
</table>

Botanical name: Senna alexandrina

Mill.

C. lanceolata Pers. is a synonym of Chamaecrista desvauxii var. mollissima
C. lanceolata Link is a synonym of Senna sophora var. sophora

tion - a form of chasmogamy, and pollination takes place before flowers open[46,49]. However, Gupta and Pareek[27] reported a relatively large percentage (%) of cross-pollination done by the beetles. The flowering duration is quite long (range). The pollen grains are triangular, smooth, 2.8 to 4 mm, and highly fertile (98%). Flowering lasts 35−40 days[47,50−52]. The nature and spectrum of existing intra-specific variability are limited due to the self-pollinating nature of the crop. Pandse et al.[53] analyzed the senna collections from different parts of India, but they needed assistance identifying significant variations among them. There was a lack of intraspecific variability, possibly due to limited cross-pollination[21].

In the senna plant, high heritability has been observed for fresh and dry leaf weight, plant height, total pod production, and sennosides concentration[45,50]. According to Sankararayanan and Muthuswamy[56] and Singh et al.[57], the leaflet significantly contributes to dry leaf yield at the genotypic level. Sennoside content in senna has been subject to mutagenic-induced variability, as demonstrated by Khalatkar and Bharagava’s[58] investigation. South India has been cultivating the introduced Arabian genetic stocks with little variation for more than 150 years. From existing variability, Gujarat Agricultural University has developed two late flowering varieties for leaf yield through selection after several generations. Forty accessions collected from different parts of India were evaluated for genetic divergence and grouped into seven clusters[17,52]. Accession-wise, distinct identities were recommended for a hybridization program for recombination breeding. High sennosides leaf-yielding and widely adapted variety ‘Sona’ was released and commercialized by the CSIR-CIMAP, Lucknow[59] (Fig. 1a–d).

Agro-technology

Soil and climate

Senna grows well in sandy loam and laterite soils with low to moderate fertility but mainly on red loam, including gravelly coarse soils, alluvial loams, and rich clayey rice fields. The crop can be grown in soil with a pH range of 7.0−8.5. Senna requires dry weather with moderate temperatures. In Northern India, it is a 130−150 day summer crop, but in Southern India, it is a winter crop. It is also grown successfully as a perennial crop for
leaf yield in the hot arid conditions of Rajasthan, India, where the temperature is around 45 °C from May to June.

Crop stand in saline soil is poor but, once established, can withstand moderate saline conditions with yield reduction\(^{27}\). Deep sand (≥ 1 m) and dunes have been found suitable for their long taproot development and good branching\(^{60}\). The saline-alkali or water-logged soils are unsuitable for cultivation. Early Kharif sown crop produces luxuriant growth and remains in the field for 130–150 days. It allows three pickings of leaves and pods\(^{61}\). Plants shed leaves during the winter and, if not removed, ultimately die in the field.

**Sowing**

Seeds are used to grow commercial crops. Because sowing dates are specified, flowering and pod formation does not coincide with the monsoon season. In Northern Central India, the crop is grown after winter harvest and is sown in February–March. In Western and Central India, it is sown in July–September. In Southern India, crops are grown in two seasons: rain-fed crops are sown with the onset of the northeast monsoon in September–October and irrigation-supported crops are sown in February–March\(^{27}\).

The seed rate is about 30 kg/ha for the rain-fed crop and 15 kg/ha for the irrigation-supported crop\(^{53,62−64}\). Dry or presoaked seeds are generally broadcasted in prepared fields. It may also be drilled in rows, and the distance between rows is 30–50 cm. Seeds are placed at a 1.5–2 cm depth using a tractor-driven mechanical device. The deeper-placed seeds fail to germinate. Light irrigation is given in case of a prolonged dry spell after sowing to ensure timely and uniform germination\(^{62}\). Depending upon soil moisture, seeds germinate within 7–10 days. Since the seeds have a hard seed coat, a certain amount of rubbing of its surface by pounding the seeds lightly with coarse sand in a mortar is desirable to induce quick germination. Presoaking for 10–12 hrs improves germination by up to 90%\(^{65}\).

Seed treatment with fungicide, optimum sowing time, seeding depth, and soil moisture are essential to obtain the desired production level. A 12–15 kg/ha seed rate with 70%–80% germination produces a population of 70–75 thousand plants/ha, the desired level for economic yield\(^{66}\). The crop may be thinned after 30–35 days post-sowing to maintain the plant-to-plant distance of 30 cm. Seeds may be sown in dry conditions even in June in areas like undulated land and dunes /deserts in the arid zone. The seeds germinate after rain. In agro-climatic situations, the plant becomes perennials and gives commercial produce for 4 to 5 years. The crop hardly requires weeding and pest management, which reduces the use of hazardous agrochemicals and saves the environment. The plant can survive at low moisture, where pathogen incidences are minimal. Seed treatment with fungicide protects the seedlings from damping-off and seedlings blight. The irrigated crop produces a higher yield with superior quality.

**Fertilizer**

Senna is a leguminous plant, but it doesn’t develop nodules that fix nitrogen from the air. Generally, it thrives on the residual nutrients of a previous cereal crop. The general recommendation of fertilizer for obtaining economic yield is 80:40:20 kg/ha N (nitrogen) P (phosphorus) K (potash). Nitrogen application should be divided into four doses and applied after sowing, thinning, and first and second pickings\(^{67}\). The moderate use of organic manure is beneficial in rain-fed cultivation. However, trials conducted in different parts of India have shown that depending upon the growth, the number of pickings, residual moisture, fertility status, and growing conditions, the crop can utilize 50–100 kg of N, 20–50 kg of P\(_2\)O\(_5\) and 24–30 kg of K\(_2\)O/ha in a growing period of 130–150 days\(^{68}\). The use of potash can be avoided in potash-rich soils of North-Western India. Basak and Gajbhaye\(^{69}\) discovered that RP-charged compost was quite effective in boosting senna herbage yield and was comparable to Di-ammonium Phosphate (DAP) fertilizer.

**The ascendency of hydrogel doses on the growth and yield parameters on senna**

According to Jnanesha et al\(^{70}\), hydrogel is essential for increasing soil absorption capacity and water retention, lowering water shortage, and reducing the negative consequences of drought. While there were no statistical differences in bulk density or porosity amongst hydrogel dosages, bulk density differed considerably from the control and starting values.

**Irrigation and intercultural operations**

Senna is a rain-fed crop, but 5–6 irrigations in North India increase the herb yield. An average distributed rainfall of 24–40 cm is sufficient. In the early growth of plants, two to three weedicings are adequate to raise a good crop. Once the crop attains 20 to 24 cm height, it suppresses weed growth. As an irrigated crop, two weeding-hoeing is done, each after the first and second pickings\(^{50,62−64}\).

**Crop rotation and intercropping**

In Southern India, irrigated senna is grown after the paddy as intercrop cultivation in between rows of chilies, brinjal (Solanum melongena L.), okra (Abelmoschus spp.), and tomato (Lycopersicon esculentum Mill.). In the Northern plains of India, senna-mustard and senna-coriander rotations produced higher income, proving superior to other rotations. As a 130–150 days crop, senna fits nicely as a Kharif crop in Southern, Central, and Western India\(^{67}\). This crop has been introduced to the dense population in the agroforestry program to cover the newly reclaimed lands in Egypt\(^{71−73}\). The wild-growing populations in these countries are stripped of their leaves and pods. Crop harvested in September (rainy season) produces a higher yield than those harvested in April (dry season)\(^{69}\).

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**Fig. 1** (a) Senna (Cassia angustifolia) var. ‘Sona’, (b) and (c) seeds, (d) pods.

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\(^{27}\) **In Press.** Cassia aungustifo-
The horticultural and medicinal herb Senna

Senna can be propagated in the arid region’s Silvi-herbal system. Even in extreme drought conditions, when other crops fail, farmers and residents receive constant economic returns. Silvi-herbal activities can be a part of an alternative and viable land-use strategy in dry climates.

Harvesting

Six to seven fresher leaves with elliptical, deep green broad leaflets have been shown to have a higher sennoside concentration and are hence more valuable. The initial picking should take place between 70 and 90 days after planting, when the sennoside concentration is at its greatest, to obtain the appropriate biomass level. The majority of the growing tips are removed by hand picking, which promotes more leafy growth and delays flowering. While the final selection takes 130–150 days, the second picking takes 90–110 days. The last harvesting includes entire plants (leaves and pods). The produce is sold by weight. Leaves containing ≥2% and pods with ≥2.5 sennoside are acceptable to the industries. The collection of young leaves and pods does not fully compensate for the loss in weight at harvest. Hence, mature leaves are picked in the first and second pickings, whereas the third picking consists of remaining leaves and pods (of all age groups). In the case of pods, the collection at 15 to 24 days of age strikes a balance between weight and content. There is a decrease in sennoside content in the older pods because of high fiber content.

Since the leaf is the preferred crude drug in Europe as an herbal tea ingredient, its yield can be increased up to 75% at the expense of pod yield through defoliation at the 40–60 days stage, which delays the reproductive phase and induced leaf growth. Growth, dry matter yield, and sennoside content are increased by the six-weekly spray of 50–500 IBA at the two to three-leaf stages, but this was not realized in field conditions.

The crop is grown as a perennial in the arid zone and harvested from 5−10 cm above the ground. The crop blooms three times a year; thus, three harvestings can be done. The best times for harvesting are the second fortnight of October, February, and May. October cutting should not be delayed because Senna is susceptible to cold.

Yield

Except for seeds, almost all parts of the plant contain sennosides. Besides leaves and pods (rich in sennosides), the peduncle, rachis, and stem bark have 2.73%, 2.89% and 1.92% of total sennosides, respectively. Under irrigated and appropriate management conditions, a good crop of senna can produce 15 q/ha of dry leaves and 7 q/ha of pods. Under rain-fed environments, leaves yield is about 10 q/ha, and pod yield is about 4 q/ha. The irrigated crop is considered superior quality and fetches a higher market price. Senna is generally received in the market during June, July, and August.

On the contrary, a significant part of the rain-fed crop, which is poor in appearance, is collected from February to March. The yield of dry herbs may be increased with an increase in spacing or number of plants/hills. Three plants/hill at a distance of 30 cm in rows significantly increased the yields of dry pods. A 15q/ha yield can be obtained if the crop is grown for seed.

Drying and storage

After harvesting or collecting senna leaves and pods from wild-grown plants, they are usually preferable to dry in the Sun for 4 to 6 hours and then shade dry in a thin layer in well-ventilated sheds. The drying process takes 4 to 5 days.

Seed

At the dough stage, collect the seed and dry it properly. Ripe seeds should be light yellow to yellow. Crops grown for quality seed production should not be collected for crude drug manufacture.

Diseases and pests

Senna is tolerant to the most common fungi and pests. Plants are protected from infection by hot and dry growing conditions. According to Gupta and Pareek, die-back is the fungus-caused shedding of leaves and stems that turn black. The three main diseases that affect senna are damping-off (Rhiizoctonia bataticola), leaf spot (Cercospora spp.), and leaf blight (Phyllísticta spp.). Seed treatment with Thiram/Captan (2.5 kg/ha) and the fortnightly spray of 0.15% solution of Diathan-M-45 can control the diseases. However, chemical fungicide spray should be avoided to protect the quality of the drug. White angled sulphur (Antos clorinde) of senna is a pest that damages senna plants’ leaves and significantly impacts leaf yield.

Chemical compositions and their estimation

The use of senna as a laxative dates back to the 9th or 10th centuries, long before the chemistry of a chemical was known. Kirtikar and Basu listed the usefulness of the senna plant in treating liver complications, abdominal troubles, loss of appetite, spleen enlargement, dyspepsia, jaundice, anemia, fever, rheumatism, tumors, bronchitis, skin diseases, and poisoning. However, many researchers have investigated the plant’s laxative properties. The purgative drug is the chemical anthraquinone from rubarb, aloe, senna, and cascara (Fig. 2a–d). This was identified as glycosides. Additional research indicated that natural products also contain reduced anthraquinone derivatives (oxanthrones, anthrals, and anthrones) and dianthrones, compounds generated by the union of two anthrone molecules (Fig. 2a–d). Tutin was the first to identify and isolate aloe-emodin and Rhein (aglycones) from senna leaf, and the number of compounds found grew. Stoill discovered two active crystalline glycosides, sennoside A and sennoside B, which generated glucose and the aglycones sinnidin A and sinnidin B when hydrolyzed.
active elements comparable to leaves but in greater concentrations. Alexandrian Senna and Indian Senna can be distinguished by 6-hydroxymusizin and tinnevellin glucosides, respectively. Many chemicals include sennoside C and D, palmidin A, rhein-anthrone 8-glycoside, rhein 8-diglycoside, aloe-emodin 8-glycosides, aloe-emodin-anthrone-glycoside, rhein-1 glucose, emodin-8-0-glucoside were isolated [80,81]. Some of the compounds were found to be pharmacologically active. Besides sennosides and other flavonoids as mentioned earlier, isorhamnetin and kaempferols as glycosides (kaempferin) are also present in senna leaves [80,81]. Leaves also contain 7% mucilage. Roots contain physcion, physcionin, chrysphain, and sennadin C. Pharmacologically, the most active constituents in senna are sennoside A and B (Fig. 2a−d), dianthrones (dimer) of the anthrone skeleton.

Senna's fresh leaves include glycosides that contain extra sugar groups. These are naturally degraded to sennoside A and B. Lamili et al. [80] identified two naphthalene glycosides from Alexandrian and Indian senna leaves, namely 6-hydroxy musizin and tinnevellin (Fig. 2a−d). In sensitive senna plants, chrysophanol is the first anthraquinone to develop. Through successive oxidation of the 3-methyl groups of chrysophanol, the ontogenic sequence was in close agreement with the biogenetic order, resulting in aloe-emodin, emodin, and eventually rhein. Thus ontogenic sequence was in close accord with the biogenetic order. Later, glycosylation occurs in the presence of light, and the glycoside is produced and translocated to various body areas. Flowers have the most considerable quantities (> 4%), followed by leaves (> 2%) and fruits (> 2%), with roots and stems having the lowest concentrations [82−84].

Sennosides do not occur in living plants. However, sennosides are formed after dehydration of leaves by rapidly warming at 60 °C (dried within a few hours) and allowed gradually to lose water at room temperature. The degree of water loss in leaves and the number of sennosides formed are strongly associated [85−87]. Aflatoxins, secondary metabolites of Aspergillus flavus Link and A. parasiticus, sometimes are associated with senna pods, which are highly toxic and carcinogenic to mammals. Müller and Basedow [88] reported that the leaves and flowers of senna were usually free from aflatoxins. Still, pods may contain 2 µg/kg to 245 µg/kg against the tolerable limit of 2 µg/kg for aflatoxin B1 and 4 µg/kg for the sum of aflatoxins B1, B2, G1, and G2 (fixed by the European Union). Aflatoxin content in pods is doubled in the controlled Sun drying and increased by four times in shade drying.

Sennosides A to D are the purgative sennosides among the known sennosides [89−90]. For estimating the presence of sennosides and their quantification, many isocratic HPLC methods without perfect baseline resolution have been described. A simple liquid chromatographic method was developed to...
Long-term continuous use of sennosides may cause spasmodic gastrointestinal problems, cardiac arrhythmias, nephropathies, edema, accelerated bone deterioration, teacyan, aspartyl glucosamine secretion, hypogamena globulinemia, and hypokalemia caused by lesser electrolytes (especially potassium). Contradiction to earlier belief is that pregnant and lactating women should not use senna because it is a “stimulant laxative” of choice during pregnancy and lactation. Sennosides did not stimulate uterine motility in pregnant ewes. Further, the absence of abnormal stool consistency in infants breastfed by a senna laxative-ingesting mother was observed. In contrast, Faber et al. recommended taking non-standardized laxatives during pregnancy. Anthraquinone purgatives in excess may cause the degeneration of neurons and may be genotoxic or have a carcinogenic risk for the man. Heidemann et al. showed that an extract of senna and aloe-emodin was genotoxic and examined in vitro. However, the effect of the drug fructus senae under in vivo conditions has not been reported. The sennosides and rhein were negative under in vitro and in vivo conditions.

The high dose of long-term daily use of sennoside and dianthrone in the ascending and descending colon decreases maximal contraction. The finding that continuous treatment with androids had no aberrant motility pattern except a residual pharmacological activity 48 hours after the last high dosages were similar to sensitivity to rhein, an active metabolite of sennosides. Treatment with sennoside did not affect the serum aldosterone level and mucosal Na⁺/P⁵⁺-ATPase activities in the small intestine and colon. Further, despite chronic diarrhoea over six months, there were no signs of habituation or secondary hyperaldosteronism due to sennosides or dianthrone. The higher average number of aberrant crypts per focus can predict tumor outcomes when the rats were treated with the highest dose of glycosides and the 1, 2-dimethyl hydrazine (DMH) than DMH alone. This suggested that senna and cascara glycosides might be weak promoters in rat colon carcinogenesis. Anthroid laxatives induced apoptosis of colonic epithelial cells in men within 6 hours after ingestion. Rhein, the active metabolite of sennoside laxative, is a cytotoxic substance capable of producing apoptosis and works as a substrate for the MR1 (Multiple drug resistance-associated protein 1) drug efflux pump. This cytotoxicity has nothing to do with topoisoasemase II or DNA intercalation. The ability to extrude the anthranoid laxative may be vital for protecting the epithelium. It would be interesting to look at MR1 levels in chronic anthranoid laxative users. MR2 expressions are linked to a lower incidence of colon cancer in anthranoid laxative users, while MR1 mutations or polymorphisms may also play a role. Continuous usage of senna laxatives was linked to severe symptoms such as fluid and electrolyte loss and chronic diarrhoea. Severe hepatotoxicity is infrequent. It could, however, be explained by the liver being exposed to hazardous anthraquinone glycoside metabolites in high quantities. According to an objective causality assessment, hepatotoxicity may have been linked to using senna laxatives. According to the experimental model, anthraquinone derivatives may accumulate in the kidneys and produce nephrotoxicity. Studies on the antimutagenic and genotoxic potentials of aqueous senna
extracts (SAE) in a cell-free system have single and double-strand breaks in plasmid DNA.

Nonetheless, they are not cytotoxic or mutagenic to Escherichia coli strains\[123\]. In effect, SAE can protect Escherichia coli IC 203 (nvrAOXYR), and IC 205 (nvrAmut M) strains from H2O2-induced mutagenesis and toxicity, pointing to a new antioxidant/antimutagenic function of SAE. Senna-containing laxatives accidentally ingested by young children can cause severe diaper rash, blisters, and skin sloughing\[126,127\].

Overall, senna is an important crop plant with a wide range of medicinal and other uses. While it is primarily used for its laxative properties, it also has potential for use in other areas, such as natural dyeing and paper production. As with all medicinal plants, it is important to use senna responsibly and under the guidance of a healthcare professional.

Conclusions

Senna, known since 1600 BC, is the unique drug for the animal kingdom in modern and traditional systems of medicine with little or more toxicity to the human being. Its chemical constituents, structures, and pharmacological and toxicological features have all been extensively investigated. The uniqueness of the drug is due to its chemical components, mainly anthraquinones glucosides. Bacteria in the colon convert these molecules to rhein-anthrone, which has two effects. It does two things: first, it stimulates colon activity, which speeds up bowel movements, and second, it promotes colon fluid secretion, which helps to prevent persistent constipation, which is a significant human health risk. Genetic studies that serve as the foundation for understanding the genetic diversity and developing superior varieties, such as having increased sennoside content on consistent quality, have yet to receive much attention.

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Conflict of interest

The authors declare that they have no conflict of interest.

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References

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accessions of ashwagandha. *Nucleus* 423:1–9


73. Arya R. 2003. *Yield of Cassia angustifolia* in combination with
three different species in a silvi–herbal trial under hot arid condi-
tions in India. Bioscience 86(2):165–69
74. Bhatia RK, Lohar DR, Chawan DD, Garg SD. 1978. Chemical con-
77. Tutin F. 1913. Chemical Society 103: 2006–23
78. Stoll A, Becker B, Kessmaul W. 1949. The isolation of anthraglyco-
sides from senna. Helv Chim Acta 32:1892–903
glycosides in Cassia senna and Cassia angustifolia. Planta Med
43(1):11–17
82. Erni F, Frei RW. 1978. Two –dimensional column liquid chromato-
graphic technique for resolution of complex mixture. J Chromat A 149:661–69
83. Frahm-Leliveld JA. 1960. Chromosome numbers in leguminous 
84. Verma RK, Unijal GC, Singh SP, Sharma JR, Gupta MM. 1996. 
Reversed-phase high-performance liquid chromatography of 
Cassia angustifolia. Phytochem Anal 7:73–75
85. Labadie RP. 1970. The anthracene derivatives in Rhamnus fran-
gula L. I. The aglycones. Pharm Webl 105:189–95
86. Auterhoff H, Scheriff FC. 1960. Dianthenes of pharmacologically
important hydroxyanthraquinones. Arch Pharm 293(65):918–24
88. Muller P, Basedow T. 2007. Aflatoxin contamination of pods of 
Indian Cassia senna L. (Caesalpinaceae) before harvest, during 
drying and storage: Reasons and possible methods of reduction. 
Metabolism of sennosides by human intestinal bacteria. Planta
Med 40(3):225–36
of sennoside C on purgative activity of sennoside A in mice. Planta
Med 42(3):302–3
for the analysis of sennosides in Cassia angustifolia by high-
92. Sun Y, Li X, Yu X. 2004. Determination of sennosides and 
degraded products in the process of sennoside metabolism by 
HPLC. Se Pu. 22(1):48–50
graphic determination of sennosides in Cassia angustifolia 
leaves. JAAC International 89:937–41
Enzyme- linked immunosorbent assay for total sennosides using 
anti-sennoside A and anti-sennoside B monoclonal antibodies. 
Fitoterapia 80(1):28–31
An insight into the potential variations of Ashwagandha (Indian 
ginseng) for better therapeutic efficacy. Acta Ecol Sin 001:1–7
96. Agarwal V, Bajpai M. 2010. Pharmacognostical and biological 
studies on senna and its products: an overview. Int. J. Pharma, Bio
Sci 1(2):107
97. Leng-Peschlow E. 1986. Dual effect of orally administered sennos-
ides on large intestine transit and fluid absorption in the rat. J
Pharm. Pharmacol 38:606–10
98. Godding EW. 1988. Laxatives and the special role of senna. Phar-
macology 36:230–36
Bournemouth, British Herbal Medicine Association.
100. Leng-Peschlow E. 1993. Sennoside-induced secretion and its rele-
ance for the laxative effect. Pharmacology 47:14–21
101. Waller SL, Misiewicz JJ. 1969. Prognosis in the irritable-bowel 
syndrome. Lancet ii: 00:753–56
fibre + senna oncolonic transit in loperamide-induced constipa-
tion. Pharmacology 47(Suppl.1):242–48
metabolism of the sennosides. Pharmacology 36:138–43
demonstration of a positive effect of rhein anthrone on peri-
static reflex of guinea pig ileum. Pharmacology 47(Suppl
1):40–48
105. Rumsey RDE, Squires PE, Read NW. 1993. In vitro effects of senna-
side on contractile activity and fluid flow in the perfused large 
testine of the rat. Pharmacology 47:32–39
106. Yamauchi K, Yagi T, Kuswano S. 1993. Suppression of the purga-
tive action of rhein anthrone, the active metabolite of Sennos-
ides A and B, by calcium channel blockers, calmodulin antago-

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