

Anatomy of Some *Cassia* L. and *Senna* Mill. species (Fabaceae), from the Middle and Southern Iraqi Districts: A Review Studies

Muazaz A. AL-Hadeethi^{1*}, Mouhannad M. Aljaf², Ali T. AL-Taie³ and Phanom Sutthisaksopon⁴

^{1,2}Department of Biology, College of Education for Pure Sciences ibn Al-Haitham, University of Baghdad, Iraq.

³Continuing Education Center, Mustansiriyah University, Iraq.

⁴Faculty of Environmental Culture and Ecotourism, Srinakharinwirot University, Bangkok, Thailand

Abstract

The third largest plant family is the legume family Fabaceae, which was previously, called Leguminosae under the subfamily Papilionaceae. The Iraqi flora states that it consists of 650 genera and 17,000 species, while modern sources state that it includes more than 751 genera and 19,500 species.

One of the genera of this family is the *Cassia* plant. Despite its medical and economic importance, in addition to the beauty of its flowers as one of the best ornamental plants, it has not received a comprehensive study in Iraq, and previous studies have not shed light on its anatomical aspects in separating and distinguishing among species spread in the central and southern provinces of Iraq.

Nine species were reported in this study, which showed a significant overlap of species within the genus, many of which were reclassified into other genera. Nine species were collected, four of which remained within the genus *Cassia*: *Cassia fistula* L., *Cassia javanica* L., *Cassia nodosa* (Buch.-Ham. ex Roxb.), and *Cassia singueana* (Del.) Lock. The last three were recorded as new cultivated species for the first time in Iraq: *Cassia javanica*, *Cassia singueana*, and *Cassia nodosa*. The other five species were recorded within the new genus *Senna*: *Senna occidentalis* L., *Senna artemisioides* (Gaudich. ExDC) Randell, *Senna didymobotrya* (Fresen) Irwin & Barneby, *Senna surattensis* (Burm.f) Irwin & Barneby, and *Senna sulfurea*, two of which are recorded for the first time as new cultivated species in Iraq: *Senna surattensis* and *Senna sulfurea*.

Keywords: Anatomy, *Cassia*, Fabaceae family, Review study, Legumes

تشريح بعض أنواع نبات الكاسيا و سنا (*Cassia* L. and *Senna* Mill. العائلة البقولية)، من مناطق وسط وجنوب العراق: مراجعة دراسات

معزز عزيز الحديثي^{1*}، مهند محمود الجاف²، علي طالب الطائي³، فانوم سوئيساكسوبون⁴

^{1,2} قسم علوم الحياة، كلية التربية للعلوم الصرفة ابن الهيثم، جامعة بغداد، العراق

³ مركز التعليم المستمر، الجامعة المستنصرية، العراق

⁴ كلية الثقافة البيئية والسياحة البيئية، جامعة سريناخارينوروت، بانكوك، تايلاند

المستخلص:

تعد الفصيلة البقولية (Fabaceae) ثالث أكبر عائلة نباتية، المسماة سابقاً Leguminosae ضمن الفصيلة الفرعية Papilionaceae. وتشير النباتات العراقية إلى أنها تتكون من 650 جنساً و17000 نوع، بينما تشير المصادر الحديثة إلى أنها تضم أكثر من 751 جنساً و19500 نوع. من أجناس هذه العائلة نبات الكاسيا، ورغم أهميته الطبية والاقتصادية، بالإضافة إلى جمال أزهاره كأحد أفضل نباتات الزينة، إلا أنه لم يحظى بدراسة شاملة في العراق، ولم تُسلط الدراسات السابقة الضوء على جوانبه التشريحية في الفصل والتمييز بين أنواعه المنتشرة في محافظات وسط وجنوب العراق.

تم الإشارة إلى تسعة أنواع في هذه الدراسة والتي أظهرت الدراسة تداخلاً كبيراً لأنواع هذا الجنس، إذ تم إعادة تصنيف الكثير منها إلى جنس آخر. تم جمع تسعة أنواع خلال الدراسة الحالية، أربعة منها بقيت ضمن جنس الكاسيا وهي: *Cassia fistula* L. و *Cassia javanica* L. و *Cassia Buch.-Ham.ex Roxb.* و *Cassia nodosa* و *Cassia singueana* (Del.) Lock، والثلاثة الأخرى تم تسجيلها كأنواع مستزرعة جديدة لأول مرة في العراق وهي *Cassia javanica* و *Cassia singueana* و *Cassia nodosa*. أما الخمسة أنواع الأخرى فتم تسجيلها ضمن الجنس الجديد السنا وهي *Senna occidentalis* L. و *Senna artemisioides* (Gaudich.ExDC) Randell و *Senna didymobotrya* (Fresen) Irwin & Barneby و *Senna surattensis* (Burm.f) Irwin & Barneby و *Senna sulfurea*، اثنان منها تسجل لأول مرة كأنواع مستزرعة جديدة في العراق وهي *Senna surattensis* و *Senna sulfurea*.

الكلمات المفتاحية: تشريح، كاسيا، العائلة البقولية، دراسة مرجعية، بقوليات.

Introduction

Taxonomic position of the Fabaceae family

The Fabaceae family is one of the largest plant families and in terms of its taxonomic position it was divided into three subfamilies by Bentham & Hooker (1862) Papilionoideae, Caesalpinioideae and Mimosoideae. However, (Hutchinson, 1934) made them independent families, namely Papilionaceae, Caesalpinioideae and Mimosaceae. Modern phenotypic and molecular studies have been used to confirm the fact that the Fabaceae family is a monophyletic family (Kajita et al., 2001). Monophyletic family) and studies of DNA sequences and characteristics of the plastome genome (Choi and Choi, 2017) have also been used to confirm this fact.

Common names of the Fabaceae family and general description of the genera

*Corresponding author.

Email: muazaz.a.h@ihcoedu.uobaghdad.edu.iq

<https://10.36531/ijds.2025.156227.1094>

Received 2024-12-29; Received in revised form 2025-05-02; Accepted 2025-05-09

The common names of the legume family are the Bean family, Pea family, and the Legume family (Steven et al., 1995). The basis for naming it Fabaceae is taken from the Latin word (*faba*), which means bean, which is one of the most famous genera of this family. As for its other name, Leguminosae, it refers to the fruit of these plants, which is in the shape of a legume, and it was called Papilionaceae because its flower resembles a butterfly corolla Papilionaceous (Doyle and Luckow, 2003).

The plants of the family are trees, shrubs, or herbs and in many different forms, some of which are in the form of climbers. Out of approximately 380 families of angiosperms, only ten families can form symbiotic relationships with nitrogen-fixing bacteria in the root nodules.

The Fabaceae family is one of the most prominent of these families (Soltis et al., 1996). Many legumes add bacteria to their roots in special structures called root nodules. These bacteria are called Rhizobia and have the ability to take nitrogen (N₂) from the air and convert it into the form (NO₃, NH₃) so that the legume plant can absorb it. This process is called nitrogen fixation (Sprent, 2001).

The leaves in the Fabaceae family are usually alternate and compound, often even or odd pinnately compound as in the genera *Caragana* and *Robinia*, and sometimes trifoliate as in the genera *Trifolium* and *Medicago*, and rarely palmately compound as in the genus *Lupinus*. In the subfamilies Mimosoideae and Caesalpinioideae, the leaves are Bipinnate as in the genera *Acacia* and *Mimosa*. The leaves always contain stipules and take different shapes, they may be leaf-like as in the genus *Pisum*, or thorn-like as in the genus *Robinia*, or the stipules may be indistinct, and the edges of the leaf are either smooth, Entire or serrate, in some genera the leaflets are transformed into tendrils and we see this in *Vicia* (Watson and Dallwitz, 1992).

The flowers of the genera are bisexual, hermaphrodite, actinomorphic or zygomorphic, the flowers usually have five fused sepals and five petals, either separate or papilionaceous, the keel (with the stamens and pistil inside it and two separate lateral ones) wings (one posterior, which is the largest in size), the stamens are usually ten, either diadelphous or monadelphous or numerous and distinct, the flowers are arranged in unlimited inflorescences that may be racemes or spikes as in *Ceratonia* and may be gathered in a semi-capitulum as in *Trifolium*, and insects pollinate these plants, this family is characterized by it has a special type of fruit, which is the legume, which is a pod that opens along the two strands when the seeds ripen The seed has different shapes and has a large embryo, and the endosperm is usually absent (Hill, 1937).

Medicinal and economic uses of the Fabaceae family

Legumes are an essential food source as edible grains for humans, such as *Vicia*, *Lens*, *Phaseolus* and *Cicer*, as they contain proteins in much higher proportions than any other vegetables, and their nutritional value reaches the value of fresh meat. They are also an important food source as animal feed, such as clover and alfalfa (Hill, 1937). Studies have shown that legume seeds are rich in fats, proteins and water-soluble sugars (Pinzon-Torres et al., 2009). They also contain minerals such as potassium, magnesium, manganese and copper the credit for increasing the production of crops grown after harvesting legumes is because the latter works as a green manure that increases soil fertility (Viswanathan et al., 2001).

Some plants belonging to the Fabaceae family have many medical and therapeutic benefits, the most prominent of which is the plant *Genista tinctoria*, whose emulsion is drunk to treat rheumatism, gout, low blood pressure, expel sand and small stones in the urinary system, and to treat constipation and fluid accumulation in the body's tissues or cavities (Saad, 1984). Previous studies have also shown that licorice powder *Glycyrrhiza glabra* is useful as a laxative, improves the taste of medicines, and softens mucous membranes (Al-Shahat, 1986). Its extract has also been used in many agricultural fields by spraying on plants or by soaking the seeds of plant crops before planting them (Al-Hadeethi, 2008). *Phaseolus* are also considered plants with important medical benefits, as their seed powder is used to treat itchy skin infections and eczema (Ruwaiha, 1983). Some genera of the legume family are used in industries, for example, *Sesbania* is used as a source of wood.

Etymology of the word Cassia, taxonomic status

Cassia is an ancient Jewish word (*quetsioth*) first used by the scientist Dioscorides and Cassia means the shape of the bark-cinnamon-like bark (Frodin, 2004). The scientist Linnaeus (1753) is considered the first to classify the genus *Cassia* in his book (*Species Plantarum*) as belonging to the Fabaceae family of the order under the family Caesalpinioideae, contained more than 500 to 600 species spread throughout the world (Airy-Shaw, 1973) while another source stated that it consists of 692 species (Tripathi and Mondal, 2012). Cassia was previously among the 25 largest genera of dicotyledonous flowering plants (Irwin and Turner, 1960) as Bentham and Hooker (1862) with studies on the Cassia and also the study of Bentham (1871) which led to its classification into three subgenera, namely *Cassia*, *Senna* and *Lasiorbegma*. This classification remained in place until the scientists Irwin and Barneby (1982) made taxonomic and nomenclature changes that eventually led to the separation of the genus *Cassia* into three genera, namely *Cassia*, *Senna* and *Chamaecrista*, relying in its classification on the

characteristics of the stamens and the characteristics of the horns and the presence or absence of nectary glands on the leaf axis. Lock (1988) also noted a series of problems that followed the previous study that arose due to the change in the name, as a group of researchers, especially on African floras, preferred to keep the name *Cassia* in the species that did not overlap between African floras and South America, but this did not solve the problem because many species of this genus are widespread in tropical regions on different continents, which prompted him and the scientists Randell and Barlow to reclassify some species. In continuation of the study of Irwin and Barneby (1982), the number of *Cassia* species became only 30 species, while the number of *Senna* species became 260, and 270 species of the genus *Chamaecrista*.

It is worth noting that the name *Cassia* is given to a number of species of the genus *Cinnamomum* belonging to the Lauraceae family (Haw, 2017). The Iraqi Botanical Encyclopedia (Townsend and Guest, 1974) states that the genus *Cassia* consists of two secondary genera: Subgenus: *Cassia* L. It contains one species, *Cassia fistula* L. The second is Subgenus: *Senna*, which includes eight species, *Cassia occidentalis* L., *Cassia obtusifolia* L., *Cassia sophera* L., *Cassia artemisioides* Gaudich, *Cassia corymbosa* Lam., *Cassia senna*, *Cassia italica* (Mill) F.W.Andr and *Cassia didymobotrya* Fres. While Chakravarty (1976) stated that there is only one species in Iraq, *Cassia artemisioides*.

Cassia is a medicinal plant known for its laxative and purgative properties. Its use is widespread in India, where Indian exports reach more than 5,000 tons per year, and the demand for it in the market increases by approximately 10% to 15% annually (Seethapathy et al., 2015).

Cassia is widespread in most tropical and subtropical countries and has great biological and medical effectiveness. For example, it is used as antibacterial, antifungal, and other antifungals (Maneemegalai and Naveen, 2010 and Junior et al., 2006). Some of its species are used as an anti-histamine release substance. Some of its species are used to maintain the integrity of the nerves and memory and also prevent the aggregation and clotting of blood platelets (Sung et al., 2004 and Kim et al., 2007). The extract of the leaves of some of its species is used to treat cough, acute bronchitis, and syphilis (Anis et al., 2012). It is also worth noting that some of its species are not edible because their seeds are poisonous (Bakhiet and Adam, 1996) or cause chronic liver diseases (Amao et al., 2010). These are the many valuable medical properties of the *Cassia* genus. *Cassia* is due to the active metabolic substances present in it, as the chemical analysis of its different types resulted in its containing active compounds such as flavonoids, tannins, alkaloids, saponins, steroids, phenols, and others (Bhalerao and Kellar, 2012, Awomukwu et al., 2015 and Lavanya et al., 2017).

Morphological characteristics, common and medicinal uses of the studied species

Figures 1 refer to some morphological characters in the same species.

1. *Cassia fistula* L.

Fast-growing trees, abundant in tropical countries, native to India, Malaysia, Indonesia, Amazonia and Sri Lanka, and spread in different countries such as China, East, and South Africa, and is the national symbol of Thailand, it is widely planted in gardens and on roadsides as ornamental trees for the beauty of its bright yellow flowers. Its common names include cucumber in Arab countries such as Saudi Arabia, Qatar and Iraq, and Amaltas in India. Globally, it is known as the Indian laburnum tree and the golden shower tree, in addition to being called purging *Cassia*, purging fistula and purging *Cassia* (Karaboon et al., 2005 and Neelam et al., 2011).

Cassia fistula trees are medium-sized, 5-10 m tall, with spreading branches and smooth, thin bark on young stems. Leaves are alternate, pinnate, 30-40 cm long, with 4-8 pairs of leaflets 7.5-15 cm long and 2-5 cm wide. They have a smooth margin and bright yellow flowers in terminal, pendulous clusters. The calyx is oblong and the corolla consists of five free, almost equal petals. Stamens are 10, the upper three are 0.7 cm long, and the filaments are attached to the anthers basifixed, while the lower three are dorsifixed and the other four are medium-sized, 1 cm long. The filaments are attached to the last anthers freely (versatile). The pistil is sessile or stalked and the fruit is short in length from 40-60 cm long and 1-2 cm in diameter, cylindrical, hanging or round, seeds lenticular (Orwa et al., 2009).

Cassia fistula trees are a rich source of flavonoids, so they are used as antioxidants and anti-inflammatory agents, in addition to other medical uses (Sivakumaran et al., 2016 and Sharma, 2017). In China, its bark is used as a source of red dyes because it contains tannins. The pulp of the fruits and seeds is used as a laxative, and the wood is hard, so it is used in the manufacture of agricultural tools and in building bridges and supports (Brach and Song, 2006). In Nigeria, a study showed that *Cassia fistula* fruits are more effective than *Senna* (*Cassia acutifolia*) as a laxative, in addition to its very low toxicity in laboratory animals, as the study showed that there is no toxicity or destructive effect on the kidneys and livers of the animals studied (guinea pigs, mice and rats). After dissecting the animals and isolating their organs, no necrosis, inflammation, or fibrosis of the liver cells was observed, and they are similar to the natural state. It was proven that it is safe for human use as a laxative drug and a substitute for local *Senna* (Akanmu et al., 2004).

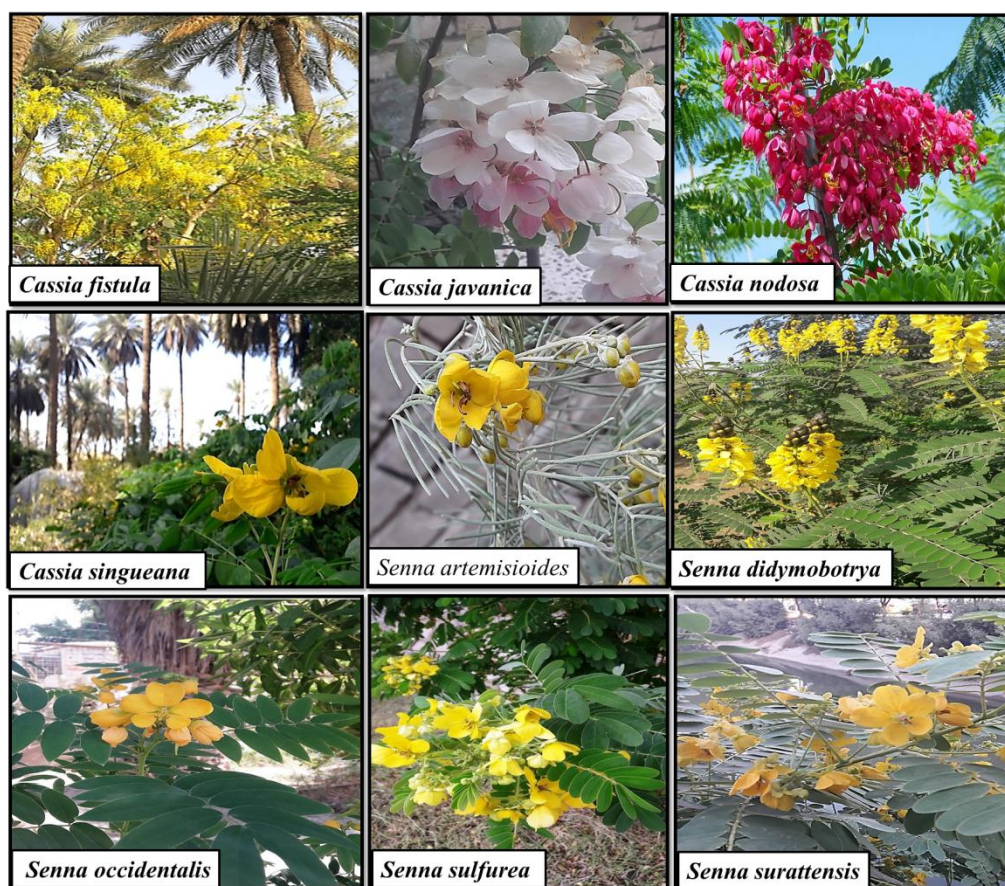


Figure 1. Shape of *Cassia* and *Senna* species in Iraq

The methanolic extract of *C. fistula* seeds can be used as a medicine (Jothy et al., 2011). Previous studies have found that the ethanolic extract of cassia roots and leaves has an activity against a wide range of bacteria such as *Streptococcus*, *Staphylococcus*, *Salmonella*, *Shigella*, *Echerichia coli*, *Pseudomonas* and *Bacillus*. The concentration of 200 µg showed moderate to good effect against these pathogens (Awal et al., 2010). The aqueous extract of the flowers has also proven effective against fungi (Duraipandiyan and Ignacimuthu, 2007). The extract of its fruits and seeds has been used to kill parasitic worms (Irshad et al., 2010). Therefore, it is recommended to use and benefit from it in the pharmaceutical industries (Srividhya et al., 2017). It is called a bactericide Disease killer (Mounika et al., 2017).

2. *Cassia javanica* L.

It is difficult to determine the origin of this species because it is widespread throughout America, Malaysia and tropical Asia such as China, Thailand and Vietnam. These trees are called in most countries Pink and white shower due to the color of their pink and white flowers and also called Apple blossom Cassia because their flowers are easily similar in appearance to the flowers of the apple tree (Andrew et al., 2015 and Neog et al., 2013). In Iraq, it is locally known as Nodosa, as its name overlaps with that of the species *C. nodosa*, as some sources consider the species name Nodosa synonymous with Javanica and not an independent species (Sharma et al., 2014). *Cassia javanica* trees are small to medium-sized, 25-40 meters tall, deciduous or semi-deciduous, the leaves consist of 15-5 (20) pairs of leaflets with an ovate-elliptical to oblong shape and the base Rounded and the apex is acute to rounded, the stalk is 1.5-4 cm long, the inflorescence is arranged in a terminal or lateral inflorescence, more than 16 cm long, with many flowers and sepals, green or dark red, ranging in length from 10-4 mm, and the petals are 35-15 mm long and their colors range from whitish pink to red, the stamens are ten in number, three of them are longer than the others, 2 cm long, and four are shorter, 1 cm long, and the last three are reduced with very small anthers, the fruits are hanging and round, 60-20 cm long, and the seeds are numerous (Orwa et al., 2009 and Sanyal, 2015).

Cassia javanica, like other *Cassia* species, is a rich source of flavonoids, anthraquinones, and polysaccharides. It is used as an antidiabetic, antioxidant, and anticancer agent. It has been used for a long time in folk medicine to treat various diseases, as it is used as an antipyretic, antipyretic, and as a cold and flu medicine, as well as in the treatment of malaria, pain, and digestive system diseases (Sharma et al., 2014).

3. *Cassia nodosa* Buch. -Ham.ex Roxb

They are trees that are abundant in India and are planted in Malaysia, Thailand, China, and other Asian countries and can grow easily in basic lands without further attention and investment (Brach and Song, 2006; Kapoor, 2000). In Egypt, they are spread in public gardens to benefiting from them in shading (Abdel-Chani et al., 2011). They are known locally in Iraq by the same scientific name, *nodosa*. They are planted in Baghdad for the beauty of their flowers. They are treeing whose length ranges from 24-12 meters. The leaves consist of 12-6 pairs of oblong leaflets and are slightly extended. Their base is oblique. The length is from 5-6.3 cm and width is from 2.5-3.1 cm. They have clear veins. The sepals are green and covered with hair (Hairy Ovate). The petals are reddish-pink, oval in shape. The inflorescences are dense and the fruits look like a rounded pod. (Ridley et al., 1967; Hooker et al., 1879), and the methanolic extract of *C. nodosa* shoots was used against four types of cancers, namely breast cancer, colon cancer, lung cancer and hepatocellular carcinoma, and the plant is used as an antioxidant (Jain et al., 2013) in addition to the antimicrobial activity of its leaf extracts (Sharma et al., 2013).

4. *Cassia singueana* (Del.) Lock

Widespread shrubs in African countries such as Niger, Mali, northern Nigeria, Sudan, eastern and southern Africa (Ottu et al., 2013) are widespread in Baghdad and are known as *Cassia carnival*. This species was included in the genus *Senna* by Lock (1988). It is a deciduous shrub with 5-8 pairs of elliptical leaflets, emarginated at the apex, 2-5 cm long, and 1-3 cm wide. The stalk and axis are 20 cm long and there are thin club-shaped glands between each pair of leaflets. The flowers are in the form of cluster inflorescences and the clusters are at the end of the branches. The fruits are semi-hard when ripe, pointed at the apex, 10-15 cm long, and 5-8 cm in diameter. The seeds are arranged in a single row (Hutchinson and Dalziel, 1958).

This plant is used as a medicinal plant in northern Nigeria to treat certain diseases such as acute malaria. The methanolic extract of its leaves is also used as an antipyretic and analgesic and to treat some diseases, especially those that cause high temperature (Adzu et al., 2003, Dave and Ledwani, 2012; Hiben et al., 2016). In Kenya and Burkina Faso, the hot extract of its leaf powder is given as oral doses to treat malaria and fever (Nanyingi et al., 2008). The bark of the roots of this species also has a soothing effect on some pains (Adzu and Gamaniel, 2003).

5. *Cassia artemisioides* and *Senna artemisioides* (new binomial) (Gaudich. Ex DC) Randell

It is a shrub native to Australia and is often grown in warm regions of the world. It is currently classified as a genus of *Senna artemisioides*. This type of shrub is evergreen, densely branched, 0.6-3 meters long. The stem and branches are short and the leaves have short petioles ranging from 12-6 mm. The number of pairs of leaflets is 6-3, needle-shaped, silver in color. The auricles are very short. The racemes consist of 9-5 flowers, their length is between 20-8 mm, and the bracts are oval. The petals range in shape from ovate to elongated, their length is 9-6 mm, and their width is 7-4 mm. They are yellow and have fine black veins. The sepals are unequal and the stamens are ten in number, all of which are fertile. Two of them are 6.5 mm long, while the remaining eight are 4 mm long. The ovary and style are smooth except for the stigma surface. The fruit Compressed in shape and the seeds are obovate (Townsend and Guest, 1974 and Ajaib et al., 2011). Chemical studies of this species have proven the presence of anthraquinone, known for its antioxidant properties (Zaman et al., 2011). This species is considered a harmful weed as the pods of this plant are toxic to livestock, causing diarrhea, difficulty walking, and increased heart rate and may lead to death in some cases. (Simmonds et al., 2000)

6. *Cassia didymobotrya* and *Senna didymobotrya* (new binomial) (Fresen) Irwin&Barneby

These are shrubs called locally African Cassia and in Africa and India they are called Peanut Butter Senna, and they are also called Popcorn Cassia. This species is also classified within the genus *Senna*, *Senna didymobotrya*. Africa is the original home of this species, while in India this species is grown as a green manure for agricultural lands, in addition to being an ornamental plant for gardens and on the sides of roads (Irwin and Barneby, 1982). The shrubs of this species produce golden yellow flowers that open from buds that are closed with dark black oval bracts. The branches are arched with compound leaves 10-15 cm long containing 8-18 pairs of oblong-elliptical leaflets with rounded petioles 1-8 cm long. The inflorescences are axillary, erect, spike-like, or raceme-like, 10-50 cm long, consisting of 20-30 flowers. The sepals are five unequal, green in color, oblong to ovate. The petals are five unequal, ovate to obovate, with a claw 1 mm long, smooth, and the petal is finely veined. Are 10 stamens, three of which are the longest, two are the shortest, and the remaining five are medium-sized. The female organ consists of an ovary, a thin style 1 cm long, and a punctiform stigma. The fruit is a flat pod, linear to oblong. Linear-Oblong, number of seeds ranges from 9-16 seeds (Singh and Singh, 2010; Orwa et al., 2009). This species has wide medical uses, especially in Africa, as the extract of the roots, leaves, and stems is used as

a laxative and antiseptic drink to treat abdominal pain. It is also taken to expel intestinal worms and get rid of ringworms. The powder of the roots and leaves mixed in water is used to treat reproductive diseases. It can also be said that it is a good treatment against fungal and bacterial infections, high blood pressure, and sickle cell anemia of blood cells and in treating hemorrhoids. It also treats a wide range of gynecological diseases such as inflammation of the fallopian tubes, fibroids, and backache. It also stimulates increased lactation and induces uterine contractions. (Alemayehu et al., 2015, Jaca, 2017; Jeruto et al., 2017)

7. *Cassia occidentalis* L. and *Senna occidentalis* L. (new binomial)

They are shrubs known as Kasondi in Hindi, Kasmard in Sanskrit, Coffee senna in English, Negro coffee in Africa, and local, seed, or seasonal cassia in Iraq. They generally grow in Burma, Sri Lanka, Australia, and the United States of America. This species is the national symbol of southern India (Kirtikar et al., 1999; Kaur et al., 2014). This species was reclassified and included in the genus *Senna occidentalis* by Irwin and Barneby (1982).

Cassia occidentalis shrubs have alternate pinnate leaves with 6-8 pairs of leaflets. The leaves are broadly lanceolate to ovate with a sharp apex, with a gland near the base of the leaf axis. The seeds are oval, 4 mm long, and flattened (Amponsah et al., 2016). This species has great medical importance as it was used in Greek medicine to treat liver diseases (Jafri et al., 1999) and in Jamaican medicine to treat diarrhea, dysentery, constipation, fever, eczema and venereal diseases. The seeds of this plant are a good source as an alternative to vegetable proteins and are rich in vitamin B3, calcium, iron, zinc, phosphorus and magnesium (Manikandaselvi et al., 2016). Its flowers are used to treat skin rashes. The dried leaf extract can be used therapeutically to protect against liver toxins (Uzzi and Grillo, 2013; Sastry et al., 2011). The importance of its seeds also lies in their antibacterial properties against respiratory tract bacteria such as *Staphylococcus aureus* and *Streptococcus pneumoniae* (Rajni and Navneet, 2014).

8. *Cassia surattensis* and *Senna surattensis* (new binomial) (Burm.f) Irwin& Barneby

It is a shrub native to India, Southeast Asia, and tropical Australia. It was reclassified in 1982 and included in the genus *Senna surattensis* by Irwin and Barneby (1982). It is also called Egyptian cassia. It is fast-growing, blooms abundantly in the dry season, its length is 12-15 meters. The leaves are pinnate, 8-18 cm long, containing 6-9 pairs of opposite leaflets with an obovate to elliptical or oblanceolate shape. The upper surface of the leaflets is green and smooth, while the lower surface is covered with a fine white or bluish dust-like substance. The apex is rounded and sunken, while the base is oblique. There are also clavate glands between the first and second pairs and sometimes between the leaflets of the third pair (Randell and Barlow, 1998, Kumar, 2016; Sihanat et al., 2016). The inflorescences are racemes, 0.4-2.5 cm long, the petals are yellow or orange, ovate or oblong-ovate, the calyx is inverted lanceolate, oblong, and the male organ, Androecium, consists of 10 stamens, all fertile, and the anthers are unequal, opening with apical slits. The female organ consists of a green style, 2-3 cm long, and the ovary has hairs. The pods are pendulous, chartaceous, compressed, 7-10 cm long, and 1.1-1.5 cm wide. The seeds are arranged in a single row, brown (Wagner et al., 2014; Sanyal, 2015).

The extract of the leaves of this species is used as an antidiabetic agent at a concentration of 500 mg/kg, and is used therapeutically against increased blood fats (Mazumeder et al., 2009). It is also considered a strong antioxidant. In one study that included seven types of *Cassia*, they were: *C. fistula*, *C. sophera*, *C. surattensis*, *C. grandis*, *C. nodosa*, *C. occidentalis* and *C. didymobotrya* were found to be the most effective in fighting oxygen free radicals that cause cell and tissue damage and various disorders such as heart disease, aging, Alzheimer's, mutations and cancer (Lee et al., 2003 and Tadhani et al., 2007). Therefore, it is considered a natural antioxidant due to its content of phenolic and flavonoid compounds that are considered safe to use (Kumaran and Karunakaran, 2007 and EL-Hashash, 2010). The extract of the stems and leaves is also used as antibacterial and antifungal (Kittur et al., 2015).

9. *Cassia sulfurea* and *Senna sulfurea* (new binomial) (Colladon) H.S. Irwin&Barneby

It is a shrub that is closely intermingled with *Cassia surattensis*, so much so that the local name *Cassia glauca* is used for both species. It is native to India, Burma, Malaysia, Thailand, and is also found in Brazil (Monkheang et al., 2011). It was reclassified and included in the genus *Senna sulfurea* by Irwin and Barneby (1982). There is no difference in appearance between *S. surattensis* and *S. sulfurea*, except that *S. surattensis* has smaller and more numerous leaflets, and the stipitate pod is shorter, so Randell and Barlow (1998) from Australia considered these two species to be subspecies of *S. surattensis*.

• Anatomical studies of *Cassia*

Figures 2,3,4,5 and 6 refer to some anatomical characters in the same species.

Phenotypic characteristics are directly affected by the environment, causing phenotypic changes and leading to taxonomic confusions. Classifiers have relied on other characteristics and techniques to solve complex taxonomic problems, such as leaf epidermis anatomy (Stace, 1980). Therefore, anatomical characteristics often

provide valuable taxonomic evidence and help in identifying species (Devecchi et al., 2014), placing groups in their correct location, and understanding the relationships that govern them (Al-Badri, 2014). Cassia has received many anatomical studies worldwide due to its importance. Perhaps the oldest study that dealt with the anatomy of plant families, including the legume family, is the study of Solereder (1908) found that some genera of Caesalpinioideae contain crystals composed of calcium oxalate, individually or in groups, also noted the presence of secretory cells, gum cells, cavities, and secretory ducts and mentioned that tannin sacs, which It is widely distributed in Papilionideae and is not common in this subfamily. His study also included the anatomy of the Cassia leaf and showed that its epidermis consists of a single layer, also showed that the secretory cells in Cassia often cause clear dots in the leaf and are oval in shape in the columnar tissue while they are spherical in shape in the spongy parenchyma.

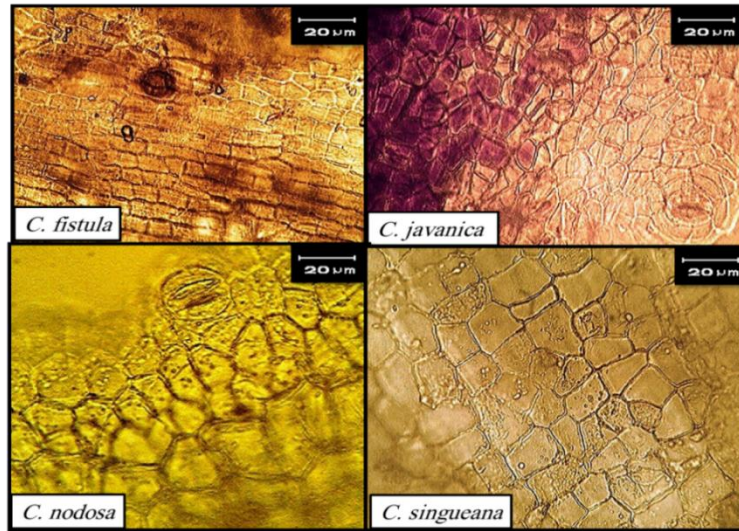


Figure 2: Shapes of normal epidermal cells and stomatal complexes in the epidermis of stems of species belonging to the genus *Cassia*.

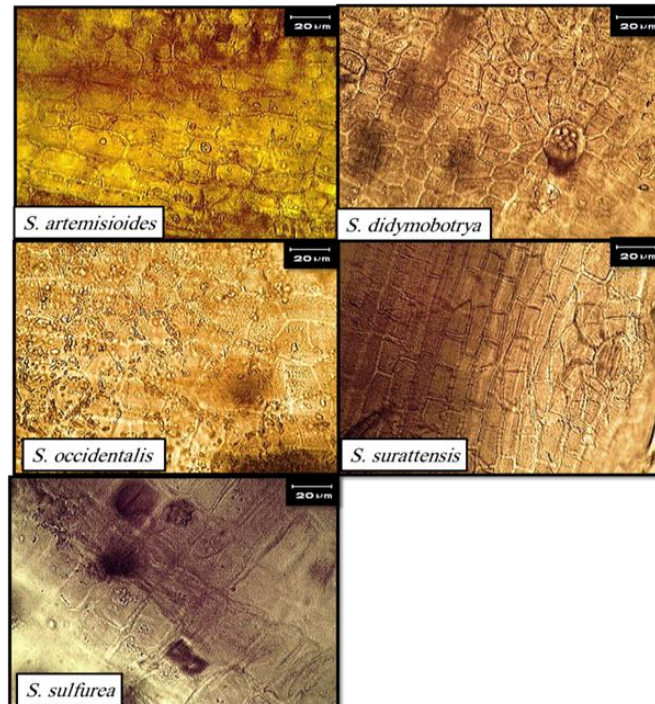


Figure 3: Shapes of normal epidermal cells and stomatal complexes in the epidermis of stems of species belonging to the genus *Senna*.

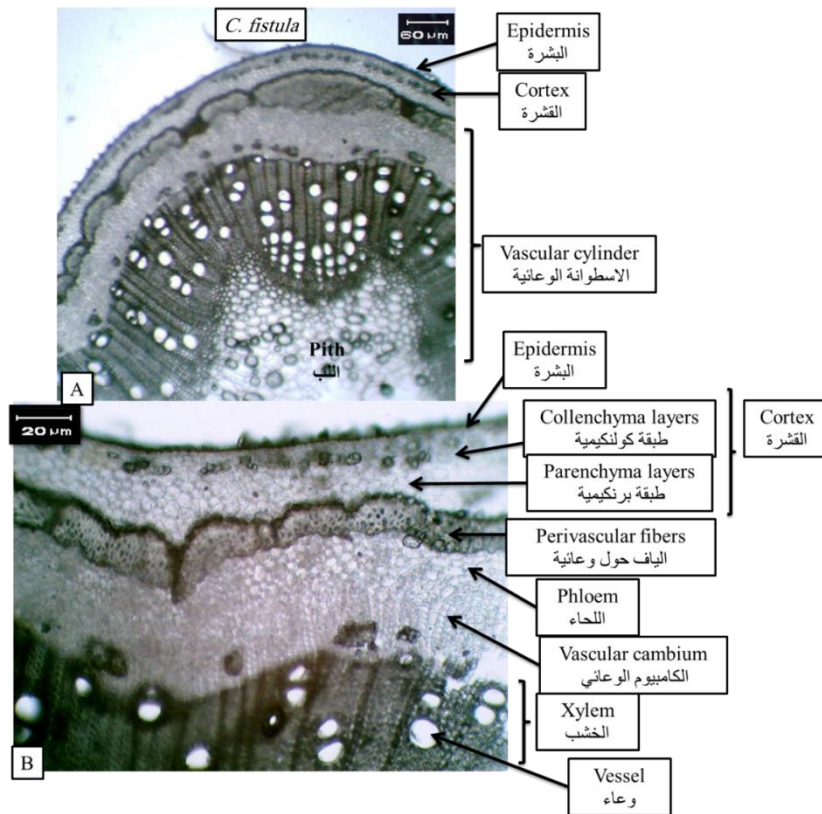


Figure 4: Cross-sectional characteristics of the stem of *C. fistula*.

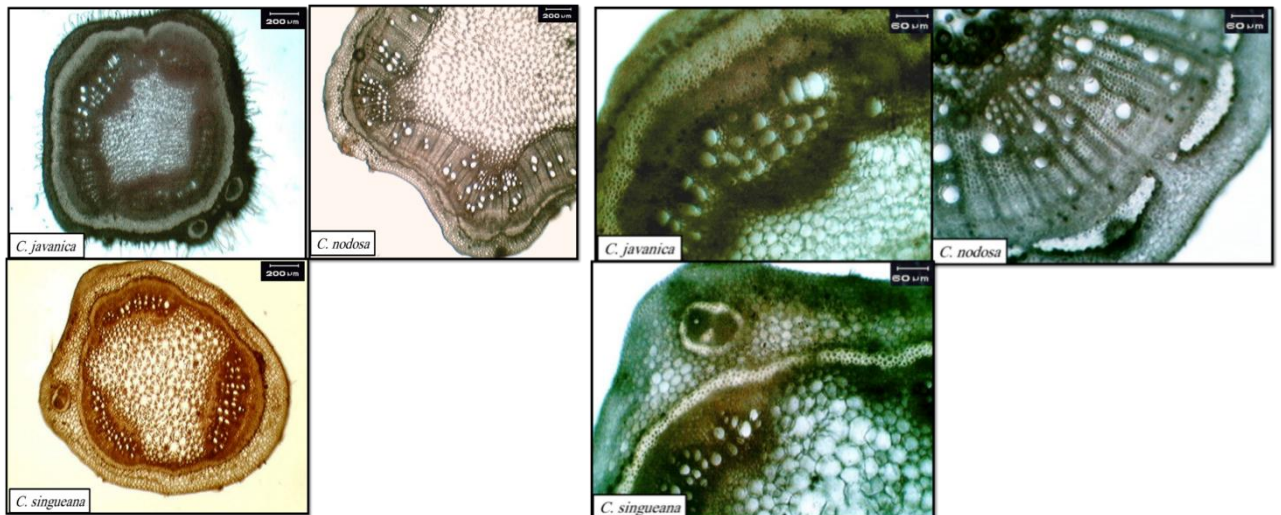


Figure 5: Characteristics of the cross-sections of the stems of species belonging to the genus *Cassia*.

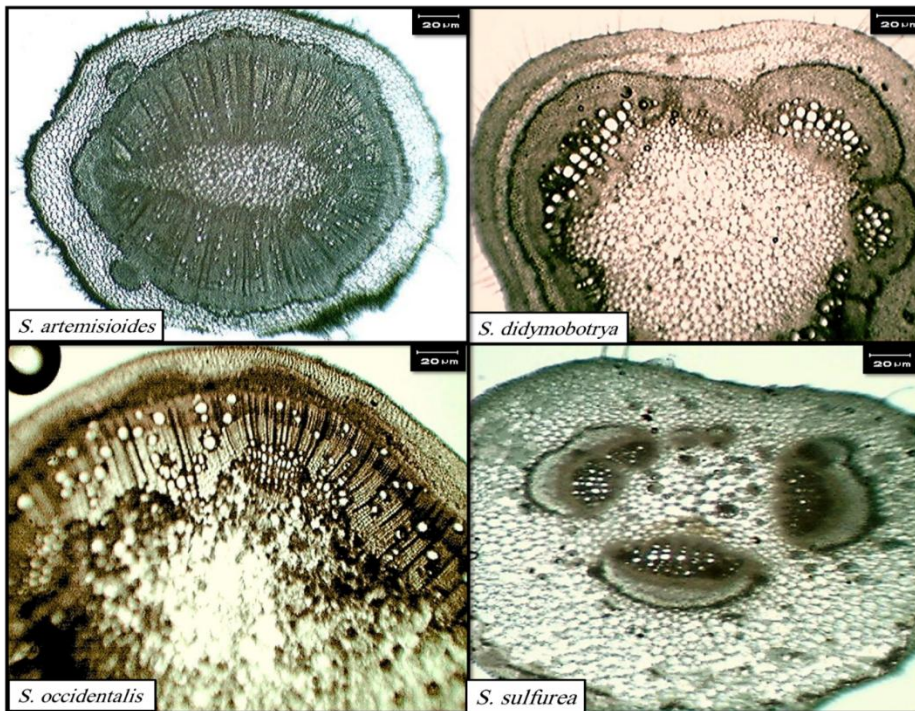
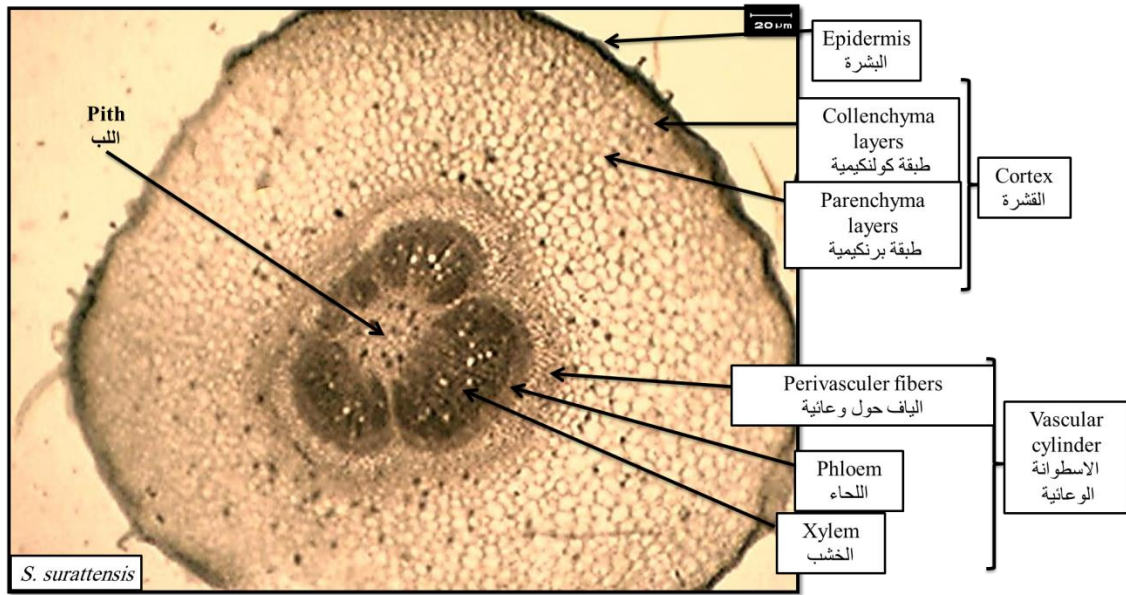


Figure 6: Characteristics of the cross-sections of the stems of species belonging to the genus *Senna*

Watari (1934) studied the leaves cross-sections of Cassia and included the anatomy of the vascular tissue of the petiole and leaf axis. Martin (1946) studied the anatomy of the seeds of four species of Cassia, namely Cassia ligustina, Cassia occidentalis, Cassia fasciculata, and Cassia tora. Metcalfe and Chalk (1950) studied the types of crystals in species of Caesalpinioideae and the types of stomata. In Australia, Symon (1956) studied the seeds of six species of Cassia and found that they were polyembryony.

The anatomy of the petioles of 62 species from Cassia was also studied by Irwin (1964). Carvalho (1967) studied the venation patterns of 34 species of Caesalpinioideae spread in Brazil, nineteen of which belong to the genus

Cassia. He concluded that it is possible to use this characteristic with some other characteristics of the leaves to distinguish taxonomic ranks at the level of types, Okpon (1969a) studied the surface covering of different parts of the Cassia plant and found two types of hairs, which are unicellular and multicellular hairs, also studied the vascular anatomy of the cotyledons and described them in two types of Cassia, *Cassia aeschynomene* and *Cassia laevigata*.

In the same year, Okpon (1969b) studied the stomata of Cassia and found that although the parallel type of stomata is the most common, he noticed the presence of another type, which is actinocytic type.

As for Pandey (1970) studied the characteristics of the epidermis and leaflets of 12 types of Cassia, the study included the shape of the epidermal cells, stomata, the surface covering, and the numbers and sizes of hairs.

Shah and Gopal (1971) described the stomata of 19 species of Caesalpinioideae, including 11 species belonging to the genus Cassia, and concluded that they have similar growth patterns in different parts of the same plant.

Melotte (1972) studied the anatomy of the leaflets of *Cassia laevigata* Willd., *Cassia acutifolia* and *Cassia angustifolia* Vahl.

In India, Patel et al., (1976) studied the cross-sections of the fruits of the species *Cassia occidentalis* and described them anatomically. Kamra (1976) from Sweden studied the seeds and fruits of 165 species of forest plants from nine countries using X-ray imaging, the studied species included *Cassia fistula*, *Cassia javanica* and *Cassia nodosa*.

Chouse and Jamal (1978) studied the anatomy of the wood of some Cassia species and Ghose et al., (1980) study the anatomical characteristics of the wood of some ornamental trees, including Cassia. In Ireland, Smith (1983) studied the anatomy of the cotyledons of a large number of genera of the legume family, including the Cassia genus. Carvalho (1983) presented a study on the anatomy of the Cassia leaf, and Mathur (1985) conducted a comparative study of two species of Cassia, including the characteristics of the epidermis.

In Saudi Arabia, Al-Daiji et al. (2013) presented a study that included the leaves and stems of three species of *Cassia italic*, *Cassia occidentalis* and *Cassia alexandrina*, in addition to a study of crystals.

Kamble (2013) conducted an anatomical study of the roots, stems and leaves of *Cassia alata* L. after treating them with the herbicide (2,4-D). In Malaysia, an anatomical study was presented on the seeds of *Cassia surattensis* (Kumar et al., 2014), and from India and West Bengal, Dubey and Sawant (2015) conducted an anatomical study on the species *Cassia tora*, while Kamarapu (2015) studied the cross-sections of the leaves of the species *Cassia roxburghii*, including the epidermis and hairs, and was conducted on the nectary glands located at the base of the stalk of *Cassia hirsuta* L. using an electron microscope (Sharmila and Yogamoorthy, 2015). An anatomical study of the transverse sections of the auricles located on both sides of the stalk of *Cassia alata* was presented to study the nectary tissues by Veeravagavan and Ramamoorthy (2016).

In Iraq, there are no detailed and comprehensive anatomical studies of the species found in Iraq, except for two anatomical study and a few physiological and genetic studies, the first one by Al-Tamimi (2008) presented a comparative anatomical study of three species belonging to three genera of the Caesalpinaceae family, which dealt with one species of the Cassia genus, *C. didymobotrya*, the study included the epidermis of the leaf, the venation system, and cross-sections of the stems, petioles, and leaf.

The second study of the Cassia by Al-Lamy and AL-Hadeethi (2018) have addressed comparative anatomical of some *Cassia* L. species from middle and south of Iraqi districts. The study showed a large taxonomic overlap of the species of this genus, as many of them were reclassified to another genus. Nine species were collected during the current study, four of which remained within the genus Cassia: *Cassia fistula*, *Cassia javanica*, *Cassia nodosa* and *Cassia singueana*, and the last three were recorded as new cultivated species for the first time in Iraq: *Cassia javanica*, *Cassia singueana* and *Cassia nodosa*. The other five species were recorded within the new genus Senna: *Senna occidentalis*, *Senna artemisioides*, *Senna didymobotrya*, *Senna surattensis* and *Senna sulfurea*. Two of them were recorded for the first time as new cultivated species in Iraq: *Senna surattensis* and *Senna sulfurea*. The focus was on the various anatomical aspects of the stems, leaf blades, petioles, and calyx. The study showed important taxonomic results in isolating the species of the genus Cassia from each other as well as isolating the Cassia species from the Senna species.

The study also revealed that the green leaves and calyx leaves of Cassia species were hypostomatic, meaning that the stomata were only present on the lower surface. As for the species of the genus Senna, they were amphistomatic, meaning that the stomata were present on both their upper and lower surfaces. The genus Senna was also distinguished by the presence of a distinctive pattern for the stomatal complex, which is the actinocytic pattern in the species *S. artemisioides*.

The study by Al-Lamy and AL-Hadeethi (2018) of the leaf surface covering was important in isolating the species, based on the difference in their lengths, shapes and distribution in different areas of the plant parts, all of them were of the type of non-glandular, single-celled, single-row hairs, except for the species *C. fistula*, which was distinguished by containing glandular hairs on the surface of its stems, and the species *C. javanica* was unique

in having branched hairs on the epidermis of its leaflets. This study showed also that the cross sections of the leaf are bifacial, meaning that they have two layers spongy and palisade in the mesophyll, except for the species *S. artemisioides*, which is characterized by being isobilateral, meaning that it has two palisade layers with a spongy layer between them, while the transverse sections of the calyx leaves were homogeneous, meaning that the mesophyll contains only the spongy layer. The study also highlighted the difference in the distribution of crystals, starch granules and aleurone granules, as the species *C. nodosa* was characterized by the presence of starch granules with a centrally wrinkled hilum, and the presence of oil droplets was recorded in *C. fistula* and *C. nodosa*. All these results gave great and distinct anatomical taxonomic importance in separating the species under study from each other, and this study is the first in Iraq.

On the other hand, some studies in Iraq have addressed other sides like Al-Amri et al. (2009) presented a study that included the phenotypic characteristics of the *Cassia italica* Mill and the effect of alcoholic and hot aqueous extracts on the growth of selected types of bacteria and yeasts, Jalal et al. (2009) also studied the genetic effect of aqueous extracts of the seeds of the Senna on Soybeans, and Senna leaves in white mice. Also, a study by Al-Mohammadi et al. (2013), they showed the response of caraway plant to spraying Senna extracts, cauliflower and vitamin complex. In another study, some chemical, vegetative, and reproductive characteristics were adopted in the numerical classification of six species of the legume family, including *Cassia occidentalis* (Abbas et al., 2015). Hussein (2016) conducted a study that included early detection of chromosomal duplication resulting from the effect of collagen in the species *Cassia angustifolia*. Finally, Youssef et al. (2016) focused on the research of plant extracts of *Cassia acutifolia* leaves in the growth of *Candida albicans* yeast isolated from women infected with it. Moreover, in study on twelve species belong to Mimosoideae family, Alrawi et al., (2023) found various differences among those species in anatomical properties due to the variance among them depending on their pedigrees and their habitats.

Conclusion

Legumes are an essential food source as edible grains for humans, and they also contain minerals such as potassium, magnesium, manganese, and copper the credit for increasing the production of crops grown after harvesting legumes is that the latter works as a green manure that improves soil fertility. Cassia from the Fabaceae family is widespread in most tropical and subtropical countries. It has great biological and medical effectiveness and these are the many valuable medical properties of the Cassia genus. Cassia is caused by the active metabolic substances present in it. for these important plants must know taxonomy and active chemical compounds found in them, to be used in herbal medicine instead of using it as just decoration.

References

1. Abbas, Y. K., Sakr, R. A., & Hamad, K. T. (2015). Numerical classification of some species of the legume family Leguminosae. *Journal of the College of Education for Pure Sciences*, 5 (2), 142–165.
2. Abdel-Chani, M., Bornkamm, R., El-Sawaf, N., & Turkey, H. (2011). Plant species distribution and spatial habitat heterogeneity in the landscape scope of urbanizing desert ecosystems in Egypt. *Urban Ecosystems*, 14 , 585–616. <https://doi.org/10.1007/s11252-010-0159-x>
3. Adzu, B., & Gamaniel, K. (2003). Sedative effects of *Cassia singueana* root bark. *Journal of Natural Remedies*, 3 (2), 134–137.
4. Adzu, B., Abbah, J., Vongtau, H., & Gamaniel, K. (2003). Studies on the use of *Cassia singueana* in malaria ethnopharmacy. *Journal of Ethnopharmacology*, 88 (2–3), 261–267. [https://doi.org/10.1016/S0378-8741\(03\)00224-8](https://doi.org/10.1016/S0378-8741(03)00224-8)
5. Airy-Shaw, H. K. (1973). *A dictionary of the flowering plants* (8th ed.). Cambridge University Press.
6. Ajaib, M., Dinkhan, Z. U., Butt, G. Y., & Ullah, N. (2011). *Senna artemisioides* of family Leguminosae and *Mansoa alliacea* of family Bignoniaceae: Two new records to flora of Pakistan. *Biologia*, 57 (1–2), 1–5.
7. Akanmu, M. A., Iwalewa, E. O., Elujoba, A. A., & Adelusola, K. A. (2004). Toxicity potentials of *Cassia fistula* fruits as laxative with reference to Senna. *Asian Journal of Biomedical and Pharmaceutical Sciences*, 7 , 23–26.
8. Al-Amiri, M. M., Al-Alaq, S. A., & Al-Ibrahimi, L. (2009). Study of the morphological characteristics of the Senna plant *Cassia italica* Mill. and the effect of alcoholic and hot aqueous extracts on the growth of selected types of bacteria and yeasts. *Iraqi Journal of Market Research and Consumer Protection*, 40–29 (1), 1–10.

9. Al-Badri, D. K. S. (2014). *Anatomical and taxonomic characteristics of selected species of wild dicotyledons growing in Diyala Governorate* (Master's thesis). College of Education for Pure Sciences, University of Diyala.
10. Al-Bair, H. Y., Al-Qaisi, M. D., & Obaid, A. N. (2016). The effect of some plant extracts of *Cassia acutifolia* leaves on the growth and activity of *Candida albicans* yeast isolated from disease cases. *Journal of Madinah University College*, 8 (1), 14–30.
11. Al-Daiji, A. R., Al-Halwa, N. H., Al-Watban, A. A., & Al-Zaidi, M. (2013). Anatomical study of the vegetative parts of three wild species of the genus *Senna* Miller in the Kingdom of Saudi Arabia. *Saudi Journal of Biological Sciences*, 20 (5), 85–92. <https://doi.org/10.1016/j.sjbs.2013.04.001>
12. Alemayehu, I., Tadesse, S., Mammo, F., Kibret, B., & Endale, M. (2015). Phytochemical analysis of the roots of *Senna didymobotrya*. *Journal of Medicinal Plants Research*, 9 (34), 900–907. <https://doi.org/10.5897/JMPR2015.6163>
13. Al-Hadeethi, M. A. H. (2008). *Effect of concentrations and number of sprays of some growth regulators and licorice extract on growth, yield, and its components of wheat *Triticum aestivum* L.* (Master's thesis). College of Education II (Ibn Al-Haitham), University of Baghdad.
14. Alrawi, M. Sh., Aldobaissi, I., & Almehemdi, A. F. (2023). Anatomical study of twelve *Mimosoideae* species in Iraq. *Iraqi Journal of Desert Studies*, 13 (2), 72–82. <https://doi.org/10.36531/ijds.2023.140026>
15. Al-Lamy, Z. A., & Al-Hadeethi, M. A. (2018). *Comparative anatomical study of some *Cassia* L. species (Fabaceae) from middle and south of Iraqi districts* (Master's thesis). University of Baghdad, College of Education for Pure Sciences / Ibn Al-Haitham.
16. Al-Muhammadi, A. N. A., Almehemdi, A. F. A., Al-Ubaidi, A. F., & Nasrallah, A. Y. (2013). Response of caraway plant to spraying extracts of kajrat and senna and vitamin complex and their effect on volatile oil and active ingredient. *Tikrit University Journal of Agricultural Sciences*, 13 (2), 237–250.
17. Al-Shahat, N. A. Z. (1986). *Medicinal plants and herbs*. National Research Center.
18. Al-Tamimi, H. J. M. (2008). *A comparative anatomical study of some species of the Caesalpinioaceae family in Iraq* (Master's thesis). Karbala University, Scientific Journal.
19. Amao, S. Y., Ajani, R. S., & Oladapo, O. (2010). *Cassia alata* alters liver structure in rat. *African Journal of Biomedical Research*, 13 (3), 231–233.
20. Amponsah, I. K., Menasah, A. Y., Ampofo, E. K., Bekoe, S. O., Sarpong, F. M., & Gibira, Y. (2016). Pharmacognostic studies of the leaves and seeds of *Cassia occidentalis* (Linn.) (Leguminosae). *Journal of Pharmacognosy and Phytotherapy*, 5 (3), 250–255.
21. Andrew, M. G., Friedman, M. H., & Northrop, J. (2015). *Cassia javanica, Kenyan cassia* (UF/IFS Extension, University of Florida; p. 102).
22. Anis, M., Siddique, I., Naz, R., Ahmed, M. R., & Aref, I. M. (2012). Advances in micropropagation of a highly important *Cassia* species: A review. In A. Bandani (Ed.), *New perspectives in plant protection* (pp. 191–206).
23. Awal, M. A., Ahsan, S. M., Haque, E., Asghorq, H., & Ahmed, M. (2010). *In vitro* antibacterial activity of leaf and root extract of *Cassia fistula*. *Dina Journal of Medical and Pharmaceutical Research*, 3, 10–13.
24. Awomukwu, D. A., Nyananyo, B. L., Ikpeama, A. I., & Adieze, C. U. (2015). Comparative chemical constituents of some *Cassia* species and their pharmacognostic importance in southeastern Nigeria. *Science Journal of Chemistry*, 3 (3), 40–49. <https://doi.org/10.11648/j.sjc.20150303.11>
25. Bakhiet, A. O., & Adam, S. E. I. (1996). Toxicity to bovines' chicks of *Cassia italic* seeds. *Phytotherapy Research*, 10 (2), 156–160. <https://doi.org/10.1002/ptr.2600100208>
26. Bentham, G. (1871). Revision of the genus *Cassia*. *Transactions of the Linnean Society of London*, 27, 503–591.
27. Bentham, L. G., & Hooker, J. D. (1862). *Genera plantarum* (Vol. 1, Issue 1, p. 524). Reeve & Co. Ltd.
28. Bhalerao, S. A., & Kelkar, T. S. (2012). Traditional medicinal uses, phytochemical profile and pharmacological activities of *Cassia fistula* Linn. *International Research Journal of Biological Sciences*, 1 (5), 79–84.
29. Brach, A. R., & Song, H. (2006). Efloras: New directions for online floras exemplified by the flora of China project. *Taxon*, 55 (1), 188–192. <https://doi.org/10.2307/25065532>
30. Carvalho, D. M. G. (1983). Anatomia foliar de *Cassia ensiformis* Vell. (Leguminosae-Caesalpinioideae). *Arquivo do Jardim Botânico do Rio de Janeiro*, 27, 157–169.
31. Carvalho, F. D. (1967). Contribution to the study of the foliage of Leguminosae of Cerrados. *Anais da Academia Brasileira de Ciências*, 39, 509–520.

32. Chakravarty, H. L. (1976). Plant wealth of Iraq (Vol. 1). Baghdad, Botany Directorate, Ministry of Agriculture and Agrarian Reform.
33. Choi, I. S., & Choi, B. H. (2017). The distinct plastid genome structure of *Maackia fourieri* (Fabaceae: Papilionoideae) and its systematic implications for genistoids and tribe Sophoreae. *PLoS ONE*, 12 (4), 1–19. <https://doi.org/10.1371/journal.pone.0175052>
34. Chouse, A., & Jamal, A. (1978). Studies on the bark anatomy of some *Cassia* species. *Indian Journal of Botany*, 1 (1–2), 91–97.
35. Dave, H., & Ledwani, L. (2012). A review on anthraquinones isolated from *Cassia* species and their applications. *Indian Journal of Natural Products and Resources*, 3 (3), 291–319.
36. Devecchi, M. F., Pirani, J. R., & Meio-de-Pina, G. F. D. (2014). Comparative leaf anatomy and morphology of some Brazilian species of *Crotalaria* L. (Leguminosae: Papilionoideae: Crotalariaeae). *Acta Botanica Brasilica*, 28 (4), 583–593. <https://doi.org/10.1590/S0102-33062014000400010>
37. Doyle, J. J., & Luckow, M. A. (2003). The rest of the iceberg: Legume diversity and evolution in a phylogenetic context. *Plant Physiology*, 131 (2), 900–910. <https://doi.org/10.1104/pp.017982>
38. Dubey, P. B., & Sawant, B. S. (2015). Pharmacognostic study of *Cassia tora* L.: A review. *Journal of Pharmaceutical Science and Innovation*, 4 (4), 208–211. <https://doi.org/10.7/ijrsi.2015.4420>
39. Duraipandiyan, V., & Ignacimuthu, S. (2007). Antibacterial and antifungal activity of *Cassia fistula* L.: An ethnomedicinal plant. *Journal of Ethnopharmacology*, 112 (3), 590–594. <https://doi.org/10.1016/j.jep.2007.04.002>
40. El-Hashash, M. M., Abdel-Gawad, M. M., El-Sayed, M. M., Sabry, W. A., Abdel-Hameed, E. S., & Abdel-Lateef, E. E. (2010). Antioxidant properties of methanolic extracts of the leaves of seven Egyptian *Cassia* species. *Acta Pharmaceutica*, 60 (3), 361–367. <https://doi.org/10.2478/v10008-010-0028-6>
41. Frodin, G. D. (2004). History and concepts of big plant genera. *Taxonomy*, 53 (3), 753–776.
42. Ghouse, A. K. M., Hashmi, S., & Jamal, A. (1980). Certain anatomical characteristics of the bark of some ornamental trees suitable for arid zone environment. *Annals of Arid Zone*, 19 (4), 425–426.
43. Haw, S. G. (2017). Studies on ancient history: Cinnamon, *Cassia* and ancient trade. *Journal of Ancient History and Archaeology*, 4, 5–18. <https://doi.org/10.1515/jah-2016-0022>
44. Hibeen, M. G., Sibhat, G. G., Fanta, B. S., Gebrezgi, H. D., & Tesema, S. B. (2016). Evaluation of *Senna singueana* leaf extract as an alternative or adjuvant therapy for malaria. *Journal of Traditional and Complementary Medicine*, 6 (1), 112–117. <https://doi.org/10.1016/j.jtcme.2015.04.002>
45. Hill, A. F. (1937). *Economic botany: A textbook of useful plants and plant products*. McGraw-Hill Book Company.
46. Hooker, J. D. (1879). *Flora of British India* (Vol. II). L. Reeve and Co. Ltd.
47. Hussein, J. Q. (2016). Early detection of chromosome duplication resulting from the effect of colchicine in *Cassia angustifolia*. *Diyala Journal of Agricultural Sciences*, 8 (2), 50–57.
48. Hutchinson, J., & Duizel, J. M. (1958). *Flora of West Tropical Africa* (2nd ed., Vol. 1, No. 2). Whitefriars Press.
49. Hutchinson, J. (1934). *The families of flowering plants* (Vol. II). Clarendon Press.
50. Irshad, M., Singh, M., & Rizvi, M. A. (2010). Assessment of anthelmintic activity of *Cassia fistula* L. *Middle-East Journal of Scientific Research*, 5 (5), 346–349.
51. Irwin, H. S. (1964). *Monographic studies in Cassia* (Leguminosae-Caesalpinioideae): Section *Xerocalyx* (Memoirs of the New York Botanical Garden, Vol. 12, pp. 1–114). New York Botanical Garden.
52. Irwin, H. S., & Barneby, R. C. (1982). The American Cassiinae: A synoptical revision of Leguminosae tribe Cassieae subtribe Cassiinae in the New World (Memoirs of the New York Botanical Garden, Vol. 35, No. 1, p. 465). New York Botanical Garden.
53. Irwin, H. S., & Turner, B. L. (1960). Chromosomal relationships and taxonomic considerations in the genus *Cassia*. *American Journal of Botany*, 47 (4), 309–318. <https://doi.org/10.1002/j.1537-2197.1960.tb07040.x>
54. Jaca, T. (2017). *Senna didymobotrya* (Fabaceae: Caesalpinioideae): Northwestern, eastern and southern Africa and Madagascar. *Flowering Plants of Africa*, 65, 68–75.
55. Jafrari, M. A., Subhani, M. J., Javed, K., & Singh, S. (1999). Hepatoprotective activity of leaves of *Cassia occidentalis* against paracetamol and ethyl alcohol intoxication in rats. *Journal of Ethnopharmacology*, 66 (3), 255–361. [https://doi.org/10.1016/S0378-8741\(98\)00160-5](https://doi.org/10.1016/S0378-8741(98)00160-5)
56. Jain, R., Agrawal, O. P., Jain, N. K., & Jain, S. C. (2013). Phytochemical and biological evaluation of *Cassia nodosa* root bark. *Journal of the Indian Chemical Society*, 90 (12), 2287–2290.

57. Jalal, A. S., Ali, N. A. H., & Al-Douri, S. H. (2009). Genetic effect of aqueous extracts of seeds of glutinous bean plants, soybeans, Senna leaves and their mixture in white mice. *Iraqi Journal of Biotechnology*, 8 (2), 513–520.
58. Jeruto, P., Arama, P., Anyango, B., Nyunja, R., Taracha, C., & Opiyo, S. (2017). Morphometric study of *Senna didymobotrya* (Fresen.) H.S. Irwin and Barneby in Kenya. *Journal of Natural Sciences Research*, 7 (6), 54–69.
59. Jothy, S. L., Zakaria, Z., Chen, Y., Lau, Y. L., Latha, L. Y., & Sasidharan, S. (2011). Acute oral toxicity of methanolic seed extract of *Cassia fistula* in mice. *Molecules*, 16 (7), 5268–5282. <https://doi.org/10.3390/molecules16075268>
60. Junior, C. V., Rezende, A., Silva, D. H. S., & Bolzani, I. C. V. (2006). Ethnopharmacological, biological and chemical aspects of the *Cassia* genus. *Química Nova*, 29 (6), 1279–1286. <https://doi.org/10.1590/S0100-40422006000600024>
61. Kajita, T., Ohashi, H., Tateishi, Y., Bailey, C. D., & Doyle, J. J. (2001). *rbcl* and legume phylogeny with particular reference to Phaseoleae, Millettieae and Allies. *Systematic Botany*, 26 (3), 515–536. <https://doi.org/10.2307/3647899>
62. Kamarapu, P. (2015). Pharmacognostic, phytochemical and pharmacological studies of *Cassia roxburghii*. *Journal of Bioengineering and Biomedical Science*, 5 (2), 152–158. <https://doi.org/10.4172/2155-9845.1000152>
63. Kamble, S. I. (2013). Effect of agrochemical (2,4-D) on anatomical aspects of *Cassia tora* Linn. *BioScience, Biotechnology, and Research Asia*, 10 (2), 885–889.
64. Kamra, S. K. (1976). Use of X-ray radiography for studying seed quality in tropical forestry. *Silvae Genetica*, 131, 1–34.
65. Kapoor, V. P. (2000). *Cassia nodosa* (pink cassia) seed: A new source of commercial gum. *Journal of Scientific and Industrial Research*, 59, 23–31.
66. Karaboon, S., Ripona, S., Thanapornpoonpong, S.-N., Pawelzik, E., & Veerasilp, S. (2005). Breaking dormancy and optimum storage temperature of golden shower (*Cassia fistula*) seeds. In *Conference on International Agricultural Research for Development, Stuttgart-Hohenheim* (p. 17).
67. Kim, D. H., Yoon, B. H., Kim, Y. W., Lee, S., Shin, B. Y., Jung, J. W., Kim, H. J., Lee, Y. S., Choi, J. S., Kim, S. Y., Lee, K. T., & Ryu, J. H. (2007). The seed extract of *Cassia obtusifolia* ameliorates learning and memory impairments induced by scopolamine or transient cerebral hypoperfusion in mice. *Pharmacological Sciences Journal*, 105, 82–93.
68. Kirtikar, K. R., & Basu, B. D. (1999). *Indian medicinal plants* (2nd ed.). Singh and Singh.
69. Kittur, B. S., Srinivas, Y., & Deshpande, S. R. (2015). Evaluation of leaf and stem extracts from *Cassia gluca* L. for antimicrobial activity. *International Journal of Pure and Applied Zoology*, 3 (1), 98–102.
70. Kumar, U. S. U. (2016). Bioactivity determination of *Cassia surattensis* seed extract (Master's thesis). Institute for Research in Molecular Medicine, University Sains Malaysia.
71. Kumar, U. S. U., Jothy, S. L., Gothai, S., Dharmara, J. S., Chen, Y., & Sasidharan, S. (2014). Standardization and quality evaluation of *Cassia surattensis* seed extract. *Research Journal of Pharmacy and Biological and Chemical Sciences*, 5 (5), 355–363.
72. Kumaran, A., & Karunakaran, J. (2007). In vitro antioxidant activities of methanol extracts of five *Phyllanthus* species from India. *Letters in Food Science and Technology*, 40, 344–352.
73. Lavanya, B., Narayanan, N., Maheshwaran, A., Suganya, S., Sree, Y. S., Aravindan, S. V., & Vigneshwar, M. (2016). Basic anatomical and pharmacognostical study of *Cassia fistula* Linn. (Caesalpinioideae). *International Journal of Pharmaceutical and Biological Sciences*, 6 (3), 105–120.
74. Lee, S. E., Hwang, H. J., Ha, J. S., Jeong, H. S., & Kim, J. H. (2003). Screening medicinal plant extracts for antioxidant activity. *Life Sciences*, 73 (2), 167–179. [https://doi.org/10.1016/S0024-3205\(03\)00354-2](https://doi.org/10.1016/S0024-3205(03)00354-2)
75. Linnaeus, C. (1753). *Species plantarum*. Cambridge University Press.
76. Lock, J. M. (1988). *Cassia* sect. *Senna* (Leguminosae-Caesalpinioideae) in Africa. *Kew Bulletin*, 43 (2), 333–342. <https://doi.org/10.2307/4110016>
77. Maneemegalai, S., & Naveen, T. (2010). Evaluation of antibacterial activity of flower extracts of *Cassia auriculata*. *Ethnobotanical Leaflets*, 14, 8–20.
78. Manikandan Selvi, S., Vadivel, V., & Brindha, P. (2016). Studies on physicochemical and nutritional properties of aerial parts of *Cassia occidentalis* L. *International Journal of Pharmaceutical Sciences and Research*, 37 (2), 141–146.
79. Martin, A. C. (1946). The comparative internal morphology of seeds. *American Midland Naturalist*, 36, 513–660. <https://doi.org/10.2307/2421536>

80. Mathur, M. (1985). Comparative structure of epidermal structure and seed analysis of two Cassia species. *Geo Bios New Reports*, 4 (1–2), 96–97.
81. Mazumder, P. M., Farswan, M., & Parcha, V. (2009). Effect of an isolated active compound (CG-1) of Cassia gluca leaf on blood glucose, lipid profile and atherogenic index in diabetic rats. *Indian Journal of Pharmacology*, 41 (4), 182–186. <https://doi.org/10.4103/0253-7613.56155>
82. Melotte, R. (1972). Anatomical and micrographic study of the leaflets of five Cassia species from eastern Rwanda. *La Cellule*, 69 (2), 137–151.
83. Metcalfe, C. R., & Chalk, L. (1950). *Anatomy of the dicotyledons* (Vol. 1). Clarendon Press.
84. Monkheang, P., Sudmoon, R., Tanee, T., Noikotr, K., Bletter, N., & Chaveerach, A. (2011). Species diversity, usages, molecular markers and barcodes of medicinal Senna species (Fabaceae , Caesalpinioideae) in Thailand. *Journal of Medicinal Plants Research*, 5 (26), 6173–6181. <https://doi.org/10.5897/JMPR11.1139>
85. Nanyingi, M. O., Mbaria, J. M., Lanyasunya, A. L., Wagate, C. G., Koros, K. B., Kaburia, H. F., Munenge, R. W., & Ogaro, W. O. (2008). Ethnopharmacological survey of Samburu District, Kenya. *Journal of Ethnobiology and Ethnomedicine*, 4 (1), 14. <https://doi.org/10.1186/1746-4269-4-14>
86. Neelam, C., Ranjan, B., Komal, S., & Nootan, C. (2011). Review on Cassia fistula . *International Journal of Research in Ayurveda and Pharmacy*, 2 (2), 426–430.
87. Neog, P., Choudhury, S., Bhattacharjee, A., Chetia, P., Laskar, M. A., & Choudhury, M. D. (2013). Cassia javanica Linnaeus [Caesalpinaceae]: Phytochemical analysis and antimicrobial activity against multi-drug resistant hospital isolates of Staphylococcus . *Pleione*, 7 (2), 406–412. <https://doi.org/10.11609/j.issn.1008-2026.7.2.406-412>
88. Okpon, E. N. U. (1969a). Morphological notes on the genus Cassia : I. (1. Comparative morphology of seeds and polyembryony; 2. The vascular pattern in the cotyledons; 3. Types of hairs). *Notes from the Royal Botanic Garden Edinburgh*, 29 (2), 185–196.
89. Okpon, E. N. U. (1969b). Morphological notes on the genus Cassia . II: Stomatal distribution and morphology, floral ontogeny and aestivation. *Notes from the Royal Botanic Garden Edinburgh*, 29 (3), 331–342.
90. Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., & Anthony, S. (2009). *Agroforest tree database: A tree reference and selection guide* (2nd ed., p. 22). World Agroforestry Centre.
91. Ottu, O. J., Atawodi, S. E., & Onyike, E. (2013). Antioxidant, hepatoprotective and hypolipidemic effects of methanolic root extract of Cassia singueana in rats following acute and chronic carbon tetrachloride intoxication. *Asian Pacific Journal of Tropical Medicine*, 6 (8), 609–615. [https://doi.org/10.1016/S1995-7645\(13\)60125-3](https://doi.org/10.1016/S1995-7645(13)60125-3)
92. Pandey, Y. N. (1970). Cuticular studies in Cassia . *Journal of the Indian Botanical Society*, 49 , 151–157.
93. Patel, B. R., Patel, N. D., & Dave, Y. S. (1976). Pericardial study in the developing fruit of Cassia occidentalis L. *Flora*, 165 , 215–222. [https://doi.org/10.1016/S0367-2530\(17\)30071-3](https://doi.org/10.1016/S0367-2530(17)30071-3)
94. Pinzón-Torres, J. A., Dossantos, V. R., Schiavinato, M. A., & Maldonado, S. (2009). Biochemical, histochemical and ultrastructural characterization of Centrolobium robustum (Fabaceae) seeds. *Hoehnea*, 36 (1), 149–160. <https://doi.org/10.1590/S0015-58722009000100011>
95. Rajni, S., & Navneet, G. S. (2014). Antibacterial and phytochemical analysis of Cassia occidentalis L. seeds against respiratory tract pathogens. *Indian Journal of Natural Products and Resources*, 5 , 52–55.
96. Randell, B. R., & Barlow, B. A. (1998). *Senna Flora of Australia* (Australian Biological Resources Study, pp. 89–138). Australian Government Publishing Service.
97. Ridley, H. N. (1967). *The flora of the Malay Peninsula* (Vol. 1). L. Reeve and Co. Ltd.
98. Ruwaih, A. (1983). *Herbal medicine* (4th ed.). Dar Al-Qalam.
99. Saad, S. I. (1984). *Flowering plants: Their origins, development, and classification* (6th ed.). Dar Al Fikr Al Arabi.
100. Sanyal, S. (2015). Evaluation of exomorphic characters of some Indian species of Cassia occurring in and around Kolkata, West Bengal with an overview on cytotoxicity. *International Journal of Innovative Science, Engineering & Technology*, 2 (2), 414–430.
101. Sastry, V. S., Girija, S. V., Appalanaidu, B., Srinivas, K., & Annapurna, A. (2011). Chemical and pharmacological evaluation of aqueous extract of seeds of Cassia occidentalis . *Chemistry and Pharmaceutical Research Journal*, 3 (2), 566–575.
102. Seethapathy, G. S., Ganesh, D., Kumar, J. U. S., Senthilkumar, U., Neumaster, S. G., Ragupathy, S., Shaanker, R. U., & Ravikanth, G. (2015). Assessing product adulteration in natural health products for laxative-yielding plants, Cassia , Senna , and Chamaecrista , in southern India using DNA barcoding. *International Journal of Legal Medicine*, 129 (4), 693–700. <https://doi.org/10.1007/s00414-015-1178-8>

103. Shah, G. L., & Gopal, B. V. (1971). Structure and development of stomata on the vegetative and floral organs in some members of Caesalpiniaceae. *Annals of Botany*, 35 (142), 745–759.
104. Sharma, A., Ahmad, S., & Harikumar, S. L. (2014). Pharmacognosy, phytochemistry & pharmacology of *Cassia javanica* Linn.: A review. *International Journal of Pharmacognosy and Phytochemical Research*, 3 (4), 101–105.
105. Sharma, D. K. (2017). Enumeration on phytochemical, pharmacological and ethnobotanical properties of *Cassia fistula* Linn: Yellow shower. *The Journal of Pharmacognosy and Phytotherapy*, 6 (5), 300–306.
106. Sharma, R. A., Bhardwaj, R., & Sharma, P. (2013). Antimicrobial activity of sequential extracts from leaves of *Cassia nodosa* Buch. *African Journal of Pharmacy and Pharmacology*, 7 (27), 1876–1879. <https://doi.org/10.5897/AJPP12.015>
107. Sharmila, T. S., & Yogamoorthi, A. (2015). Studies on micro-morphological characteristics of extrafloral nectar gland of *Cassia hirsuta* Linn. *International Journal of Recent Scientific Research*, 6 (6), 4904–4908.
108. Sihanat, A., Rungsihirunrat, K., Palanurej, C., & Ruangrunsi, N. (2016). Characteristics and number of trichomes of leaves from selected *Cassia* spp. in Thailand. *Bangkok Health Science and Technology Journal*, 14 , 10–20.
109. Simmonds, S., Holst, P., & Bourke, C. (2000). The palatability and potential toxicity of Australian weeds to goats (RIRDC Publication No. 00/103). Rural Industries Research and Development Corporation.
110. Singh, S. A., & Singh, N. R. (2010). Antimicrobial activity of *Cassia didymobotrya* and *Phlogacanthus thyrsoiflorus* . *Journal of Chemical and Pharmaceutical Research*, 2 (4), 304–308.
111. Sivakumaran, G., Rao, M. R. K., Prabhu, K., Kalaiselvi, V. S., Jones, S., Johnson, W. M., & Antony, J. (2016). Preliminary GC-MS analysis and antioxidant study of one Ayurvedic medicine *Manasa mitra vatakam* . *International Journal of Pharmaceutical Sciences Review and Research*, 37 (1), 190–199.
112. Smith, D. L. (1983). Cotyledon anatomy in the Leguminosae. *Botanical Journal of the Linnean Society*, 86 (1), 325–355. <https://doi.org/10.1111/j.1095-8339.1983.tb00775.x>
113. Solereder, H. (1908). Systematic anatomy of the dicotyledons (Vol. 1). Clarendon Press.
114. Soltis, D. E., Soltis, P. S., Morgan, D. R., Swenson, S. M., Mullin, B. C., Dörn, J. M., & Martin, P. G. (1996). Chloroplast gene sequence data suggest a single origin of the predisposition for symbiotic nitrogen fixation in Angiosperms. *Proceedings of the National Academy of Sciences*, 92 (7), 2647–2651. <https://doi.org/10.1073/pnas.92.7.2647>
115. Sprent, J. (2001). Nodulation in legumes . Royal Botanic Gardens, Kew.
116. Srividhya, M., Hridya, H., Shanthi, V., & Ramanathan, K. (2017). Bioactive amentoflavone isolated from *Cassia fistula* L. leaves exhibits therapeutic efficacy. *3 Biotech*, 7 (1), 33. <https://doi.org/10.1007/s13205-016-0586-z>
117. Stace, C. (1980). Plant taxonomy and dicotyledons . Clarendon Press.
118. Steven, J. F., Hart, T., Han, R. C., Van-Elema, E. T., Uander, E. M., Wilderboer, M., & Zwaving, J. H. (1995). Distribution of alkaloids, tannins in the Clusiaceae. *Biochemical Systematics and Ecology*, 23 , 257–276. [https://doi.org/10.1016/0305-1978\(95\)00016-0](https://doi.org/10.1016/0305-1978(95)00016-0)
119. Sung, B. K., Kim, M. K., Lee, W. H., Lee, D. H., Shin, B. Y., Jung, J. W., Kim, H. J., Lee, Y. S., Choi, J. S., Kim, S. Y., Lee, K. T., & Ryu, J. H. (2004). Growth responses of *Cassia obtusifolia* toward human intestinal bacteria. *Fitoterapia*, 75 (5), 505–509. [https://doi.org/10.1016/S0367-326X\(04\)00063-8](https://doi.org/10.1016/S0367-326X(04)00063-8)
120. Symon, D. E. (1956). Polyembryony in *Cassia* . *Nature*, 177 , 177–191.
121. Tadhani, M. B., Patel, V. H., & Subhash, R. (2007). In vitro antioxidant activities of *Stevia rebaudiana* leaves. *Journal of Food Composition and Analysis*, 20 (3–4), 323–329. <https://doi.org/10.1016/j.jfca.2006.03.006>
122. Townsend, C. C., & Guest, E. (1974). *Flora of Iraq* (Vol. 3). Ministry of Agriculture and Agrarian Reform.
123. Tripathi, S., & Mondal, A. K. (2012). Comparative quantitative and qualitative studies of stomata of selected six medicinally viable species of *Cassia* L. *International Journal of Life Sciences, Biotechnology and Pharma Research*, 1 (3), 104–113.
124. Uzzi, H. O., & Grillo, D. B. (2013). The hepatoprotective potentials of aqueous leaf extract of *Cassia occidentalis* against paracetamol-induced hepatotoxicity in adult Wistar rats. *International Journal of Herbal Pharmacology and Research*, 2 (3), 6–13.
125. Veeravagavan, S., & Ramamoorthy, D. (2016). Seed-based anatomical studies in stipular extrafloral nectary tissues in *Cassia alata* Linn. *International Journal of Current Research*, 8 (2), 25955–25960. <https://doi.org/10.24940/theijst/2016/v4/i12/P1612-0288.pdf>

126. Viswanathan, M. B., Thangadurai, D., & Ramesh, N. (2001). Biochemical and nutritional evaluation of *Neonotonia wightii* (Wight and Arn.) Lackey (Fabaceae). *Food Chemistry*, 75 (3), 275–279. [https://doi.org/10.1016/S0308-8146\(01\)00217-8](https://doi.org/10.1016/S0308-8146(01)00217-8)
127. Wagner, W. L., Herbst, D. R., & Lorence, D. H. (2014). *Flora of the Hawaiian Islands*. Smithsonian Institution.
128. Watari, S. (1934). Anatomical studies on some leguminous leaves with special reference to the vascular system in petioles and rachises. *Journal of Faculty of Science, Imperial University of Tokyo*, 4 (3), 225–365.
129. Watson, L., & Dallwitz, M. J. (1992). The families of flowering plants. *An International Journal for Botany and Mycology*, 14 (5), 486. <https://delta-intkey.com>
130. Zaman, K., Khan, M. R., Ali, M., & Maitland, D. J. (2011). New anthraquinone dimer from the root bark of *Cassia artemisioides* (Gaudich. ex DC) Randell. *Journal of Asian Natural Products Research*, 13 (1), 62–67. <https://doi.org/10.1080/10286020.2010.523124>