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REVIEW ARTICLE

ORIGIN, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETIC DIVERSITY, BREEDING AND CULTIVATION OF STAR ANISE

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In this review article on Origin, Taxonomy, Botanical Description, Genetic Diversity, Breeding and Cultivation of Star Anise are discussed.

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ABSTRACT

Star Anise belongs to the family *Illiciaceae,* genus *Illicium* and species Illicium verum. Indian Name are in Hindi : Anasphal Malayalam : Takkolam Marathi : Badian Oriya : Anasphul Tamil : Anashuppu Telugu : Anaspuvu Urdu : Badyani**.** Foreign Name are in Chinese : Ba jiao Czech : Badyan Dutch : Steranijs French : Anis de la chine German : Sternanis Indonesia : Bunga lawang Italian : Anice stellato Nepali : Star phul Russian : Badyan Spanish : Badian**.** Other common names are Badian star anise, Chinese anise, Chinese aniseed, Chinese star anise, Indian anise, Star aniseed, True star anise**.** In China, it is called Chinese star anise and Bajiaohuixiang. French: Anis de la Chine, Anise etoile, Badiane, Japan: Dai-uikyo, Hakkaku-uikyo, German: Stenanis, Italian: Anice stellate, India: Sonf, Anasphal, Spanish: Anisestrellado, Badian, Indonesian: Bungalawang, Malay: Bungalawang, Portuguese: Anis estrelado, Badiana da China, Anis da China**.** Star Anise is a plant that brings high economic efficiency to farmers. However, to bring out the best quality of Star Anise, you need to pay attention to grow star anise technique and environmental influences. Star anise is an aromatic spice that resembles a star and is highly valued for its distinct flavour and aroma. It has some health advantages beyond just taste.Star anise gives food an extra flavour boost. We can identify India's cultural and culinary legacy based on our knowledge of star anise cultivation there. Understanding the cultivation process is essential to ensuring the long-term sustainability of star anise cultivation in India and the quality of the spices produced. The scientific name for star anise is *Illicium verum*, from southwest China—a rich cultural and culinary legacy. Initially used in Chinese medicine, this healing spice eventually entered Asian and Middle Eastern cuisine. Star anise is a common ingredient in many kitchens worldwide, appreciated for its flavour and possible health benefits.. It gives a distinct taste to a variety of dishes.Star anise is a spice from an evergreen tree. The Farmers have developed better growing practices for star anise cultivation in India and found the perfect growing conditions over time to produce high-quality and highly demanded spice " Star anise". Star anise is the dried fruit of a small to medium evergreen tree. The tree bears fruit after about 6 years and can have a productive life of up to 100 years. Each point of the star-shaped husk contains a shiny amber-coloured seed. Both the seed and husk are used for the ground spice. In ancient times, this treasure from Asia was so valuable that Marco Polo kept its origin a secret. Star anise is an eight-pointed star with delicious flavors of fennel and green anise. It is the perfect companion for your punches, mulled wines, and infused rums, and it also finds its place in broths, chutneys, compotes, and syrups. Star anise is a star-shaped spice derived from the fruit of a small evergreen tree native to China and Vietnam. It has a distinct licorice-like flavour and is commonly used in Asian cuisine, herbal teas, and traditional medicine. Star anise is rich in bioactive compounds, including antioxidants, polyphenols, and anethole, which contribute to its health benefits. It also contains shikimic acid, a key ingredient in antiviral medications. Due to its antimicrobial, anti-inflammatory, and digestive properties, star anise is considered a healthy spice when consumed in moderation.

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INTRODUCTION

Star Anise belongs to the family *Illiciaceae/ Magnoliaceae,* genus *Illicium* and species Illicium verum (Mia, 2016; Shahrajabian et al., 2019; Indianspices, 2024; Researchgate, 2024; ACIR, 2024; Espicebazaar, 2024; Wikipedia, 2024a). Plant is known by

different local names in different regions of the world. It is called bādiyān (Persion), phoolchakri (Hindi), badiane (French), badian (Urdu), and star anise (English) (Boota et al., 2018). *Illicium* comes from the Latin *illicio* meaning "entice" or "seduce". *Verum* means "true" or "genuine". The name "badian" appears to derive, via French *badiane*, from the apparently descriptive Chinese name for it, pinyin: *bājiǎo*, lit. "eight horns". However, a derivation from the Persian *bādiyān,* "fennel", exists, with the Oxford English Dictionary indicating that its origin before that is unknown (Inaturalist, 2024). Indian Name are in Hindi : Anasphal Malayalam : Takkolam Marathi : Badian Oriya : Anasphul Tamil : Anashuppu Telugu : Anaspuvu Urdu : Badyani (Espicebazaar, 2024;,Indianspices, 2024). Foreign Name are in Chinese : Ba jiao Czech : Badyan Dutch : Steranijs French : Anis de la chine German : Sternanis Indonesia : Bunga lawang Italian : Anice stellato Nepali : Star phul Russian : Badyan Spanish : Badian (Indianspices, 2024; Espicebazaar, 2024). Other common names are Badian star anise, Chinese anise, Chinese aniseed, Chinese star anise, Indian anise, Star aniseed, True star anise (Iplantz, 2024). In China, it is called Chinese star anise and **Bajiaohuixiang**. French: Anis de la Chine, Anise etoile, Badiane, Japan: Dai-uikyo, Hakkaku-uikyo, German: Stenanis, Italian: Anice stellate, India: Sonf, Anasphal, Spanish: Anisestrellado, Badian, Indonesian: Bungalawang, Malay: Bungalawang, Portuguese: Anis estrelado, Badiana da China, Anis da China (Rocha and Tietbohl, 2016a). Star Anise is a plant that brings high economic efficiency to farmers. However, to bring out the best quality of Star Anise, you need to pay attention to grow star anise technique and environmental influences (Ngoc Nguyen, 2022).

On the basis of a study of allozyme variation in 4 enzyme systems of the seeds (9 loci), the frequency of the various alleles is given, together with the expected and actual distribution of genotypes in cultivated populations from different regions of the USSR (northern Crimea and south of western Siberia) (Shumskaya and Garifullina, 1990). The proportion of polymorphic loci was 31. 35-32.67% and the mean number of alleles/locus 1.22 (Shumskaya and Garifullina, 1990). In no case did the observed distribution of genotypes accord with that expected on the basis of the Hardy-Weinberg law (Shumskaya and Garifullina, 1990). Populations from the different regions differed in the distribution of genotypes at the polymorphic Est1 locus. Ameliorative selection over 5 generations in the population introduced from the Crimean province of the Ukraine into Siberia reduced the mean populational values for genetic diversity. The populations were genetically similar (Shumskaya and Garifullina, 1990). Star anise's job moonlighting as Tamiflu caught my eye because star anise is in a group of plant families with a very interesting pedigree (Frazer, 2009). It is in the Illiciaceae (Ill-ik-ee-ay'-see-ay), a small family whose members are all in one genus – Illicium. There are only about 40 species in the whole family (the pea family, for comparison, contains about 20,000), and their most distinctive characteristic are those beautiful star-shaped fruits, like the brown whorl at left (Frazer, 2009). They are woody trees or shrubs with shiny simple evergreen leaves and special spherical ethereal oil cells (full of anethole, in this case) in the bark, leaves and (obviously) fruit. Like retirees and Mexican drug-lords, they seem to prefer life in the tropics and sub-tropics (Frazer, 2009).

Illicium verum has a long history as a medicinal plant in Asian countries (Rocha and Tietbohl, 2016a). The fruit consists of eight follicles, spreading, woody and brown when mature, dehiscent by the ventral side (Rocha and Tietbohl, 2016a). Trans-anethole is the major component of essential oil from star anise (Rocha and Tietbohl, 2016a). This essential oil is widely used in food industry (Rocha and Tietbohl, 2016a). Star anise essential oil exhibits high antioxidant, insecticidal, antimicrobial, and antifungal activity (Rocha and Tietbohl, 2016a). Illicium verum Hook. f. (Schisandraceae), commonly known as star anise, is the fruit of a medium-sized tree that grows in North America, Atlantic region, and tropical and subtropical zones of Asia (Rocha and Tietbohl, 2016a). The fruit is a capsule-like, with a star-shaped aggregate of 5–10 radiating pointed sections, in a boat format, about eight on average (Rocha and Tietbohl, 2016a). Tough-skinned and rust colored, the fruits measure up to 3 cm long. Seeds are shiny brown or reddish with a high oil content, whose main component is trans-anethole (85–90%) (Rocha and Tietbohl, 2016a). The fruits and essential oils are commonly sold in markets and are frequently used as a well-known spice in the food industry (Rocha and Tietbohl, 2016a). Furthermore, they are frequently used as a flavoring in confectionery, tobacco, liqueurs, pastilles, and pharmaceutical preparations (Rocha and Tietbohl, 2016a). This plant is propagated by seed and mainly cultivated for perfume, medicines, and as a culinary spice in southern China, as well as in Vietnam (Rocha and Tietbohl, 2016a). The fruits are harvested before they ripen, then sun dried. The flowers are seen from March to May, and the fruits ripen from September to October (Rocha and Tietbohl, 2016a).

The *Illicium verum* (star anise) has long been used in traditional medicine and food industry with the actions of preventing cold, and relieving pain. Sometimes, it gets contaminated with highly poisonous Japanese star anise (*Illicium anisatum* L.) which contains toxic sesquiterpenes (Boota *et al*., 2018). Traditional uses of *Illicium verum* are evidenced from south and west Asia, where it has been consumed for a number of disorders (Boota *et al.,* 2018). Several bioactive constituents such as sesquiterpenes, phenylpropanoids, lignans, flavonoids and other compounds have been recognized from *Illecium verum* (Boota *et al*., 2018). The pharmacology studies demonstrated that its active compounds possess broad range of pharmacological uses, especially in cytotoxic, antioxidant, anti-inflammatory, sedative and antimicrobial activities. In addition, it is the chief source of anticancer agent (shikimic acid) (Boota *et al*., 2018). *I. verum* (Star anise*)* is native to China and Vietnam, where it has been used for over 3000 years. The generic name *llicium* comes from a Latin word, "alluring" means - fragrance. For centuries, this plant has been grown in temple and tombs by Japanese (Boota *et al.,* 2018). In the seventeenth century, it was introduced in Europe where it found its applications in food industry and used in baked food and jams as well as in the manufacture of anise-flavored liqueurs such as anisette and pernod (Boota *et al*., 2018). Star anise has been utilized frequently in Persian and Mughal Indian biryani rice dishes and curries. It was used as a substitute in commercial drinks for aniseed during 17th century (Boota *et al.,* 2018). Although star anise grows in variety of climates and environmental conditions, this herb is proliferated by seed and requires a larger quantity of water and acidic soil to grow well (Boota et al., 2018). It should be protected from low temperature (Boota *et al.,* 2018). Star anise grows in following countries: China, Japan, Laos, Philippine, Indonesia, Vietnam and Jamaica (Boota *et al.,* 2018). There are many producers working on it. More than 2000 t of star anise seeds per annum are produced by Vietnam. Around 1600 t of seeds are traded to Cuba and the Soviet Union. China is the world's largest producer of *I. verum* (Star anise) (Boota *et al*., 2018). The

star anise production in China in 2015-2016 was 95,000 tons. It has been transported to the dry and low temperature areas (Boota *et al.,* 2018).

Illicium is an ancient genus and member of the earliest diverging angiosperms known as the Amborellales, Nymphaeales, and Austrobaileyales (ANA) grade (Ranney *et al.,* 2018). These adaptable, broadleaf evergreen shrubs, including ≈40 species distributed throughout Asia and North America, are valued for diverse culinary, medicinal, and ornamental applications (Ranney *et al.,* 2018). The study of cytogenetics of *Illicium* can clarify various discrepancies and further elucidate chromosome numbers, ploidy, and chromosome and genome size evolution in this basal angiosperm lineage and provide basic information to guide plant breeding and improvement programs (Ranney *et al.,* 2018). All taxa appeared to be diploid and $2n = 2x = 28$, except for *Illicium floridanum* and *Illicium mexicanum* which were found to be $2n = 2x = 26$, most likely resulting from dysploid reduction after divergence into North America (Ranney *et al.,* 2018). The base chromosome number of $x = 14$ for most *Illicium* species suggests that *Illicium* are ancient paleotetraploids that underwent a whole genome duplication derived from an ancestral base of $x = 7$ (Ranney *et al*., 2018). Information on cytogenetics, coupled with phylogenetic analyses, identifies some limitations, but also considerable potential for the development of plant breeding and improvement programs with this genus (Ranney *et al.,* 2018). The ancient origin of ANA grade angiosperms (including *Illicium*), morphological similarity with early fossils, and limited molecular divergence suggests that these lineages may provide features and insights into the foundational traits of early angiosperms (Ranney *et al*., 2018). There have only been limited reports on chromosome numbers and relative genome sizes for species and cultivars of *Illicium*. A base chromosome number of $x = 14$ and diploidy has been reported for *Illicium anisatum*, *Illicium parviflorum*, *Illicium ternstroemioides*, and *Illicium verum* (Ranney *et al*., 2018). After many millions of years of divergence, there are now ≈40 extant species of shrubs and small trees within the genus *Illicium,* including six found in the New World and the remaining species distributed throughout Asia (Ranney *et al*., 2018). *Illicium* are also of interest because of their unique and diverse plant metabolites that have both medicinal and culinary uses. Certain species of *Illicium* have been used in traditional medicine for treating pain, rheumatism, and skin inflammation (Ranney *et al*., 2018). Most plant organs of *Illicium* are noticeably pungent with a strong odor of anise/terpenes. Extensive studies have been conducted to identify these compounds that include prenylated C_6–C_3 compounds, neolignans, and secoprezizaane-type sesquiterpenes that are found exclusively in *Illicium* (Ranney *et al.,* 2018). Many species have attractive, tropical-looking evergreen leaves and distinctive showy flowers in whites, pinks, and reds in spring and summer/fall (Ranney *et al.,* 2018).

Traditional Chinese medicines consider as both medicine and food item, because most of Chinese medicine are used as pigments and flavors in the preparation of Chinese food items (Shahrajabian *et al.,* 2019). Star anise (*Illicium verum Hook. f*.) is a medium-sized evergreen tree which is native to southwest of China; and also widely cultivated in the subtropical and tropical areas of Asia (Shahrajabian *et al*., 2019). Common name of *I. verum* has many synonyms in different areas: Chinese star anise or Bajiaohuixiang in China; Anis de la Chine, Anise etoile or Badiane in France; Dai-uikyo or Hakkaku-uikyo in Japan; Sternanis in Germany; Anice stellato in Italy; Sonf or Anasphal in India; Anis estrellado in Spain; Bunga lawing in Indonesia and Malaysia (Shahrajabian *et al.,* 2019). Star anise is extensively cultivated in a limited area with particular ecological factors in Kwangsi in South East China and Tonkin in Indo-China. Chinese star anise is considered as one of the flavors used in China five spices (Shahrajabian *et al.,* 2019). In traditional Chinese medicine, it is called as warming yang and dispelling cold, and regulating the flow of Qi to relieve pain or common cold (Shahrajabian *et al.,* 2019). It has been also reported that its crude fruits and its powders were used in traditional teas to treat nervousness and sleeplessness and also as a sedative (Shahrajabian *et al*., 2019). Dried ripe, star anise fruit and seed are used as important spice in Asian cooking especially in Chinese, Vietnamese and Indian cuisines (Shahrajabian *et al.,* 2019). Vietnam produces more than 5000 t of star anise seeds per annum; and it is estimated that the combined production of China and Vietnam is more than 25,000 t per annum (Shahrajabian *et al.,* 2019). Moreover, 200-250 t of essential oil are shipped to France and the Czech Republic (Shahrajabian *et al.*, 2019). In China, which is the largest supplier of star anise to the world market, Vietnamese star anise is blended and then exported to France. In France, it is used as a raw material in the production of alcoholic beverages (Shahrajabian *et al*., 2019). Star anise has long been used in traditional Chinese medicine and the food industry with the effects of dispelling cold, regulating the flow of Qi, and relieving pain (Shahrajabian *et al.*, 2019). *Illicium verum Hook. f*. mainly grows in the provinces of Guangxi, Guangdong and Yunnan, covered nearly 80% in the world (Shahrajabian *et al*., 2019). This plant also has been reported to possess anti-bacterial, anti-cancer and of course anti-inflammatory characteristics (Shahrajabian *et al.,* 2019). Chinese anise star can alleviate inflammatory responses and is a common flavor in medicinal tea, cough mixtures and pastilles (Shahrajabian *et al.,* 2019). Star anise is classified in the division Magnoliohpyta, class Magnoliopsida, sub-class Magnoliidae, order Austrobaileyales, family Illiciaceae. Among all *Illicium* species present throught the world, such as *Illicium dunnianum*, *Illicium griffithii*, *Illicium verym* and *Illicium anisatum*, just *Illicium verum Hooker anisatum* is non-poisonous and has been used in culinary preparation and also as famous traditional medicine. Dried fruit of Chinese star anise is used as a remedy to treat infant colic (Shahrajabian *et al*., 2019). It was found that the fruit is also most toxic, followed by the seed, root, leaf and bark. It is very difficult to detect fragments of Japanese star anise fruit in powdered Chinese Star Anise fruit (Shahrajabian *et al.,* 2019). Star anise is a medium sized tree, 8-15 m tall and 30 cm depth, with the bark which is white to bright grey. Furthermore, its leaves are 6-12 cm long, alternate, simple, leathery, entire, glabrous, shining, usually crowded in bundles at the end of the branches; it also has large flower, bisexual, 1-1.5 cm in diameter, white pink to red or greenish yellow, axillary and solitary (Shahrajabian *et al.,* 2019). Fruit is capsule like, aggregate is star shapes; each arm is seed pod. In China, star anise is frequently used as spice in Chinese cuisine. Its fruit has an agreeable, aromatic, sweet taste and a pleasant fragrance resembling anise (Shahrajabian *et al*., 2019). Fruits are picked before the ripe and dried, and seeds are shiny brown or reddish with high oil content (Shahrajabian et al., 2019). Flowers bloom from March to May, and the fruits ripe from September to October. Anethole of star anise has been utilized in folk medicine industry because of its soothing and antispasmodic properties (Shahrajabian *et al.,* 2019). Estragole (4-allyl anisole, 1-methoxy-4-enylbenzene) is a naturally occurring compound which can be extracted from Anise, and Chinese star anise; flavors and fragrances containing estragole are used in food products, perfumes,

soaps and detergents (Shahrajabian *et al.,* 2019). Traditionally, the oil of star anise used topically for rheumatism and otalgia and also as an antiseptic. Star anise oil is a pale yellowish liquid (Shahrajabian *et al.,* 2019). Star anise is socially accepted in occasions and is traditionally being used in high altitude regions of Arunachal Pradesh where dried seedless fruits are used as incense, flavouring tea, preparation of butter salted tea or sugar tea for sweet fragrance and to increase and improve the potency and strength of alcohol. Also, used as medicine to cure cough, toothache and sinusitis, used as an anti-fungal agent and food preservative (Shahrajabian *et al.,* 2019). Leaves in combination with juniper/thuja/pine leaves are burnt for making smoke which is believed to be scared and help in purifying surrounding air (Shahrajabian *et al.,* 2019). Its oil is useful in flatulence, spasmodic pains and dysentery, it also relieves colic and is a common ingredient of cough lozenges. Moreover, its oil is used as an applicant in rheumatism and also applicant as an antiseptic. Besides, it is also useful against body lice, bedbugs and is an ingredient of cattle sprays. Other usages of star anise oil is in fevers, scabies, constipation and insomnia (Shahrajabian *et al.,* 2019). Dried star anise fruit is almost composed of 49 compounds which may included trans-anethole (81.40%), limoene (6.50%), chavicol (2.10%), and also ani-saldehyde (1.81%) (Shahrajabian *et al.,* 2019). It also stated that the dried star anise fruit is composed of nearly 8-12% essential oil. Star anise primarily contains anethole and fatty oil. It is primarily located in the woody shell, to a lesser extent in the seed. Anethole is only slightly soluble in water but exhibits high solubility in ethanol. Besides, it is distinctly sweet, measuring 13 times sweeter than sugar (Shahrajabian *et al.*, 2019). The essential oil (*anisi aetheroleum*) extracted from steam distillation of ripe ob both *I. verum* and *P. anisum* contain trans-anethole from 80%-95% or more, which is responsible for its characteristics taste and smell, and of course medical properties, followed by chavicol methyl ether (estragole), anisaldehyde and cis-anethole (Shahrajabian *et al.,* 2019). Star anise is one of the most effective oils against *T. confusum*. In traditional Chinese medicine, *I. verum* has long been used with the actions of dispelling cold and relieving pain (Shahrajabian *et al*., 2019). Chinese star anise is used extensively in the both Indian diet and medicine because it does not have any adverse influence and also easily absorbs (Shahrajabian *et al.,* 2019). They have also found that the oil of star anise is stimulant, stomachic, carminative, mildy expectorant and diuretic. It has been also reported that the fruit of the plant has been used in traditional medicine for treatment of stomach aches, vomiting, rheumatic pain, insomnia and skin inflammation (Shahrajabian *et al.,* 2019). Its fruit is an important traditional Chinese medicine as well as a commonly used spice (Shahrajabian *et al.*, 2019). The use to facilitate birth and to increase the libido, as well as to relieve menopausal discomforts; and its oil is applicant in rheumatism as recommended by some folk remedies (Shahrajabian *et al*., 2019). Trans-anethole, p-anisaldeyde, farnesol, and estragole are main aroma compounds of Chinese star anise. They have also shown that 47 compounds accpunted for more than 90% in total Chinese star anise aroma molecules, including trans-anethole (75.76%), p-anisaldehyde (8.65%), estragole (4.70%), farnesol (3.26%), limonene (1.01%), linalool (1.44%), caryophyllene (1.03%) and 4,-methoxypropiophenone (0.72%) (Shahrajabian *et al.,* 2019). Crude extract of Chinese star anise can be applied as an optional control of house fly at breeding sites (Shahrajabian *et al*., 2019).

Medicinal herbs are one of the imperative sources of drugs all over the world (Patra et al., 2020). Star anise, an evergreen, medium-sized tree with star-shaped fruit, is an important herb with wide distribution throughout southwestern parts of the Asian continent (Patra *et al.,* 2020). Besides its use as spice in culinary, star anise is one of the vital ingredients of the Chinese medicinal herbs and is widely known for its antiviral effects (Patra *et al*., 2020). It is also the source of the precursor molecule, shikimic acid, which is used in the manufacture of oseltamivir (Tamiflu®), an antiviral medication for influenza A and influenza B (Patra *et al*., 2020). Besides, several other molecules with numerous biological benefits including the antiviral effects have been reported from the same plant (Patra *et al.,* 2020). Except the antiviral potential, star anise possesses a number of other potentials such as antioxidant, antimicrobial, antifungal, anthelmintic, insecticidal, secretolytic, antinociceptive, anti-inflammatory, gastroprotective, sedative properties, expectorant and spasmolytic, and estrogenic effects (Patra *et al.,* 2020). Star anise is the ripe, dried fruit of *Illicium verum*. It's fruit is an important element as a spice in oriental cuisine (Patra *et al*., 2020). More recently in the west it is used in baking, liquor production and enhances the flavour of meat (Patra *et al*., 2020). Star anise is rich in flavonoids and is a major source of a neutral organic compound called shikimic acid, famous for its antiviral effects (Patra *et al.,* 2020). So on top of boosting flavours and providing flavonoids, it may help modulate a healthy gut microbiota through its antimicrobial effects demonstrated in this recent review. This is a reason star anise is a great ingredient to add into one of our botanical blends (Patra *et al.,* 2020).

Star anise, a tree species normally regarded as one of the valuable spice is normally observed in the high altitude region of Arunachal Pradesh (Angami *et al.,* 2021). This spice has been an integral part in the social and traditional life of the native tribal of the region since yore (Angami *et al.,* 2021). Star anise is utilized in different ways *viz*. for savouring local cuisines, flavouring tea, used as a medicine to cure various ailments (Angami *et al.,* 2021). With the demand in pharmaceutical industries the spice thus contributes to the livelihood security of the locals (Angami *et al*., 2021). Possessing good amount of nutritional values makes this spice a valuable crop for nutritional security (Angami *et al.,* 2021). They remain largely underutilized and people are unaware of the nutritional factor though inadvertently utilized (Angami *et al*., 2021). Lack of consciousness and awareness coupled with habitat destruction may lead to the genetic erosion and threatened the species resource, which ultimately need to be conserved and further studies are required for its nutrient and phyto-pharmacological properties (Angami *et al.,* 2021). Though it has much importance in commercial purposes, research and knowledge on this species is meagre and its utilization for human consumption has not yet been fully exploited (Angami *et al.,* 2021). Arunachal Pradesh is the largest of India's eight North Eastern Himalayan states, recognized for its diverse biodiversity and distinctive physiography (Angami *et al.,* 2021). Due to its high unique locations and vast range of agro-climatic conditions from sub-tropical to temperate and alpine ranging between 26°28' and 29°28' N latitude and 91°35' to 97°27' E, the state is regarded a natural resource storehouse (Angami *et al.,* 2021). Temperate forests cover around 34% of the state's total geographical area, and they are home to a diverse range of aromatic, medicinal, ethnobotanical, economic, and commercially valuable plants and tree species. One of the most valuable tree species in the state is star anise (Angami *et al.,* 2021). Due to its good demand in spice and pharmaceutical industries it serves as a source of income for the rural poor in most of the star anise growing areas of the state. Dried seed pods are economically valuable having good market potential for spices and

pharmaceutical purposes. Fruit is considered to be carminative, aromatic stimulant, stomachic and galactagogue (Angami *et al*., 2021). It is used as medicine to cure abdominal pain, cough, dyspepsia, food poisoning, vomiting, toothache and sinusitis. It is also used as an antifungal agent and food preservative (Angami *et al.,* 2021).

Illicium verum has been classified as "both food and medicine" by the Ministry of Health, the People's Republic of China, denoting its low toxicity to humans (Gupta and Sarwat, 2022). It is an aromatic evergreen tree commonly called as star anise or Chinese star anise. It is widely distributed in China, Pakistan, and other Asian countries (Gupta and Sarwat, 2022). The active constituents include monoterpenoids, sesquiterpenoids, phenylpropanoids, lignans, flavonoids, and volatile compounds. It also contains tannins, bitter principles and essential oils like transanethole, limone, α-pinene, β-phellandrene, farnesol, safrol, and α-terpineol (Gupta and Sarwat, 2022). It has its use in phytotherapy and aromatization of foods, cosmetics, and pharmaceutical products. The analgesic, antioxidant, anti-inflammatory, anticonvulsive, insecticidal, antimicrobial, antifungal, and sedative activity of star anise has been reported in several studies. The cytotoxic potential of *I. verum* is also reflected in the literature (Gupta and Sarwat, 2022). Treatment with *I. verum* against colon cancer shows a dose-dependent change in the nuclear morphology and decrease in the mitochondrial membrane potential. Inhibition in the cell migration, invasion, and colony formation is also observed when cells are treated with various doses of *I. verum* (Gupta and Sarwat, 2022).

The brittle black stars that smell akin to licorice and bring a rich sweetness to many Chinese dishes and Vietnamese pho are the dried fruits or pericarps of an evergreen tree that you can grow at home (GWD, 2022). Star anise gets its name from the Latin words for true seduction. If you've ever experienced the lush, potent fragrance of star anise, you know how well this name fits (GWD, 2022). While star anise tastes similar to anise, they are not related. Star anise is the primary ingredient in five spice powder, with cinnamon, cloves, fennel, and Sichuan peppercorns. Added to baked goods, herbal teas, mulled wine, poached fruit, and savory dishes, star anise brings depth and complexity. And the plant is quite lovely (GWD, 2022). Star anise trees grow fast. They can reach a height of 26 feet with a 10-foot spread, but are often kept much smaller by pruning (GWD, 2022). The leaves are lance-shaped and fragrant but not used in cooking, and the flowers are pink or dark red. The fruit is star-shaped and green until it ripens. Ripe star anise fruit is brown and woody. Each of the spikes of a star anise fruit is a carpel that contains a single seed (GWD, 2022). These plants are native to southwest China and Vietnam and prefer warm temperatures and dappled sun (think lower in the jungle canopy). They can be grown outdoors year-round in USDA Hardiness Zones 7–9. If you live in a cooler region, give your star anise full sun and protect it from wind and frost. One way to do this is to grow it in a large, wheeled container. Simply bring it indoors each winter (GWD, 2022). If grown from seed, it will take six years before you get a crop. You can also grow star anise from a branch cutting. These trees prefer loamy, slightly acidic soil (pH 6.0–7.5) and constant moisture. Your star anise tree will grow best with one inch of water each week, allowing the soil to dry out between watering (GWD, 2022). Top dressings of aged manure or compost can ensure your star anise gets the proper nutrients in spring and summer. Do not feed your tree in autumn or winter (GWD, 2022). You can also grow star anise as a hedge, but it will require regular pruning because of how quickly it grows. Pruning star anise generates amazing smells! Unripe fruits are harvested and left to dry. They can be stored for years in an airtight container (GWD, 2022). Because of the oils that make star anise so fragrant, insect pests are not a problem for this tree. Alternaria blight and downy mildew, however, can cause problems. Use neem oil or fixed copper to prevent these problems (GWD, 2022).

During our last day at Aja Ney, we came across an exciting community activity that brought together the households scattered in the valley. Did you know that the people here annually harvest the fruit of the *Illicium verum* plant from which you get the main seed pod called Star Anise. Star anise is used in culinary applications for its distinct flavor but is also employed for its medicinal benefits (Pem, 2022). "It is believed that Guru Rinpochhe drank this as tea," says Aum Kinley. "We dry it and sell it to pilgrims and also to Department of Forest." (Pem, 2022). But besides the fascinating fruit, what grabbed our attention was the way the locals were picking them (Pem, 2022). It was very difficult for us to get the shots as each worker were picking them at lightning speed and just as we were closing in, they had already finished picking the batch nearby and ran with their sacks to another part of the forest (Pem, 2022). Aja Ney is one of the most sacred pilgrimage destinations in Bhutan with over 100 sacred Neys (sites) of Guru Rinpochhe. It is believed that one good deed done in this place is equivalent to a 1000 good deeds and one chant of prayer is equivalent to another 1000 (Pem, 2022). It takes a one and half day travel to Mongar district. From the highway towards Trashigang, you take a detour towards Shermung village. A 2 hour bumpy farm road drive then takes you to Yarab village and then you need to walk for 6 hours to Aja Ney valley (Pem, 2022). The horizontal trail is relatively easier than most treks in Bhutan. It takes you through dense forests, bamboo groves and steep slopes overlooking rapid rivers. As you arrive closer to the valley, you'll see scores of ancient stupas scattered along the trail (Pem, 2022).

Illicium verum Hook f. (star anise) is considered an important species in Traditional Chinese Medicine and is also used in contemporary medicine in East Asian countries (Sharafan *et al*., 2022). It occurs in natural habitats in southeastern parts of China and Vietnam, and is cultivated in various regions in China (Sharafan et al., 2022). The raw materials—Anisi stellati fructus and Anisi stellati aetheroleum obtained from this species exhibit expectorant and spasmolytic activities (Sharafan *et al.,* 2022). The European Pharmacopoeia (4th edition) indicates that these raw materials have been used in allopathy (Sharafan *et al.,* 2022). The biological activities of the above-mentioned raw materials are determined by the presence of valuable secondary metabolites such as monoterpenoids, sesquiterpenoids, phenylpropanoids, and flavonoids (Sharafan *et al.,* 2022). Recent pharmacological studies on fruit extracts and the essential oil of this species have confirmed their antibacterial, antifungal, anti-inflammatory, and antioxidant activities and thus their medicinal and cosmetic value (Sharafan *et al.,* 2022). Illicium verum Hook f. (star anise, Chinese star anise) is a woody species commonly known as ba jiao hui xiang in China and is used in traditional Chinese medicine (TCM) as a therapeutic agent (Sharafan et al., 2022). In line with the guidelines of the Chinese Pharmacopoeia, contemporary Chinese medicine recommends *I. verum* as a valuable medicinal plant (Sharafan *et al*., 2022). In addition, two raw materials

obtained from *I. verum* (fruit—Anisi stellati fructus and essential oil—Anisi stellati aetheroleum) have been listed in The European Pharmacopoeia since 2002. Both of these materials exhibit expectorant and spasmolytic effects (Sharafan *et al*., 2022). Nowadays, *I. verum* is an important medicinal plant worldwide. The recent scientific studies have proven that the fruit and essential oil of *I. verum* are characterized by biological activities such as antibacterial, antifungal, anti-inflammatory, and antioxidant effects (Sharafan *et al*., 2022). The plant is also widely used in the food industry as a spice (Sharafan *et al.,* 2022). The main component of the *I. verum* essential oil is trans-anethole. It is extensively used in food, perfume, and pharmaceutical industries due to its sweet flavor and aromatic scent (Sharafan *et al*., 2022). Moreover, according to recent studies, trans-anethole possesses antioxidant, anti-inflammatory and anti-obesity properties, which are also significant in terms of cosmetology and medicine (Sharafan *et al*., 2022).

Star anise, is one of the most important plants of the genus Anise in the family Magnoliaceae (Qiyuan Zou *et al.*, 2023). ***I. verum*** not only has the functions of warming Yang, dispersing cold, regulating Qi and relieving pain but can also be used as a condiment to increase flavor as well as reconcile and remove fish smells. (Qiyuan Zou *et al*., 2023). Currently, 201 chemical constituents have been identified from star anise; among these, star anise oil and shikimic acid are the two most widely used and studied chemical components in star anise, with the oil accounting for a large proportion of the total (Qiyuan Zou *et al.,* 2023). Star anise is the seed pod from the fruit of the **Illicium verum** plant, an evergreen shrub native to Southwest China (Moncel, 2023). The star anise pod, which is shaped like a star (hence its name), has an average of eight points, each containing a single pea-sized seed. Both the seeds and the pod are used in cooking and contain the sweet, potent anise flavour (Moncel, 2023). Star anise is sold whole and ground (Moncel, 2023). Star anise is used in culinary applications for its distinct flavor but is also employed for its medicinal benefits (Moncel, 2023). It is grown in China, Indo-China, and Japan and sometimes referred to as Chinese star anise. Star anise is a pillar ingredient in Chinese cooking; it is one of the main flavors in Chinese five-spice powder and is also used to make tea and season roast duck and other meats (Moncel, 2023). In Vietnamese cuisine, star anise is part of the well-known soup. In Western cultures, it is more often used to flavor liqueurs, such as absinthe, sambuca, and pastis, as well as baked goods like cookies and cakes (Moncel, 2023). The star anise pod is picked before it ripens and then dried in the sun, turning it a deep brown or rust color. The distinctive flavor is derived from anethol, the same oil found in anise seed giving both a licorice taste (Moncel, 2023).

Star anise is an aromatic spice that resembles a star and is highly valued for its distinct flavour and aroma (Thomas, 2024). It has some health advantages beyond just taste (Thomas, 2024). Star anise gives food an extra flavour boost (Thomas, 2024). We can identify India's cultural and culinary legacy based on our knowledge of star anise cultivation there (Thomas, 2024). Understanding the cultivation process is essential to ensuring the long-term sustainability of star anise cultivation in India and the quality of the spices produced (Thomas, 2024). The scientific name for star anise is *Illicium verum*, from southwest China—a rich cultural and culinary legacy (Thomas, 2024).n Initially used in Chinese medicine, this healing spice eventually entered Asian and Middle Eastern cuisine (Thomas, 2024). Star anise is a common ingredient in many kitchens worldwide, appreciated for its flavour and possible health benefits (Thomas, 2024). It gives a distinct taste to a variety of dishes (Thomas, 2024). Star anise is a spice from an evergreen tree (Thomas, 2024). The Farmers have developed better growing practices for star anise cultivation in India and found the perfect growing conditions over time to produce high-quality and highly demanded spice " Star anise" (Thomas, 2024). Star anise is the dried fruit of a small to medium evergreen tree (Spicetrader, 2024). The tree bears fruit after about 6 years and can have a productive life of up to 100 years (Spicetrader, 2024). Each point of the star-shaped husk contains a shiny amber-coloured seed (Spicetrader, 2024). Both the seed and husk are used for the ground spice (Spicetrader, 2024). In ancient times, this treasure from Asia was so valuable that Marco Polo kept its origin a secret (Terreexotique, 2024). Star anise is an eight-pointed star with delicious flavors of fennel and green anise (Terreexotique, 2024). It is the perfect companion for your punches, mulled wines, and infused rums, and it also finds its place in broths, chutneys, compotes, and syrups (Terreexotique, 2024).

Star anise, star aniseed or Chinese star anise, (Chinese: pinyin: *bājiǎo*, lit. "eight-horn") is a spice that closely resembles anise in flavor, obtained from the star-shaped pericarp of *Illicium verum*, a small native evergreen tree of southwest China (ACIR, 2024). The star shaped fruits are harvested just before ripening (ACIR, 2024). It is widely used in Chinese cuisine, in Indian cuisine where it is a major component of garam masala, and in Indonesian cuisine (ACIR, 2024). It is widely grown for commercial use in China, India, and most other countries in Asia (ACIR, 2024). Star anise is an ingredient of the traditional five-spice powder of Chinese cooking (ACIR, 2024). It is also one of the ingredients used to make the broth for the Vietnamese noodle soup called *phở*. It is used as a spice in preparation of Biryani in Andhra Pradesh, a south Indian State (ACIR, 2024). Star anise contains anethole, the same ingredient which gives the unrelated anise its flavor. Recently, star anise has come into use in the West as a less expensive substitute for anise in baking as well as in liquor production, most distinctively in the production of the liquor Galliano. It is also used in the production of Sambuca and pastis (ACIR, 2024). Star anise has been used in a tea as a remedy for colic and rheumatism, and the seeds are sometimes chewed after meals to aid digestion (ACIR, 2024). Shikimic acid, a primary feedstock used to create the anti-flu drug Tamiflu, is produced by most autotrophic organisms, but star anise is the industrial source. Tamiflu is regarded as the most promising drug to mitigate the severity of bird flu (H5N1); however, reports indicate that some forms of the virus have already adapted to Tamiflu (ACIR, 2024). In 2005, there was a temporary shortage of star anise due to its use in making Tamiflu. Late in that year, a way was found of making shikimic acid artificially. A drug company named Roche now derives some of the raw material it needs from fermenting e-coli bacteria. There is no longer any shortage of star anise and it is readily available and is relatively cheap (ACIR, 2024). Star anise is grown in four provinces in China and harvested between March and May. The shikimic acid is extracted from the seeds in a ten-stage manufacturing process which takes a year. Reports say 90% of the harvest is already used by the Swiss pharmaceutical manufacturer Roche in making Tamiflu, but other reports say there is an abundance of the spice in the main regions - Fujian, Guangdong, Guangxi and Yunnan (ACIR, 2024).

Star anise is an evergreen shrub or small tree native to Asia. It's traditionally used as a spice in food, and also as medicine (Webmd, 2024). Star anise seeds contain chemicals that might have antibacterial effects. It also contains a chemical called shikimic acid, which is used to make oseltamivir (Tamiflu), a flu treatment. But it's not clear if star anise itself has antiviral effects (Webmd, 2024). People use star anise for respiratory infections, stomach disorders, colic in babies, and many other conditions, but there is no good scientific evidence to support these uses (Webmd, 2024). US FDA warned consumers not to consume teas brewed from star anise due to reports of serious side effects. Some star anise tea products have been contaminated with Japanese star anise (*Illicium anisatum*), a known poison (Webmd, 2024). *Illicium verum* (star anise or badian, Chinese star anise, star anise seed, star aniseed and star of anise) is a medium-sized evergreen tree native to South China and northeast Vietnam (Inaturalist, 2024). Its star-shaped pericarps harvested just before ripening are a spice that closely resembles anise in flavour (Inaturalist, 2024). Its primary production country is China, followed by Vietnam and other Southeast Asian countries (Inaturalist, 2024). Star anise oil is highly fragrant, used in cooking, perfumery, soaps, toothpastes, mouthwashes, and skin creams (Inaturalist, 2024).

Star anise is a perennial, evergreen tree characterized by its compact to medium-sized stature (Krusha Patel et al., 2024). Belonging to the plant family *Illiciaceae,* this botanical specimen is recognized for its distinctive star-shaped fruit (Krusha Patel *et al*., 2024). The genus *Illicium* boasts a remarkable diversity, comprising over 42 distinct species and around 166 different varieties (Krusha Patel *et al*., 2024). These numerous variations are spread across tropical regions in both East Asia and Southeast Asia (Krusha Patel *et al.,* 2024). The prevalent members within the *Illicium* genus encompass star anise *(Illicium verum),* Mexican anise (*Illicium mexicanum*), Japanese anise (*Illicium anisatum),* and star aniseed (*Illicium anisatum)*. The most widely recognized species is star anise, scientifically referred to as *Illicium verum* (Krusha Patel *et al*., 2024). Star anise is recognized for possessing a range of advantageous characteristics. These encompass acting as an antioxidant, fighting against microbes, combating fungal infections, expelling parasitic worms, deterring insects, alleviating pain sensations, safeguarding the stomach lining, inducing relaxation, mimicking estrogen, facilitating the removal of mucus, promoting the thinning of secretions, and relaxing muscle spasms (Krusha Patel *et al*., 2024). A reported analysis has revealed that the anise fruit comprises a complex blend of 49 different compounds. Notably, the most abundant compound is trans-anethole, constituting a significant 81.40% of the fruit's composition (Krusha Patel *et al.,* 2024). Alongside this dominant compound, there are other noteworthy constituents such as limonene, which contributes 6.50% to the overall makeup, and chavicol, present at a level of 2.10%. Furthermore, anisaldehyde has been identified in the composition, making up about 1.81% of the total compounds found in anise fruit (Krusha Patel *et al.,* 2024). Trans-anethole (TA) was identified as the primary constituent present in star anise essential oil (Krusha Patel *et al.,* 2024). It is widely employed in the food, perfume, and pharmaceutical sectors due to its pleasant taste and fragrant aroma (Krusha Patel *et al*., 2024).

Newly Conducted research indicates that trans-anethole holds antioxidant, anti-inflammatory, and anti-obesity attributes, all of which bear significance in the realms of both cosmetology and medicine (Krusha Patel *et al*., 2024). The antioxidant protection system substantially enhances the skin's defense mechanism against oxidative damage. Antioxidants are molecules with the capacity to hinder the oxidation of other molecules. These are elements or systems capable of interacting with free radicals and halting a sequence of reactions before vital molecules undergo harm (Krusha Patel *et al.,* 2024). Antioxidants have diverse uses spanning additional in food, cosmetics, beverages, pharmaceuticals, and the feed industry. Their functions encompass acting as health supplements, active components, and stabilizers. Antioxidants, whether derived from natural origins or created synthetically; find widespread use in the creation of cosmetic products (Krusha Patel *et al*., 2024). This essay explores the potential of star anise as a valuable botanical resource in skincare (Krusha Patel *et al.,* 2024). It begins by discussing the historical and cultural significance of star anise and its traditional uses (Krusha Patel *et al.,* 2024). The chemical composition of star anise, rich in bioactive compounds with antioxidant properties, is highlighted as a foundation for its skincare benefits (Krusha Patel *et al*., 2024). The essay delves into the antioxidant capabilities of star anise, emphasizing its ability to combat free radicals and reduce oxidative stress, crucial for maintaining skin health and preventing premature aging (Krusha Patel *et al.,* 2024). How star anise can address various skin concerns, including acne, inflammation, and hyper pigmentation, due to its anti-inflammatory attributes and its role in regulating melanin synthesis (Krusha Patel *et al.,* 2024). It recognizes the potential of star anise in the cosmetic industry, especially in response to the demand for eco-friendly and sustainable skincare solutions (Krusha Patel *et al*., 2024). It underscores the need for further research and clinical studies to validate and optimize star anise's effectiveness in various skincare applications (Krusha Patel *et al*., 2024). "Nature's Oxidant Marvel" in the skincare domain, advocating for its inclusion in advanced and effective skincare products (Krusha Patel *et al*., 2024). This exploration paves the way for further research and innovative product development, potentially integrating star anise into the holistic skincare sector (Krusha Patel *et al*., 2024).

Seeds are collected from fresh fruits of vigorously growing mature trees known for high yield. Fully matured large seeds, recognized by their characteristic brown colour, are selected (Google, 2024b). In India, star anise cultivation, though small-scale, primarily occurs in Arunachal Pradesh, particularly in regions like Upper Subansiri, West Siang, and East Siang districts, due to the specific agro-climatic conditions suitable for the crop (Google, 2024c). The crop thrives in specific conditions, including woodlands, sunny edges, and dappled shade, which are found in the traditional growing areas (Google, 2024c). Star anise is used in culinary, medicinal, and aromatic applications (Google, 2024c). While Arunachal Pradesh is the primary area, some cultivation also occurs in Himachal Pradesh and other hilly areas in the northeast (Google, 2024c). Repeated attempts to grow star anise in areas outside its traditional growing regions have often failed, suggesting the need for specific agro-climatic conditions (Google, 2024c). The fruit has a distinctive star-shaped appearance with 6-8 carpels arranged in a whorl. Each carpel contains a seed (Google, 2024c). Star anise grows as a small to medium-sized evergreen tree, typically reaching heights of 8-15 meters (Google, 2024c). Star anise is a popular spice in various Asian cuisines. It's a key ingredient in Chinese five-spice powder (Google, 2024c). Star anise is essential in pho and other Vietnamese dishes. It's used to flavor various dishes, including meat, soups, and stews. Star anise is a source of shikimic acid, which is used in the production of the antiviral drug Tamiflu (Google, 2024c). In traditional Chinese medicine, it's used for various purposes, including promoting digestion and relieving coughs (Google, 2024c). The

essential oil is used in aromatherapy, flavoring, and cosmetics (Google, 2024c). Some studies suggest that star anise may have antibacterial and antiviral properties (Google, 2024c). While generally safe when used in moderation, some related species of star anise are poisonous and should be avoided (Google, 2024c). *Illicium verum Hook.f.,* is an aromatic evergreen tree that produces purple-red flowers and star-shaped fruit with an anise scent (Yingying Cao *et al.,* 2024). It is classified within the division Magnoliophyta, class Magnoliopsida, subclass Magnoliidae, order Austrobaileyales, and family Illiciaceae (Yingying Cao *et al.,* 2024). Initially, *Illicium* was placed in the Magnoliaceae family in early taxonomic literature, but later it was reclassified into the Illiciaceae family by Smith based on floral morphology and vegetative anatomy (Yingying Cao *et al.,* 2024). Its fruit, also known as star anise, is not only a significant component of traditional Chinese medicine but also a commonly used spice (Yingying Cao *et al.,* 2024). *Illicium verum*, recognized in traditional Chinese medicine as Anisi Stellati Fructus or Bajiaohuixiang, is renowned for its medicinal properties, particularly in China (Yingying Cao *et al.,* 2024). It has been utilized in various formulations, including crude drugs, powders, and essential oils. The use of *I. verum* is documented as far back as the Ming Dynasty in the "Compendium of Materia Medica" (Yingying Cao *et al*., 2024). The Chinese Pharmacopoeia describes Anisi Stellati Fructus as having properties that warm yang, dispel cold, and regulate the flow of Qi, thereby alleviating pain or symptoms of the common cold. Clinically, it is applied to treat conditions such as abdominal colic, vomiting, and lower back pain (Yingying Cao *et al.,* 2024). Furthermore, the crude fruits or their powdered forms have been integrated into traditional teas to mitigate nervousness, insomnia, and to serve as a sedative. *Illicium verum* has been cultivated in the Zuoyou River valley in Guangxi Province since the Ming Dynasty in ancient China (Yingying Cao *et al*., 2024). With the development of China's Maritime Silk Road and the expansion of overseas trade, Fujian Province and Guangdong Province have also become production and sales locations for *I. verum* (Yingying Cao *et al.,* 2024). In December 2020, the Administration of Traditional Chinese Medicine of Guangxi Zhuang Autonomous Region and other departments included *I. verum* in the Guangxi authentic medicinal materials "Ten Herbs of Guangxi," initiating key development and utilization efforts (Yingying Cao *et al*., 2024). Because there are too many similarities in the phenotypes (tree shape, branch, stem, leaf, flower, pollen, fruit) of the Illiciaceae plants, the differences are not always obvious (Yingying Cao *et al.,* 2024). This can make it difficult to identify the species of Illiciaceae, even for professionals. Unfortunately, there is no perfect method for identification (Yingying Cao *et al*., 2024). The compounds contained in the plants vary greatly, leading to significant differences in efficacy and toxicity. As a result, there have been cases of ingestion poisoning (Yingying Cao *et al*., 2024). Typically, taxonomic research relies on morphological evaluation, a method prone to environmental influences. Discerning various morphological traits in plants necessitates observations across their entire life cycle, imposing constraints on identifying species lacking comprehensive morphological data (Yingying Cao *et al.,* 2024). In contrast, molecular identification, which utilizes DNA markers, offers enhanced precision and dependability due to the inherent genetic stability and resilience to external variables. Consequently, this approach is better suited for distinguishing closely related species (Yingying Cao *et al*., 2024). The chloroplast genome, generally spanning 100–150 kilobases and rich in evolutionary information, serves as an exemplary model for investigations into molecular biomarkers, phylogenetic analyses, evolutionary studies, and comparative genomics (Yingying Cao *et al.,* 2024). Little molecular research has been done on the Illiciaceae. This has hindered further studies of the molecular identification, phylogeny, and evolution of the genus (Yingying Cao *et al*., 2024). We report the sequence, assembly, annotation, and structural analysis of the *I. verum* chloroplast genome (Yingying Cao *et al.,* 2024). The publication of more cp genomes from the Illiciaceae will help identify genetic variation through sequence comparison and provide new insights into evolutionary history and interspecific relationships (Yingying Cao *et al.*, 2024). Star anise is a star-shaped spice derived from the fruit of a small evergreen tree native to China and Vietnam (Singh, 2025). It has a distinct licorice-like flavour and is commonly used in Asian cuisine, herbal teas, and traditional medicine (Singh, 2025). Star anise is rich in bioactive compounds, including antioxidants, polyphenols, and anethole, which contribute to its health benefits (Singh, 2025). It also contains shikimic acid, a key ingredient in antiviral medications (Singh, 2025). Due to its antimicrobial, anti-inflammatory, and digestive properties, star anise is considered a healthy spice when consumed in moderation (Singh, 2025).

In this review article on Origin, Taxonomy, Botanical Description, Genetic Diversity, Breeding and Cultivation of Star Anise are discussed.

ORIGIN AND DITRIBUTION

Star anise popularly known as 'Lissi' in West Kameng and Tawang districts of Arunachal Pradesh belongs to the family Schisandraceae, a medium size economic evergreen tree distributed between 1700 to 3000 m above msl in subtropical and temperate broad-leaved forests. However, this species is widely distributed in forests patches in Bomdila, West Kameng district due to the geographical location and micro climate condition of the district unlike other parts of the state. It grows well in sandy loam or in heavy clay or in humus on gentle slopes (Angami *et al*., 2021). Star anise originated in southern China and has been used as a medicine and spice for more than 3,000 years. During the late 1500s, star anise came to Europe via an English sailor and soon after was traded along the tea route from China through Russia. Because of its sweet flavor, star anise was mainly used in jams, syrups, and puddings and later substituted in commercial drinks for anise seed (Moncel, 2023). Star anise is suitable for planting in deep, well-drained, fertile, moist and acidic sandy loam or loamy soil. It grows poorly in dry and barren or low-lying, waterlogged areas. It is mainly distributed in Southeast Asia and North America, of which Asia accounts for 80% of its source. In Southeast Asia, the main production area is China, followed by Vietnam, Cambodia and Myanmar. In China, star anise is mainly produced in Guangxi, including Baise, Nanning, Qinzhou, Wuzhou and Yulin, where it is mostly cultivated at an altitude of 200–700 m. In Yunnan province, including Funing, Guangnan, Xichou, Pingbian and Lvchun, it is mostly cultivated at its natural distribution levels, which are up to 1600 m in elevation. The deputy director of the Anise Cinnamon Engineering Technology Research Center of the State Forestry Administration of China said that China's production of star anise accounts for about 80% of the world's production. Guangxi has the longest cultivation history and the most production, and in 2018, the Guangxi production of this plant accounted for more than 90% of the total national output. Guangxi has the reputation of being "the hometown of star

anise" (Qiyuan Zou *et al*., 2023). Star Anise is indigenous to South Eastern China. Commercial production is limited to China and Vietnam. In India, it is produced to a small extent in Arunachal Pradesh. The crop requires specific agro climatic conditions available only in the traditional growing areas, which has prevented repeated attempts of other countries to grow star anise. However it prefers woodlands, sunny edges, and dappled shade. The plant grows well in humus rich, mildly acidic to neutral soils, which are light to medium and having good drainage. It tolerates temperatures down to –10 degree C (Espicebazaar, 2024; Indianspices, 2024).

Illicium verum is thought most likely to be native to southern China and northeast Vietnam. It has been cultivated since about 2,000 BC, and it is difficult to determine whether plants growing in these areas are wild or naturalised. Star anise is cultivated in China, Laos, Vietnam, Korea, Japan, Taiwan, Hainan and the Philippines (POWO, 2024). Parts of SE Asia, SE US, Central America, and the Caribbean are the centre of origin (Plants, 2024). Star anise is distributed in Alabama, Assam, Borneo, Cambodia, North-Central, South-Central, and Southeast China, Cuba, Dominican Republic, East Himalaya, Florida, Georgia, Hainan, Haiti, Japan, Korea, Louisiana, Malaya, Central, Gulf, and Northeast Mexico, Mississippi, Myanmar, Nansei-shoto, Philippines, Sumatera, Taiwan, Thailand, Vietnam **(**Plants, 2024**).** Star anise is native to China. Its Chinese name is "Badjiao," which translates literally to "Eight Horns," referring to the eight branches that form the star. This spice is traditionally used whole in infusions or ground in the Chinese five-spice blend. Star anise, or Chinese fennel, was introduced to Europe by Marco Polo in the 14th century. In the Middle Ages, the spice was difficult to acquire, mainly due to its very high price, which made it a rare spice. It wasn't until the Renaissance and its importation by the English that its consumption became widespread in Europe (Terreexotique, 2024).

The star anise tree is not an indigenous plant in India. The star anise is native to southern China and Vietnam. In Hindi, the star anise in India is called chakr phool, or anasphal (K-agriculture, 2024). Star anise is suitable for planting in deep, well-drained, fertile, moist and acidic sandy loam or loamy soil. It grows poorly in dry and barren or low-lying, waterlogged areas. It is mainly distributed in Southeast Asia and North America, of which Asia accounts for 80% of its source. In Southeast Asia, the main production area is China, followed by Vietnam, Cambodia and Myanmar. In China, star anise is mainly produced in Guangxi, including Baise, Nanning, Qinzhou, Wuzhou and Yulin, where it is mostly cultivated at an altitude of 200–700 m. In Yunnan province, including Funing, Guangnan, Xichou, Pingbian and Lvchun, it is mostly cultivated at its natural distribution levels, which are up to 1600 m in elevation. The deputy director of the Anise Cinnamon Engineering Technology Research Center of the State Forestry Administration of China said that China's production of star anise accounts for about 80% of the world's production. Guangxi has the longest cultivation history and the most production, and in 2018, the Guangxi production of this plant accounted for more than 90% of the total national output. Guangxi has the reputation of being "the hometown of star anise". (K-agriculture, 2024). Star anise is an evergreen tree native to southwestern parts of the Asian continent, particularly China and Vietnam (Google, 2024). Native to Southern China and Southeast Asia. Primarily cultivated in China and Vietnam, with some production in Arunachal Pradesh, India. Woodlands, sunny edges, and dappled shade, with humus-rich, mildly acidic to neutral soils that are light to medium and have good drainage **(**Google, 2024c**).**

TAXONOMY

Star Anise belongs to the family *Illiciaceae/ Magnoliaceae,* genus *Illicium* and species Illicium verum (Mia, 2016; Shahrajabian *et al*., 2019; Indianspices, 2024; Researchgate, 2024; ACIR, 2024; Espicebazaar, 2024; Wikipedia, 2024a). Star anise is an evergreen small medium sized tree from the plant family Illiciaceae. The genus *Illicium* contains more than 42 species and 166 verities usually grown in tropical areas of East Asia and Southeast Asia. Variation is prevalent in morphology, habitat, and chemical composition. Most common species of *Illicium* genus are star anise (*Illicium verum*), Mexican anise (Illicium mexicanum), Japanese anise (Illicium anisatum) and star aniseed (*Illicium anisatum*). Star anise (*Illicium verum) is* the most well-known specie. The plant is cultivated for ornamental purposes due to flowers, foliage, and fragrance, leading to production of several cultivars (Boota *et al*., 2018). According to the Flora of China, the type specimen of star anise was originally obtained from Kew Gardens, England, grown and propagated in Beihai, Guangxi Province, China. The medicinal part of star anise is its fruit, which is picked in autumn and winter when the fruit turns from green to yellow. The fruit of star anise is cogwheel shaped and consists of an average of eight pods, and therefore it is generally called star anise. As mentioned earlier, the genus name *Illicium* comes from the Latin word "illicere", which can be translated as "to seduce and attract", indicating that the fruits and branches of the plant have a seductive fragrance (Qiyuan Zou *et al*., 2023).

Synonyms

Illicium verum Syn. *I. anisatum* (KSSDB, 2024).

BOTANICL DESCRIPTION

Star anise is the ripe, dried fruit of Illicium verum Hook. Filius (Magnoliaceae). The fruit whorl (2.5–4.5 cm in diameter) is formed of six to eight (rarely seven to nine), one-seeded, boat-shaped, woody, wrinkled, ridged, reddish brown follicles that are internally smooth, lustrous, and light brown, about 9–19 mm in length and surmounted on a curved peduncle. The seed is light brown, compressed-ovoid, shiny, and smooth with a conspicuous hilum and raphe. In transverse section, the exocarp consists of a striated cuticle and epidermal cells bearing stomata. The mesocarp consists of parenchymatous cells with brown contents. The cells towards the central zone are larger (up to 220 μm in length), and the inner mesocarp cells have thicker walls, the thickness increasing towards the dehiscent side of the carpel. Resin and stone cells occur scattered throughout the mesocarp, and vascular

bundles occur in between the central and inner regions. The endocarp consists of thin-walled, sclerenchymatous palisade cells up to 440 μm in length. The seed coat consists of an outer, thick-walled epidermis of sclerenchymatous, pitted palisade cells up to 200 μm in length, followed by five layers of sclerenchyma and two or more layers of parenchyma containing numerous calcium oxalate crystals. The odor and taste of star anise are anise–-like. The plant starts fruiting at the age of 6 years and continues until it is over 100 years old. Fruits are collected before full maturity and dried in the sun (Bagchi and Srivastava, 2003).

Star anise tree is evergreen and grows to a height of about 8–10 m. Leaves are aromatic. The commercial part of the tree is the fruit. It is 2.5–4.5 cm in diameter and consists of about eight boat-shaped carpels arranged in the form of a whorl around the central axis. Carpels are about 9–19 mm long and every carpel is internally reddish brown, glossy and contains a single, flat, oval, lustrous, brownish yellow, brittle seed. The fruit rightly derived the name, star anise, from the attractive star-like arrangement of carpels. It has liquorice-like bouquet which is more pungent and powerful than anise (George, 2004). This species is a small tree, 6–8 m in height, gray-brown bark, green branchlets, glabrous; crown conical to globose. All parts of the tree have an agreeable aromatic smell. The leaves are simple, usually clustered at branch-tips. They are entire, oval, tapering toward both ends, acute apex, and cuneate base. Thick and brittle leaf-blade, dark green above, paler beneath, petiole glabrous. Pink-white flowers, solitary and axillary, stout and short pedicel. Six sepals, pink at margin, 16–20 petals, broad-elliptic, smaller than sepals, white outside, red inside, dark red at the middle of the flower. Numerous stamens, shorter than petals, elliptic anther. Eight carpels, forming a conical mass, spreading into a rosette when ripe. Fruit consists of eight follicles, spreading, woody and brown when mature, dehiscent by the ventral side. Solitary seed in each follicle, brown, glossy, and glabrous. Star anise originates from northern Vietnam and southern China's woods, being cultivated in several regions, mainly Jamaica and some Asian tropical countries (Rocha and Tietbohl, 2016a). The evergreen small tree star anise usually grows upto 12-16ft height and distributed to Southeast Asia. The leaves having dimensions of 5–15 cm × 2–5 cm are lanceolate, obovate-elliptic and leathery. The flowers are pink to dim red, bisexual, axillary or subterminal, and are 1.5–4 cm, in diameter. The petals seven to twelve, extensively elliptic to broadly ovate. The carpals are 10 mm long, boat shaped, hard and wrinkled, containing a seed. The anthers have 1–1.5 mm length. The fruit is star-shaped with reddish brown color comprising of six to eight follicles that are arranged in a whorl. The seeds are shiny and brittle brown, compressed and smooth (Boota *et al*., 2018).

Its leaves are oblong-elliptic to narrowly obovate-elliptic; flowers axillary to sub-terminal, bisexual, white with yellow tinge or light greenish to yellow, fruit type and shape is dry and star shaped with 11-13 glowing boat shaped seed pods/carpel with incurved short beak (Angami *et al*., 2021). In the APG IV (2016) system, *I. verum* is classified under the genus Illicium belonging to the Schisandraceae family. The bark of *I. verum* plants is white to light gray in color. The leaves are light green, lanceolate, leathery, and alternate, measure 6 to 12 cm long, and are located at the ends of branches. The flowers are solitary, bisexual, white-yellow or greenish in color, and 1–7 cm in diameter. They grow either singly or arranged in clusters. The fruit is star-shaped and has 6–10 capsule-like follicles with a small brown seed inside each. The seeds are ovoid with a shiny and smooth surface. Each part of the fruit carries an aromatic scent (Sharafan *et al.,* 2022). *Illicium verum* Hook. F. is the English name of star anise, alias Illicium san-ki. It is a 10–15 m tall arbor plant. The leaves are either alternate or in 3–6 clusters of branches in a whirl at the top and are leathery or thick leathery, obovate-elliptical, oblique lance-shaped or oval, measuring approximately 50–150 mm long and 1–1.5 mm wide. The apex is short and acuminated or slightly obtuse-rounded, the upper midrib is slightly depressed or flat when fresh and the base is cuneate, with 4–6 pairs of lateral veins and 8–20 mm petioles. The flowers are pink to crimson, solitary in leaf axils or subterminal with a 15–40 mm long pedicel. The tepals number 7–12 and often exhibit inconspicuous translucent glandular dots. The largest tepal is broadly elliptical to broadly ovoid, 9–12 mm long and 8–12 mm wide. Its aggregated fruits tend to spread and are 35–40 mm in diameter, whereas the fruit stalks are 20–56 mm long. The seed pods number 7–8 and are 14–20 mm long with an apical rostrum and are obtusely rounded without apices. The seeds are brown and are 7–10 mm long. The star anise tree blooms twice a year, once in March–May with high yields and ripe fruits and again in August–October (Qiyuan Zou *et al*., 2023).

Illicium verum Hook. F. is the English name of star anise, alias Illicium san-ki. It is a 10–15 m tall arbor plant. The leaves are either alternate or in 3–6 clusters of branches in a whirl at the top and are leathery or thick leathery, obovate-elliptical, oblique lance-shaped or oval, measuring approximately 50–150 mm long and 1–1.5 mm wide. The apex is short and acuminated or slightly obtuse-rounded, the upper midrib is slightly depressed or flat when fresh and the base is cuneate, with 4–6 pairs of lateral veins and 8–20 mm petioles. The flowers are pink to crimson, solitary in leaf axils or subterminal with a 15–40 mm long pedicel. The tepals number 7–12 and often exhibit inconspicuous translucent glandular dots. The largest tepal is broadly elliptical to broadly ovoid, 9–12 mm long and 8–12 mm wide. Its aggregated fruits tend to spread and are 35–40 mm in diameter, whereas the fruit stalks are 20–56 mm long. The seed pods number 7–8 and are 14–20 mm long with an apical rostrum and are obtusely rounded without apices. The seeds are brown and are 7–10 mm long. The star anise tree blooms twice a year, once in March–May with high yields and ripe fruits and again in August–October (Qiyuan Zou *et al.*, 2023). Star anise is the dried, star shaped fruit of *Illicium verum*. It is an evergreen tree attaining a height of 8-15 meters and a diameter of 25 cm. The leaves are entire, 10-15 cm long, 2.5 – 5 cm broad, elliptic, flowers are solitary, white to red in colour. Fruits are star shaped, reddish brown consisting of 6-8 carpels arranged in a whorl. Each carpel is 10 mm long, boat shaped, hard and wrinkled containing a seed. Seeds are brown, compressed, ovoid, smooth, shiny and brittle (Indianspices, 2024).

Leaves are aromatic, simple and lanceolate, obovate-elliptic or elliptic, size of 5–15 cm × 2–5 cm, coriaceous to thickly coriaceous. The leaves are 5–15 cm × 1.5–5 cm, apex acute, lower side pubescent. Flowers are solitary, bisexual, pink to dark red, axillary or subterminal. The perianth has lobes 7–12, arranged spirally; stamens number of 11–20, arranged spirally, with short, thick filaments; carpels usually 8, free, arranged in a single whorl. Flower peduncle size is 1.5–4 cm, tepals number range from seven to twelve, and are broadly elliptic to broadly ovate, anther size is 1–1.5 mm, pollen grains trisyncolpate. The fruit is a

capsule-like follicetum, star-shaped, reddish-brown, consisting of six to eight follicles arranged in a whorl. Each follicle is boat-shaped, 1–2 cm long, rough and rigid, color reddish-brown, with 1 seed, opening along the ventral edge when ripe. carpels size of 10 mm long, boat-shaped; they are hard and wrinkled, containing one seed. Seeds are brown, compressed ovoid, smooth, shiny and brittle with approximate size of 8–9 mm × 6 mm (Wikipedia, 2024).

An evergreen tree up to 15 m tall. Trunk about 25 cm in diameter with white bark. Glossy, leathery leaves are held in bunches of three to six.

Flowers : Solitary, yellow-green, sometimes flushed pink to dark red, with 7-12 tepals, up to 20 stamens (male organs) and usually 7-9 carpels (female organs). Usually produced from March to May and from August to October in China.

Fruits: Star-shaped, consisting of a ring of single-seeded, dark reddish-brown carpels attached to a central column. The fruits are fleshy, but on drying become woody and wrinkled. Usually produced from September to October and from March to April in China (POWO, 2024). Leaves are aromatic, simple and lanceolate, obovate-elliptic or elliptic, size of 5–15 cm × 2–5 cm, coriaceous to thickly coriaceous. The leaves are 5–15 cm × 1.5–5 cm, apex acute, lower side pubescent. Flowers are solitary, bisexual, pink to dark red, axillary or subterminal. The perianth has lobes 7–12, arranged spirally; stamens number of 11–20, arranged spirally, with short, thick filaments; carpels usually 8, free, arranged in a single whorl. Flower peduncle size is 1.5–4 cm, tepals number range from seven to twelve, and are broadly elliptic to broadly ovate, anther size is 1–1.5 mm, pollen grains trisyncolpate. The fruit is a capsule-like follicetum, star-shaped, reddish-brown, consisting of six to eight follicles arranged in a whorl. Each follicle is boat-shaped, 1–2 cm long, rough and rigid, color reddish-brown, with 1 seed, opening along the ventral edge when ripe. carpels size of 10 mm long, boat-shaped; they are hard and wrinkled, containing one seed. Seeds are brown, compressed ovoid, smooth, shiny and brittle with approximate size of 8–9 mm × 6 mm (Inaturalist, 2024).

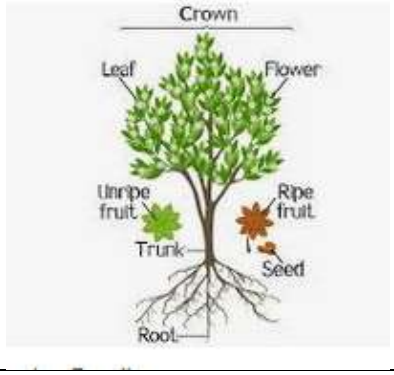
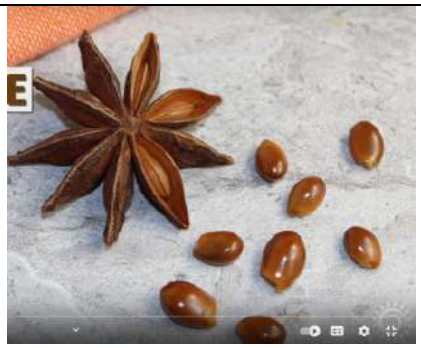
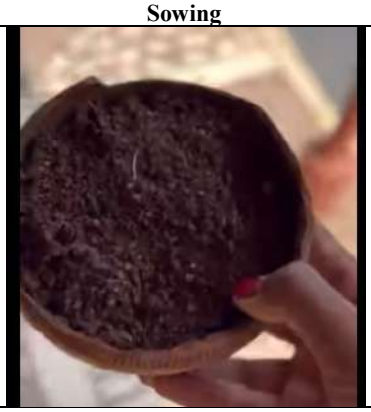
Most are understory evergreen to semi-evergreen shrubs to small trees. The crushed leaves, stems, and seeds have an anise spice fragrance. The genus name derives from the Latin term "*illici*" meaning “seductive,” in reference to its scent. Most prefer part shade to shade, but some varieties will tolerate more sun if given enough moisture. They tolerate loam or sandy soils that are moist to wet with a neutral or acid PH. In some species, the fragrant flowers are quite showy with attractive seed pods. Only the seed pods of star anise are recognized for culinary use in teas and as a spice. All other species have a variety of toxic characteristics in leaves, stems, and/or seed pods. Use as a specimen, a hedge, or along ponds and streams in a naturalized or woodland garden. Propagate by layering, stem cuttings, or seed. Star Anise is resistant to deer browsing (Plants, 2024). It has evergreen, aromatic leaves and bisexual flowers, the inner petals of which grade gradually into stamens. The flowers are radially symmetrical that lack differentiation between the outer and inner floral whorls (sepals and petals). The female portion of the flower consists of 7 to 15 carpels (ovule-bearing structures), usually in a single whorl. At maturity (after 6 years) the flower produces a characteristic woody fruit composed of a ring of several joined pod like follicles, each of which splits open along one seam to release a single seed. The fruit takes its name from the star like arrangement of its carpels around a central axis. The fruits are harvested before they ripen. The dried fruit is about 0.25 to 0.5 cm (0.1 to 0.2 inch) in diameter; individual carpels are usually about 1 cm in length and contain a single seed. Dried carpels are hard, rough, and reddish brown; the seeds are smooth, lustrous, and light brown in colour. Both the seed and the husk are used for the ground spice. The dried fruit's essential-oil content is about 3 percent, and its principal component is anethole (KSSDB, 2024). It is a medium-sized tree, 8 to 15 m (26 to 50 ft) tall, with a slender trunk up to 25 cm (10 in) in diameter and a low-branching habit, forming a densely leafy pyramidal crown. The bark is pale grey and smooth. Leaves are elongated-oval, 5 to 12 cm long, glossy green and have a thick, leathery texture. They are alternately arranged along the stems at the ends of the branches, where they remain in all seasons. The flowers are white, greenish-yellow or purple, depending on the variety, 1 to 1.5 cm in diameter and perfect, having both female and male parts. They are borne singly on leafy stems and bloom mainly from spring to summer, though with light blooms on and off at other times of the year. Fertilised flowers develop into pale yellow-green, spoke-wheel-shaped fruit, 3 to 4.5 cm (1.2 to 1.8 in) in diameter, consisting of seven or eight segments, each with a single seed inside. They become dark brown and dry when mature, about ten to twelve months after fruit-set, the segments easing apart into a star shape and opening to expose the seed (Iplantz, 2024).

Star anise is the dried, star shaped fruit of *Illicium verum*. It is an evergreen tree attaining a height of 8-15 meters and a diameter of 25 cm. The leaves are entire, 10-15 cm long, 2.5 – 5 cm broad, elliptic, flowers are solitary, white to red in colour. Fruits are star shaped, reddish brown consisting of 6-8 carpels arranged in a whorl. Each carpel is 10 mm long, boat shaped, hard and wrinkled containing a seed. Seeds are brown, compressed, ovoid, smooth, shiny and brittle (Espicebazaar**,** 2024). Leaves are aromatic, simple and lanceolate, obovate-elliptic or elliptic, size of 5–15 cm × 2–5 cm, coriaceous to thickly coriaceous. The leaves are 5–15 cm × 1.5–5 cm, apex acute, lower side pubescent. Flowers are solitary, bisexual, pink to dark red, axillary or subterminal. The perianth has lobes 7–12, arranged spirally; stamens number of 11–20, arranged spirally, with short, thick filaments; carpels usually 8, free, arranged in a single whorl. Flower peduncle size is 1.5–4 cm, tepals number range from seven to twelve, and are broadly elliptic to broadly ovate, anther size is 1–1.5 mm, pollen grains trisyncolpate. The fruit is a capsule-like follicetum, star-shaped, reddish-brown, consisting of six to eight follicles arranged in a whorl. Each follicle is boat-shaped, 1–2 cm long, rough and rigid, color reddish-brown, with 1 seed, opening along the ventral edge when ripe. carpels size of 10 mm long, boat-shaped; they are hard and wrinkled, containing one seed. Seeds are brown, compressed ovoid, smooth, shiny and brittle with approximate size of 8–9 mm × 6 mm (Spicenice, 2024).

The star-like arrangement of its carpels around a central center gives rise to the fruit’s moniker. Individual carpels are typically about 1 cm long and contain a single seed; the dried fruit is about 0.25 to 0.5 cm in diameter. Carpels are firm, rough, and brownish brown when dried, whereas seeds are smooth, glossy, and light brown. The star anise in India contains about 3% essential oil. It also contains a large amount of anethole which imparts taste to the spice and adds fragrance to dishes (K-

agriculture, 2024). A medium-sized evergreen tree. Star-shaped, capsule-like, with 5-10 radiating pointed sections, each containing a seed pod. Shiny brown or reddish, with a high oil content, the main component of which is trans-anethole. Seen from March to May, and the fruits ripen from September to October. Star anise is propagated by seeds or cuttings. Seeds germinate best when temperatures are around 65-70°F (18-20°C). Gather mature star anise fruits, clean, remove seeds, stratify, and keep in a cool, wet environment for a few weeks to induce germination and break dormancy (Google, 2024c).

Botanical description is given in Fig. 1

		
Tree	**Tree**	**Fruit and Seeds**
		
Seeds	**Sowing**	**Sown**
		
Coverd with soil	**Waterd**	**Seedling**
		
Planted	**Flower buds**	**Leaves and Flowers**

Continue …..

		
Flowers	**Flowers**	
		
Unripe fruits	**Unripe fruits**	**Unripe fruits**
		
Fruits	**Fruit**	**Dry Fruits**
		
Powder	**Growing areas**	

Fig. 1: Botanical Description of star anise Pollination

Star anise plants rely on both self-pollination and external pollinators, particularly bees, for successful reproduction and fruit production. The plant has a self-pollination mechanism, where pollen transfers within the same flower, ensuring reproduction even without external pollinators. However, the yield and quality of the fruit benefit significantly from insect pollination, especially from honey bees (Pollination, 2024):

Self-Pollination: Star anise flowers can be pollinated within the same flower, a mechanism called self-pollination. This ensures that even without external pollinators, the plant can still reproduce and produce seeds.

Insect Pollination: While self-pollination is possible, the presence of insects, especially honey bees, enhances the yield and quality of the fruit.

Importance of Bees: Studies have shown that honey bees are effective pollinators of star anise, with their activity peaking during midday.

Pollination Benefits: Pollination by insects leads to increased seed production and fruit quality compared to situations where insects are excluded.

Star anise flowers are truly a sight to behold. Their star-shaped blooms, typically pale yellow to white, create a striking visual that catches the eye. The arrangement of petals, sepals, stamens, and pistils is meticulously designed. This organization not only facilitates self-pollination but also encourages cross-pollination, ensuring the plant's reproductive success. Self-pollination is made possible by the close proximity of reproductive parts within each flower. This mechanism allows for efficient pollen transfer, ensuring that fertilization can occur even in the absence of external pollinators. However, the allure of star anise flowers extends beyond self-pollination. Their delightful fragrance and unique visual appeal attract various pollinators, enhancing the chances of cross-pollination and contributing to genetic diversity. Star Anise has a fascinating self-pollination mechanism. The pollen transfers within the same flower, ensuring that reproduction can occur even in the absence of external pollinators. This method offers significant benefits, including increased genetic diversity and improved fruit yield. When plants can also engage in cross-pollination, they enhance their resilience and productivity. Several species play a crucial role in the pollination of Star Anise. Common pollinators include bees, butterflies, and moths, each contributing uniquely to the plant's reproductive success. Bees are particularly effective due to their foraging habits, while butterflies and moths add to the diversity of pollination. Their interactions with the flowers ensure a robust pollination process. Star Anise flowers employ various mechanisms to attract pollinators. One of the most notable is their delightful fragrance, which draws in creatures looking for nectar. Additionally, the flowers' bright colors and distinctive star shape enhance visibility, making them hard to miss. Together, these features create an inviting environment for pollinators, ensuring the continuation of this beautiful plant (Rankel, 2024).

GENETICS AND CYTOGENETICS

Star anise (*Illicium verum*) typically has a chromosome number of 2n = 28 (diploid, 2x = 14), meaning each cell contains 28 chromosomes, organized into 14 pairs. The base chromosome number of x = 14 for most *Illicium* species suggests that *Illicium* are ancient paleote traploids that underwent a whole genome duplication derived from an ancestral base of x = 7 (Ranney et al., 2018).

The cytogenetics of star anise, scientifically known as *Illicium verum*, primarily focuses on its chromosome number and genome size, with studies indicating a diploid chromosome number of 2n=20 and a genome size of approximately 26.2 pg (Anonymus, 2024).

GENETIC DIVERSITY

Researchers have used techniques like Sequence-Related Amplified Polymorphism (SRAP) and Inter-Simple Sequence Repeat (ISSR) to assess genetic diversity in star anise. These studies have shown that a significant percentage of bands amplified by SRAP and ISSR primers were polymorphic, indicating genetic variation. For example, one study on eight cultivated populations of star anise in Southwest China found that 99.29% of SRAP bands and 99.46% of ISSR bands were polymorphic. The average Nei's gene diversity and Shannon's information index generated by SRAP were higher than those by ISSR analysis, suggesting SRAP might be a more informative technique for assessing genetic diversity in star anise. Molecular variance analysis (AMOVA) indicated that the genetic variance of star anise mainly occurred within populations rather than among them. High genetic identity among populations was revealed by both SRAP and ISSR analysis.

Illicium verum an ecologically significant endemic plant, predominantly grows in Guangxi, China, which is the primary region for its cultivation. This area accounts for more than 80% of the total cultivation and yield in China. Despite its importance, comprehensive studies on the chloroplast (cp) genome of *I. verum* are limited. In our research, we sequenced and analyzed the complete cp genome of *I. verum* and conducted a comparative analysis with nine related species from the families Magnoliaceae, Schisandraceae, and Illiciaceae. The cp genome of *I. verum* spans 143,187 base pairs (bp), comprising a large single copy (LSC) region of 100,868 bp, a small single copy (SSC) region of 20,235 bp, and two inverted repeats (IR) regions, each 11,042 bp in length. We identified 81 simple sequence repeats (SSRs) within this genome. The chloroplast genome contains 78 protein-coding genes, 8 ribosomal RNA (rRNA) genes, and 35 transfer RNA (tRNA) genes. Structurally, the IR regions exhibit greater similarity across different genera of Magnoliaceae and Illiciaceae compared to the LSC and SSC regions. Phylogenetic analysis revealed high homology between the cp genome of *I. verum* and those of *Illicium burmanicum*, *Illicium simonsii*, and *Illicium anisatum*. These findings suggest that the cp genome of *I. verum* may serve as a valuable genomic resource for elucidating the phylogenetic positions and relationships within the Illiciaceae family. This information will be instrumental for future taxonomic research on *Illicium* species and for advancing genomic studies of these plants (Yingying Cao *et al.,* 2024).

BREEDING

Germplasm

Understanding the genetic diversity of star anise is crucial for germplasm characterization, conservation, and utilization. This knowledge can help in developing improved cultivars with desirable traits, such as higher yield or disease resistance. It can also inform conservation strategies to protect valuable genetic resources.

Breeding

Star anise breeding involves collecting seeds from mature, high-yielding trees, preparing the seeds for planting (including stratification), and planting them in well-draining soil with partial shade and consistent moisture. Here's a more detailed breakdown. Seed Collection and Preparation: Source**:** Gather seeds from mature, healthy, and high-yielding star anise trees. Fruit Maturity: Collect fruits when they are fully ripe and have a reddish-brown color. Seed Extraction**:** Carefully remove seeds from the star-shaped fruits. Stratification: To improve germination, stratify the seeds in a cool, wet environment for a few weeks to break dormancy. Storage**:** Store seeds in moist sand conditions to maintain viability, as they contain fatty oils and lose germination quickly (Google, 2024a).

Cultivars / Varieties

'Alba' White flowers (*Plants, 2024*).

Star Anise Oil

The raw materials for the preparation of SAO are star anise fruits, branches and leaves, which are the main sources of aroma from these plants. The 2020 Chinese Pharmacopoeia classified SAO as a colorless or pale-yellow clear liquid, and its smell is similar to that of star anise. When cold, it often becomes turbid or will precipitate as crystals, and it turns clear after warming. It is readily soluble in 90% ethanol. This highly flavored volatile oil has long been the subject of research, as it is the main chemical component of star anise. SAO can also be used in food flavors such as alcoholic drinks, beverages, candy, baked goods and chewing gum and as a cigarette flavoring agent. It is also a good masking agent that can cover up unpleasant odors and is therefore, used in soap fragrances, mouth gargles and toothpaste. In the fragrance industry, one of its ingredients, anisole, is used to synthesize anisaldehyde, anisol, anisic acid and its esters. These monomer fragrances are widely used in toothpaste, foodstuffs, soap and cosmetics (Qiyuan Zou et al., 2023).

Skin is a dynamic organ, meaning that it is always in a state of flux. Skin cells are constantly being exfoliated and replenished and will be replaced by new skin cells. Most people's skin flaws, which are problematic to the majority of individuals, whether it be fine lines and wrinkles, age spots, broken capillaries, face discoloration including melasma, or dry/oily or scaly skin., whether it be acne, rosacea, or related disorders. Other issues could include loss of loudness, tone, and texture. Due to its high concentration of antioxidants and minerals, star anise has many positive effects on the skin. Potent phytonutrients and antioxidants found in it do wonders for the skin. Utilizing star anise in skincare regimen can help fight acne, shield against cell damage, lighten dark spots, and minimize the look of wrinkles. One of the spice's most prized aspects and essential to its plethora of uses and therapeutic properties is its high concentration of flavonoids and polyphenols, which is also one of the spice's most valuable. To achieve the best skincare effects, incorporate star anise as a component in skincare routine (Krusha Patel *et al.,* 2024).

Use

Star anise is one of the signature flavours of Chinese savoury cooking. It combines well with pork and duck and is one of the essential ingredients in Chinese master stock. All over China, five-spice powder mix is very common. This mixture contains star anise, cassia, clove, fennel and Sichuan pepper in equal parts. As star anise is pungent, only a very small quantity is required for a pleasing result. The five-spice powder mix is often added to the batter of Chinese-style fried vegetables or meat. Meat is sometimes coated with mixture of corn starch and this spice mix before deep-frying. The mix is also used for marinating meat before stir-frying. One of the popular Chinese recipes making use of the five-spice powder mix is called five-flavoured pork. The fruit as such is used for flavouring teas and pickles. It is also used for chewing after meals in order to sweeten the breath. Star anise is sold in the shops as whole and ground, but it is used for flavouring generally in the powdered form. It is an ingredient in ground spice mixtures in puréed fruits and tarts. Besides China, star anise is used in Vietnam. In North Vietnam it is popular as one of the ingredients of the five-powder mix as in China and for making beef soups. Star anise is used in different Indian curry powders for preparing meat preparations. Star anise finds application in Indian, Persian and Pakistani cuisine also. From India some of the preparations containing star anise were introduced to Indonesia, but it has been popular only in the palaces of Sultans still adhering to Royal Indian cooking style. Among other Asian countries, star anise is employed for cooking in Malaysia and southern Thailand. Star anise has found only limited use in the West. Its main application is as a substitute for anise seed in mulled wine and special desserts. The essential oil is used to flavour soft drinks, bakery products and, most importantly, liqueurs. It is also used as a flavouring agent in confectionery, candy and chewing gum. The oil finds application in a small way in perfumery and in the pharmaceutical industry (George, 2004). There is demand for star anise oil for applications in the cosmetics industry. Other applications include natural and spa-at-home products. Star anise powder or essential oil finds use in the formulations of facial

cream, gel, paste, talcum powder, toilet soap, etc. Star anise oil nowadays is increasingly used in aromatherapy, and the powdered aromatic bark as incense (George, 2004).

Illicium verum has a long history as a medicinal plant in Asian countries, especially in China. Despite star anise being a well-known spice as well as safe food, some reports observed that star anise might be contaminated with highly toxic Japanese star anise. It is therefore essential that *I. verum* fruits should be distinguished from the fruits of the toxic species of *Illicium*, particularly in powdered samples of *I. verum*. Various methods have been reported to identify and distinguish between them, such as morphological and chemical analysis by fluorescent microscopy–gas chromatography, thermal desorption–gas chromatography, and high pressure liquid chromatography-electrospray ionization-tandem mass spectrometry. Different formulations from *I. verum* include crude drug, powders, and essential oils. In addition to its culinary use, the star-shaped *I. verum* fruit has been used in traditional medicine for treatment of stomach aches, vomiting, rheumatic pain, insomnia, skin inflammation (Rocha and Tietbohl, 2016a). Star anise is one of the signature flavours of Chinese savoury cooking. All over China, five-spice powder mix is common. This mix contains star anise, cassia, clove, fennel and Sichuan pepper in equal parts. Optionally, ginger, galanga, black cardamom or even liquorice are added. These spices are kept as whole on the kitchen shelf and ground when to use. The five-spice powder mix is added to the batter of Chinese-style fried vegetables and meat. Meat is sometimes coated with a mixture of corn starch and this spice mix before deep-frying. The mix is also used for marinating meat before stir-frying. One of the popular Chinese recipes which make use of the five-spice powder mix is called flavoured pork. Star anise flavour combines well with pork and duck. Star anise is also one of the essential ingredients in Chinese master stock and is a component of the ground spice mix of puréed fruits and tarts (George, 2012). Besides China, star anise is used on a large scale in North Vietnam. There, it is popular as one of the spices for the five-spice powder mix as in China and for making beef soups. It is essentially used to prepare broth for the Vietnamese noodle soup called *phở.* In India also star anise is a popular spice. It is one of the ingredients in Indian curry powder, *garam masala,* for cooking meat, particularly in Kerala state. It is also used in preparations such as *biryani* and chicken curry to impart the special flavour. Persian and Pakistani cuisine employs star anise to a certain extent as in North India. Some of the preparations using star anise were introduced from India to Indonesia in the past; but it remains admired only in the palaces of Sultans still adhering to the Royal Indian cooking style. Among other Asian countries, star anise is employed for cooking in Malaysia and southern Thailand. Thai iced tea (*Cha dam yen*) is brewed from black tea which is flavoured with star anise powder. It finds limited application in western cuisine. This spice is marketed as whole and ground, but it is the powder form which is often used for flavouring any preparation (George, 2012).

Star anise is a good substitute for anise seed in mulled wine and alcoholic beverages. In alcoholic beverages such as Pastis and Absinthes which are popular in France, star anise oil is used for flavouring. The oil is also used for flavouring soft drinks and special desserts. Star anise fruits after grinding or its volatile oil find application as a flavouring agent in chewing gum and chocolates. The essential oil from star anise fruits is also used in the confectionery trade to flavour licorice candy and other candies, and in the baking trade to flavour cakes, cookies and biscuits. The whole fruits are sometimes used in craft works for garnishing dishes or floated on a pot of tea (George, 2012). Star anise is a powerful antioxidant. The antioxidant property and sensory characteristics of star anise along with four other spices of the Chinese five-spice powder have been studied in cooked ground beef. Thiobarbituric acid (TBA) values were determined as a measure of antioxidant property. Even with star anise at 0.1 % level in the cooked beef, only lower pooled mean TBA values were recorded. Star anise flavour was inversely correlated with rancid odour. Another study was conducted using powders and ethanol/water extracts of star anise and caraway, all of which exhibited strong antioxygenic activity. However, volatile oil from star anise showed relatively higher antioxygenic activity than that of black caraway. In an investigation carried out with 68 Chinese herbs suitable for medical or food uses, star anise and five others were found to have the highest total contents of phenolics and flavonoids and maximum antioxidant activities (George, 2012). There is demand for star anise oil for applications in the cosmetics industry. Other applications include natural and spa-at-home products. Star anise powder or essential oil finds use in the formulations of facial cream, gel, paste, talcum powder, toilet soap, etc. Star anise oil nowadays is increasingly used in aromatherapy, and the powdered aromatic bark as incense (George, 2012).

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lung swelling (irritation) bronchitis, cough, the flu (influenza) and swine flu. For medicinal teas, pastilles, and cough mixtures star anise is used as a common ingredient. It is used to treat rheumatism traditionally. Other benefits of star anise tea include vitalizing body organs and glands such as the heart, brain, liver, and lungs (Boota *et al.,* 2018). Star anise is socially accepted in occasions and is traditionally being used in high altitude regions of Arunachal Pradesh where dried seedless fruits are used as incense, flavouring tea, preparation of butter salted tea or sugar tea for sweet fragrance and to increase and improve the potency and strength of alcohol. Also used as medicine to cure cough, toothache and sinusitis (by inhaling the vapour or by boiling the fruits in water), used as an antifungal agent and food preservative. Leaves in combination with juniper/thuja/pine leaves are burnt for making smoke which is believed to be sacred and help in purifying surrounding air (Angami *et al.,* 2021).

Star anise contains anethole, the same compound that gives anise, an unrelated plant, its flavor. Star anise has come into use in the West as a less expensive substitute for anise in baking, as well as in liquor production, most distinctively in the production of the liqueur Galliano. Star anise enhances the flavor of meat. It is used as a spice in preparation of *biryani* and *masala chai* in some parts of the Indian subcontinent. It is widely used in Chinese cuisine, and in Malay and Indonesian cuisines. It is widely grown for commercial use in China, India, and most other countries in Asia. Star anise is an ingredient of the traditional five-spice powder of Chinese cooking. It is also a major ingredient in the making of *phở*, a Vietnamese noodle soup. It is also used in the French recipe of mulled wine, *vin chaud* (hot wine). If allowed to steep in coffee, it deepens and enriches the flavor. The pods can be used in this manner multiple times by the potful or cup, as the ease of extraction of the taste components increases with the permeation of hot water (Wikipedia, 2024). Star anise fruits are harvested just before ripening, when the essential oil content is high, and used to produce a spice which is similar in flavour to aniseed. Star anise is widely used in Chinese, Indian, Malaysian and Indonesian cuisines and is one ingredient of Chinese five spice (along with cloves, fennel seeds, Chinese cinnamon and Sichuan pepper). In China star anise is generally used in pork and chicken dishes. It is chewed after a meal to sweeten the breath. Star anise is used in production of alcoholic beverages such as Galliano, sambuca, pastis and some types of absinthe. It is used to flavour Thai iced tea and sometimes as a cheaper substitute for anise in mulled wine. Star anise oil is used in soap, toothpaste, tobacco and perfume. The distinctive glossy brown fruits make an attractive addition to pot-pourri. Powdered bark is used as incense (*POWO, 2024*).

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The fruit yield on steam distillation an essential oil traded as 'Star anise oil'. It is a colourless to pale yellow liquid with a sweet aroma and flavour, closely similar to that of 'Anise oil' extracted from the seed of Anise (*Pimpinella anisum*), an unrelated, commercially grown herb originating from cold temperate Asia. Essential oils of both Star anise and Anise are widely used as a flavouring and fragrance by the food, pharmaceutical and cosmetic industries. They are used to give aniseed flavour and aroma to baked goods, dairy desserts, teas, liquors, such as 'Anisette de bordeaux' and 'Pastis', toothpaste, mouthwashes and medicines, as well as to fragrance perfumes and men's colognes, such as 'Brut', a long-standing brand. Apart from its commercial use, aniseed flavouring is used in home baking and is commonly available as Aniseed essence, usually found sold in small bottles in the baking section of supermarkets. Star anise oil is extracted mainly from the mature but not fully ripe fruit. However, varying amounts of dried fruit are mixed in with the distilled material. It is the fruit shell and not the seed that yields most of the oil, from 3 to 3.5% by weight. Some fruit is dried and used as a spice, most commonly in Chinese cuisine, to impart their strong aniseed aroma and flavour to stocks, soups, sauces and stews, especially chicken-based ones (Iplantz, 2024). Star anise is one of the signature flavours of Chinese savory cooking. The five-spice powder mix common in China contains star anise. It is used to flavour vegetables, meat, and to marinate meat. It is used as a condiment for flavouring curries, confectionaries, spirits, and for pickling. It is also used in perfumery. The essential oil of star anise is used to flavour soft drinks, bakery products and liquors. The fruit is anti-bacterial, carminative, diuretic and stomachic. It is considered useful in flatulence and spasmodic (Espicebazaar, 2024).

Star anise has a strong, sweet, and licorice-like flavor, making it a popular spice in Asian cuisine. It's a key ingredient in Chinese five-spice powder and is used in various dishes, including stews, soups, and braised meats. Star anise is also used to flavor alcoholic drinks, beverages, and even in baking (Google, 2024). Widely used as a spice in culinary applications, especially in Asian cuisines. Used as a flavoring in confectionery, tobacco, liqueurs, pastilles, and pharmaceutical preparations. Contains compounds with diverse biological properties, including antimicrobial, antioxidant, insecticidal, and anti-inflammatory effects. Star anise is a source of shikimic acid, a precursor molecule used in the manufacture of oseltamivir (Tamiflu®), an antiviral medication for influenza A and influenza B (Google, 2024c). Star anise is one of the most important spices in Chinese cuisine and it is the dominant flavour in Chinese five spice powder. In Chinese and Vietnamese cooking, star anise is used in soups and stocks, and in meat preparations especially chicken and pork. Star anise is also a regular ingredient in the cuisine of southern India. It is little used in western cuisine, but is excellent for enhancing the sweetness of leeks, pumpkin, and root vegetables. Star anise is an essential flavouring agent in drinks such as pastis and anisette, and in chewing gum and confectionery. It is also used in cough medicines, and sometimes added to pet foods. Star anise has a long history of medicinal and culinary use in Asian countries. It was known in Europe in the 17th century, and old recipes indicate that is was mostly used to flavour syrups, cordials, and preserves (Spicetrader, 2024). The fruit is antibacterial, carminative, diuretic and stomachic. It is taken internally in the treatment of abdominal pain, digestive disturbances and complaints such as lumbago. It is often included in remedies for indigestion and also in cough mixtures, particularly because of its aniseed flavour. For children it is effective for digestive upsets, including colic pain. Some people chew the fruit after meals for better digestion. The antibacterial effect is reported to a certain extent to be similar to penicillin. The essential oil is stimulant, stomachic, carminative, mildly expectorant and diuretic. It is an ingredient in cough drops. The oil can be applied externally to treat rheumatism and scabies. It is considered useful against body lice and bed bugs, and forms an ingredient in cattle sprays against fleas (George, 2004). Star anise has been used in a tea, and the seeds are sometimes chewed after meals for digestion. Star anise is grown in four places in China and harvested between March and May. It is also found in the south of New South Wales (Wikipedia, 2024a).

Nutritional Value

The star anise is a well-known source of carbohydrates, proteins, vitamin A and ascorbic acid. It contains proteins (2-4g), carbohydrates (65-75g), fats (4-6g) dietary fibers and sugars. Star anise is a rich source of minerals including sodium, calcium, zinc, magnesium, potassium, iron and copper etc. Almost 359Kcal energy is obtained per 100g of star anise. The aromatic odor of *Illicium verum* is because of presence of essential oil which is 2.5–3.5% in the fresh fruit and 8–9% in dried material. GCMS is generally used to find out the chemical profile of essential oils. This scented volatile oil is chiefly comprises of trans-anethol and shikimic acid (3,4,5- trihydroxy-1-cyclohexene-1-carboxylic acid). Other chemical constituents including sesquiterpenes, phenylpropanoids, lignans, flavonoids, palmitic acid are also present. The cancer preventing and antiviral actions of star anise oil is because of the high concentration of trans-anethole. It is also used as a substrate for making different pharmaceutical products, for example, chloral an anticonvulsive agent (Boota *et al.,* 2018). The chemical composition of star anise has been studied since 1983. Modern research has shown that different parts of this plant (including the roots, leaves and fruits) contain various chemical components, including a volatile oil, phenylpropanoids, sesquiterpene lactones and flavonoids. To date, 201 compounds have been identified, including organic acids, flavonoids, phenylpropanoids, lignans, sesquiterpenes, alcohols and some simple hydrocarbons. This includes 58 new compounds found more recently. Most of the new compounds found in the star anise are phenylpropanoid and lignan compounds. Chemical investigations of the genus Illicium have resulted in the isolation of prenylated C_6–C_3 compounds, neolignans and seco-prezizaane-type sesquiterpenes, which are characteristic chemical markers of this species. Phenylpropanoids and flavonoids are the most frequently reported components in the chemical composition studies of star anise and have a wide range of pharmacological effects. The chemical constituents that have been identified are listed in tables, and their corresponding structures are represented diagrammatically in the accompanying figures (Qiyuan Zou *et al.,* 2023).

Health Benefits

Star anise is used traditionally in many Chinese medicines and in Ayurveda. The fruit is antibacterial, carminative, diuretic and stomachic. If taken internally, abdominal pain, digestive disturbances and complaints such as lumbago can be cured. Leaves also have antibacterial activity. Some people chew the fruit after meals for better digestion and pleasing breath. Star anise oil is often included in cough mixtures, particularly because of its aniseed flavour, and it is an ingredient in some cough drops. The oil can be applied externally to treat rheumatism and scabies. It is considered useful against body lice and bed bugs, and forms an ingredient in cattle sprays against fleas. For children it is effective for digestive upsets, including colic pain. Hence it is a traditional practice among Hispanic and Caribbean people to give star anise tea to babies when they cry due to colic pain. The antibacterial effect is somewhat similar to penicillin. It is helpful in soothing inflamed mucous membrane of the nasal passage (George, 2012).
Economic and medicinal importance of Chinese star anise (Shahrajabian *et al.,* 2019):

1. The anti-bacterial and anti-fungal properties of Chinese star anise are useful in the treatment of diseases like asthma, bronchitis and dry cough.
2. Chinese star anise can also be used as for its sedating properties to secure a good sleep.
3. Its osil is appropriate in providing relief from rheumatism and lower back pain.
4. It can also be used as a natural breath freshener.
5. There is a compound present in Chinese star anise which is called Shikimic acid, and it is used for preparing drug for curing influenza or the flu virus.
6. Another important compound present in Chinese star anise which contains anti-oxidants properties is Linalool, and it is good for overall health.

7. The chemical compounds which derived from this important herb also have anti-oxidant, disease preventing and health promoting properties.
8. Anethole is the most important compounds in this herb, but other important compounds found in the seeds include extragol, p-anisaldehyde, anise alcohol, acetophenone, pinene and limonene.
9. In traditional Chinese and Asian medicine, it mainly uses as stomachic, anti-septic, anti-spasmodic, carminative, digestive, expectorant, stimulant and tonic.
10. The seeds are excellent source of many essential B-complex vitamins such as pyridoxine, niacin, riboflavin, and thiamin.
11. Seeds are also great source of minerals like calcium, iron, copper, potassium, manganese, zinc, and magnesium.
12. This important spice is also contain good amounts of anti-oxidant vitamins such as vitamin-C and vitamin-A.

The fruits are aromatic with a slightly bitter and astringent taste and considered as stimulant, carminative, stomachic and galactagogic. It is also used in treating vomiting, dyspepsia, abdominal pain and food poisoning. It was found to possess cancer fighting properties especially against lung cancer cells and also possesses potent antimicrobial activity. Star anise is a potential source of shikimic acid for the production of Tami flu (oseltamivir), an active drug against avian influenza or bird flu (Angami *et al.,* 2021). The essential oil contains around 85% anethole, an organic compound with stimulant, diuretic and antiseptic properties. It is used in traditional medicine against digestive complaints, such as indigestion and gas and as a treatment against respiratory ailments, such as cough and congestion. It is also prescribed against toothache and bad breath. Star anise is also the most concentrated natural source of shikimic acid, which is used to synthesise the anti-influenza drug Oseltamivir, otherwise known as Tamiflu. The pharmaceutical industry is now the largest buyer of star anise, purchasing about 90% of the harvest (Iplantz, 2024).

Here's how star anise can boost your health (Singh, 2025).

1. Boosts immunity
2. Supports digestive health
3. Possesses antifungal and antibacterial properties
4. Aids in managing respiratory issues
5. Helps balance blood sugar levels
6. Supports heart health
7. May help reduce menstrual discomfort
8. Improves sleep quality
9. Promotes skin health
10. May have anti-cancer properties

Preliminary studies suggest that the polyphenols and flavonoids in star anise have potential anti-cancer effects by inhibiting the growth of cancer cells. While more research is needed, its antioxidant-rich nature contributes to overall cellular health and disease prevention. Star anise is a powerful spice with numerous health benefits, but it should be consumed in moderation, as excessive intake may cause side effects.

Drug precursor

Star anise is the major source of the chemical compound shikimic acid, a primary precursor in the pharmaceutical synthesis of the anti-influenza drug oseltamivir (Tamiflu).[10][11][12] An industrial method for the production of shikimic acid using fermentation of *E. coli* bacteria was discovered in 2005, and applied in the 2009 swine flu pandemic to address Tamiflu shortages, eventually reversing price increases for star anise as a raw material of shikimic acid. As of 2018, fermentation of *E. coli* was the manufacturing process of choice to produce shikimic acid for synthesis of Tamiflu (Inaturalist, 2024;, Wikipedia, 2024).

Toxicity of related species

llicium verum is not toxic. However, other related species are toxic (Inaturalist, 2024; Wikipedia, 2024).

CULTIVATION

Propagation

This plant is propagated by seed and mainly cultivated for perfume, medicines, and as a culinary spice in southern China, as well as in Vietnam. The fruits are harvested before they ripen, then sun dried. The flowers are seen from March to May, and the fruits ripen from September to October (Rocha and Tietbohl, 2016a).

Flowering season starts from January to April, fruiting season from end of April, fruit mature from September onwards and harvesting starts from October to December. Propagation is by seed and since seeds lose germination power quickly, they have to be planted preferably within three days of harvest of fruits. Layering has also reported to be successful (Angami *et al.*, 2021). The invention discloses a method for propagating cuttages of star anise with short spikes, which comprises the procedures of mother tree management and protection, collection and treatment of cuttings, cuttings and post-cuttage management; by grafting the fine clones of 11 to 14-year-old star anise artificially cultivated in the nursery to graft dwarf The mother tree is managed and cultivated, and the pruned branches with a length of 4 cm to 6 cm are collected and cuttages are placed in a cutting bed equipped

with a cutting matrix. By controlling the light, relative humidity and water content of the matrix in the cutting bed, anise cutting seedlings are obtained. The quality of the spikes obtained by this propagation method is excellent and pure, easy to root, low in cost, simple in operation, fast in propagation, high in reproduction coefficient, and maintains the characteristics of an excellent clone of star anise, and the cuttage seedlings are resistant to drought, waterlogging, wind, and It has strong resistance to pests and diseases and low temperature, early fruiting, dwarfed tree crown, convenient fruit harvesting, and good economic and social benefits (Patents, 2024).

Cultivation: Propagation of star anise is by seed. Seeds are collected from fresh fruits of vigorously growing mature trees known for high yield. Fully matured large seeds, recognized by their characteristic brown colour, are selected. Seeds are sown 3–4 cm apart in a well-prepared raised bed. Since seeds quickly lose germination power, they have to be planted preferably within 3 days of the harvest of fruits. Layering has been attempted and found successful. After seedlings have produced the fourth leaf, they are transferred to a nursery and planted 25 cm apart. Once they are 3 years old, they are sufficiently grown and strong for planting in the field. Spacing for planting is about 5 m. Young trees do not require special care except weeding and manure application when necessary (George, 2004). Trees flower normally when they are about 10 years old. The nature of flowering is unusual. There are three seasons for flowering. The first blossom of the year is from March to the end of April. Flowers of this blossom are generally sterile and do not develop into fruits. The second blooming is from July to August but lasts for 2 or 3 weeks only. Flowers of this blossom are larger and fruits are developed, but some are lost at a premature stage during November–January. The third flowering season starts immediately after the second, sometimes partly dovetailing with it. Although flowers of this season are relatively small, they develop into fruits and help to produce a bigger harvest by August–October of the following year. Thus the tree flowers almost throughout the year. Flowers are bisexual, scented and colour ranges from white to red. Fruits are available all the year round with seasonal variations. Normally harvest during August–October accounts for 80 % of the production. Many fruits fall from the trees prematurely owing to strong winds and when there are sudden changes in temperature (George, 2004). Volatile oil content is about 3.5 % in the fresh fruit. Since the maximum content of essential oil is found just before full maturity and ripening, fruits should be gathered at this stage. Traditionally, children do most of the harvest. They climb the trees and gather fruits using hooks attached to long poles. Sometimes, fruits are harvested by shaking branches. In the initial years, yield of fresh fruits is small, amounting to only 0.5–1.0 kg per tree. Yield increases with age and reaches nearly 20 kg fresh fruits per tree by the 15th year. When a tree is 20 years old, full production is expected and the yield may go up to 30 kg. Harvested fruits are dried in the sun. Recently, a drying machine has been developed by modifying a tea drier with a capacity of 120–160 kg. Optimum drying time is 7.536 hours. One hundred kilogram fresh fruits yield about 25–30 kg star anise of commerce on drying and cleaning. During drying, fruits turn into deep red colour. The characteristic aroma and flavour of star anise are developed during the drying process (George, 2004).

Star anise likes moist soil, so it is necessary to choose the right planting soil to grow star anise. The soil is fertile, the cultivation layer is thick, the pH is from 6-7. Provide soil that is humus and compost rich. Soil texture should be loamy and well drained. Slightly acidic to the neutral soil is optimal. The soil is moist all year round, well-drained. Star anise should not be planted on limestone, less acidic or neutral soil, mixed sandy soil, sandy soil, the thin layer of soil with strong erosion. For growing star anise, do regular watering and keep the soil slightly moist but reduce the watering in winter. Because it is a moisture-loving plant, star anise needs a lot of water. Star anise trees need an average rainfall from 1,200 to 1,800 mm. At the maturity stage (over 10 years old), star anise has moderate drought tolerance, and flexibly adapts to different conditions of the environment. Star anise trees need water during the following periods: preparing for flowering, preparing for fruit, and before harvesting. In the first stage when planting anise, it is not advisable to leave the tree in the hot sun, there must be a cover. Under 5 years old, star anise does not tolerate strong direct light. At the age of 8 years, star anise begins to flower, along with that, the need for light also gradually increases. By the age of 20 years or more, star anise requires full light (Ngoc Nguyen, 2022). Star anise can be grown in provinces with an average annual temperature of 20-21°C. When young, star anise does not tolerate high temperatures, in the summer the seedlings easily die. On the contrary, the cold tolerance of star anise trees is relatively high, and they do not die from frost. Star anise requires dappled shade, partial sun but if you're growing star anise in a much cooler climate, plant it in a warm and sunny location. Choose a position in a way that it is not exposed to cold and dry winds. Spread a 3-inch layer of compost or aged manure on the ground surrounding the tree in the spring. This is the only fertilizer it requires. If the soil is poor, apply slow release fertilizer all-purpose fertilizer in the spring. When the plant is the young, pinch and prune it if you want to make it bushier. There are no special pruning requirements. However, you can always prune off dead, diseased and weak branches. Star anise tree takes at least 6 years to fruit if grown from seeds. These fruits (wrongly called seeds) are picked unripe while they are still green, later on, these fruits are sun-dried until their color change to reddish-brown, seeds can be removed once the fruits are ready to be stored. There are not any specific pest or disease that bothers it. Star anise itself has antibacterial and pest repellent properties (Ngoc Nguyen, 2022). Star anise is grown widely in tropical areas of East Asia and Southeast Asia. Plants are propagated from cuttings or seeds, which nestle inside the points of the star-shaped fruit. Seeds are collected from high-yielding trees and sown within three days of collection or else stored wet at 5°C for up to a year. Seedlings are planted out in a well-manured field when they are three years old. Star anise gives off a strong, attractive aroma, making it pleasant to cultivate. Dried and alcohol-preserved specimens of *Illicium verum* are held in Kew's Herbarium, where they are available to researchers from around the world by appointment. The details of some of these can be seen online in Kew's Herbarium Catalogue. Specimens of star anise fruits, seeds, oil and anisic acid are held in Kew's Economic Botany Collection, where they are available to researchers by appointment *(POWO, 2024).*

Star anise grows naturally in humid subtropical and tropical mid- to high-elevation climates, generally frost-free areas with annual lows of 13 to 19°C, annual highs of 21 to 28°C, annual rainfall of 1200 to 2700 mm and a dry season of 4 months or less. New plants are mostly raised from seed best collected from highly productive, mature trees and then sown within three days (after soaking in lukewarm water overnight). Performs well on deep, rich, free-draining clay and loam soils of a strongly to slightly acid

nature, generally with a pH of 4.0 to 6.5, and on sites with full to partial sun exposure. It has poor tolerance to soils that are alkaline, limestone-derived, slow-draining or waterlogged. The tree is slow-growing, and it takes a long time to come into bearing, with reports of small harvests starting when the tree is about five to six years old. It does not come into full production until ten years old or older (Iplantz, 2024). Prepare well-draining soil with good drainage and fertile soil. Plant stratified seeds in a nursery bed, ensuring they are covered with 1-2 cm of soil. Maintain a warm and damp environment until seedlings emerge. After 12-18 months in the nursery, transplant seedlings at the 4th leaf stage into growing beds. Plant the seedlings in the field, ensuring adequate spacing (5-7 meters apart) and using a mixture of topsoil, compost, or animal manure in the planting pits. Mulch around the plants to retain soil moisture, especially during the dry season. Regularly weed to prevent competition for resources. Provide regular irrigation to maintain consistent moisture levels. Prune the plants regularly to maintain shape and encourage healthy growth. Protect the plants from strong winds, which can damage young trees (Google, 2024a). The star anise cultivation in India requires well-draining soil and stratification in order to propagate. Let's know about planting and propagation techniques of star anise. Gather mature star anise fruits, clean, remove seeds, stratify, and keep in a cool, wet environment for a few weeks to induce germination and break dormancy. Plant stratified seeds at a depth of 1 to 2 centimetres in well-draining soil in a nursery. Till the seedlings appear, maintain the area warm and damp. Plant the seeds in the field where there are no weeds. Seedling care involves selecting a suitable site with partial shade, fertile soil, adequate spacing, regular watering, and mulch to ensure proper growth and suppress weeds. Star anise plants require regular pruning, mulching, and irrigation to maintain a constant moisture content. Their ideal growth is facilitated by protection from strong winds, and they flourish in subtropical to tropical climates. For the sustainable star anise cultivation in India, It's required organic farming and finding the best location for planting and water resource conservation, and seed propagation (Thomas, 2024). Seasonal care is needed to keep star anise plants healthy. In addition, plants require regular watering, mulched soil to hold onto moisture, shaping pruning in late winter or early spring, improved air circulation, and shelter from strong winds during stormy seasons. Star anise plants must be checked often because they are prone to pests and diseases. Diseases and pests quickly attack Star anise plants, so inspecting them for problems periodically is essential. Neem oil is one natural remedy that can help with pest control. Proper watering and avoiding waterlogged soil prevent diseases. During spring pruning, ensure good air circulation and protect plants from strong winds. Regular monitoring and quick action are essential for maintaining the health of star anise plants throughout the seasons (Thomas, 2024).

Harvesting

Star Anise is actually the fruit of the star anise plant, scientifically known as Illicium Verum Hook. Star anise is an essential ingredient in many Chinese, Vietnamese, Indonesian and Indian dishes. It is one of the spices that is used in pho, a Vietnamese noodle soup. Vietnamese star anise has a very strong, distinct flavor that is sweet and spicy, similar to licorice. There are 2 seasons of star anise in Vietnam. Spring season from February to March and autumn season in September. Anise usually blooms from March to May, until around July, September, star anise begin to ripen and enter the harvest season. Autumn harvest starts in September and lasts until the end of October each year. Due to favorable weather conditions, this crop gives more flowers. Autumn star anise is more beautiful, has larger petals and seeds inside. In the autumn, the weather is cool but it rains a lot, making the trunk of star anise easy to slip, the branches of star anise are big but brittle and easy to break. Therefore, it is difficult for farmers to harvest star anise, and the price of anise is also higher because of that (Ngoc Nguyen, 2022). Spring harvest starts in March till the end of April. With this crop, star anise usually blooms at the end of winter and after Tet, farmers can harvest this season. Star anise flowers of this season are not better than the autumn crop. Star- shaped anises have smaller size than autumn crop, even some flowers do not open but still eight points, a seed in each point. At this time, the weather conditions are less suitable for star anise than in autumn, so this season's star anise has a lower yield, but still retains the inherent characteristics of Vietnamese star anise, containing high essential oil content. Anise is native to the northern provinces of Vietnam. Currently, they are grown a lot in the provinces bordering China and the northeastern provinces of our country. Some prominent places can be mentioned such as Lang Son, Cao Bang, Bac Kan, … These are all prestigious and long-standing anise growing areas (Ngoc Nguyen, 2022). The star-shaped fruits are harvested just before ripening (Google, 2024). Star anise cultivation in India relies on optimal harvesting in late autumn to ensure fully developed and flavorful seeds. Post-harvest processing is crucial to preserve the spice's quality. To reduce moisture content and extend shelf life, farmers dry fruits in the sun or with controlled techniques. After the seeds are removed, the spice is prepared for distribution. An excellent product is delivered to markets and customers through proper post-harvest processing, which maintains the distinctive candy flavour and aromatic qualities (Thomas, 2024).

Main Areas Growing

Star anise comes in different types, which might have variances in their taste and appearance. Now let's get to know a few of them. The sweet, star-shaped spice known as star anise is mainly grown in Arunachal Pradesh, Assam, and Meghalaya in India because of the climate and soil, making it ideal for cooking. The best places in India to grow star anise are Arunachal Pradesh, Himachal Pradesh, and some hilly areas in the northeast due to the climate and soil. This spice, which has culinary and medicinal uses, is grown by local farmers and has a strong aroma. These areas' temperature, climate, and altitude offer the ideal conditions for them to thrive. Indian Star Anise: Tamil Nadu, Kerala, Karnataka, and Andhra Pradesh are the states in which this variety is grown (Thomas, 2024). A large amount of star anise in India is produced in Arunachal Pradesh (K-agriculture, 2024).

The star anise needs unique agroclimatic conditions found only in traditional producing regions, which is the reason why star anise is not massively grown in the world except for Vietnam, China and Arunachal Pradesh in India (K-agriculture, 2024). China is the primary producer of star anise, followed by Vietnam and other Southeast Asian countries (Google, 2024). ommercial production of star anise is limited today to China, Vietnam and Laos. China has the largest area under star anise cultivation. Growing areas in China are in southern and southeastern provinces, particularly mountainous elevations of Yunnan. In Vietnam, star anise is grown

in provinces adjoining the Chinese border. Lang Son province is the important area, but other provinces such as Bac Kan, Thai Nguyen, Cao Bang and Quang Ninh also produce this spice. In Lang Son province, cultivation is mostly in the districts of Van Lang, Van Quan, Tay Bac, Cao Loc, Binh Gia, Nam Truong Dinh and Bac Son. Total extent in this province is more than 9000 ha, the dominant district being in Van Quan. In the past, trees mostly belonged to collectives and to state farm enterprises.

Production

From 1990 onwards, these were dismantled and trees allocated to household management. The Vietnam government had plans to bring in an additional 20 000 ha of star anise. The area in Laos under star anise production is much smaller compared to Vietnam (George, 2004). Trade estimates of production are available. With more area, production in China is higher than that of Vietnam. It was estimated that production in both these countries together was more than 25 000 Mt in 2000. Rough trade estimates in 2010 indicate that production has reached about 40 000 Mt for the three countries together (George, 2004).

Economic Impact

The cultivation of star anise highly depends on the economy of India, which boosts the country's spice trade and pays farmers. The spice's unique flavour and aromatic properties are responsible for its widespread appeal. As people become more health conscious, this spice's potential medical benefits are driving up its popularity. The distinctive qualities of Indian star anise continue to draw customers and improve the standard of living for those engaged in its trade and cultivation (Thomas, 2024).

Storage

Store both whole or ground spice in an air-tight container away from moisture, heat, and sunlight. Whole star anise will remain fresh and vibrantly flavored for about one year, whereas the ground spice will begin to lose flavor after about six months. Toasting the ground spice before using sometimes heightens the flavour (Moncel, 2023). The whole spice will last for up to a year if kept away from bright light in an airtight container. The ground spice lasts for only 2-3 months so should be bought in small quantities (Spicetrader, 2024).

Postharvest Technology

The cutting of star anise fruit is done after ripening in summer season and then it is dried in sunlight. The flowering is observed from March to May, and its fruit get mature from September to October. The harvesting time has a greater effect on its constituent and yield of essential oil. Star anise is preserved after harvesting. When growth is completed then after 30 days seeds are collected. Seeds are put in container that do not contain excess of humidity, as it will influence the nature of the seed, the seeds are put on the fabric for 48 hours to dry in the presence of sunlight before storage. Star anise is hard in surface and should be sealed in container for proper storage. The leaves of star anise also contain numerous active components and have many uses. The leaves are harvested and dried for two days in warmth if environmental conditions are ideal. If the atmosphere is saturated, leaves are kept in storage space. These leaves are checked every day consistently to check whether they are dry or not. The leaves can also be preserved by another process: Stems and twigs are discarded first and leaves are cut into little pieces and olive oil is sprinkled on them. These olive oil leaves are kept in freezer after packing in plastic bags. These plastic bags opened only when to use them. For the short term storage they are put in air tight container and placed in vegetable compartment (Boota *et al.*, 2018).

Processing

Star anise is used in variety of ways and for various purposes. Different methods are used to get extracts and essential oil from star anise includes: Hydro distillation (HD), steam distillation (SD), solvent extraction (SE) and supercritical fluid CO2 extraction (SFE). HD or SD method, are used to extract oil in which high temperature of steam and the hydrolytic effect of water may cause thermal degradation, hydrolysis and water solubilization of some aroma constituents, yet it has reduced extraction effectiveness. SFE, extraction takes the attention of producers now days to get volatile oils from star anise. It is very easy to operate generally at normal temperature and pressure. The supercritical CO2 is totally separated from the sample at the end of the extraction, and its dissolvable power can be changed by changing the temperature and pressure. To get more volatile compounds the use of this technique now has been popular in the world. At the end of extraction essential oil and different extracts are obtained which contain shikimic acid and trans-anethol. The obtained oil and extracts are identified by smell and color (Boota *et al.,* 2018).

Value Addition

There are different commercial products in which star anise is used like: carrot powder, tomato granule and tomato powder, dehydrated garlic flake, dehydrated beet flakes, cabbage flakes and black garlic. Star anise is the great source of the shikimic acid compound, which is used by pharmaceutical companies to make anti-influenza medicine called Tamiflu. In food industry, star anise is generally used as nourishing supplement. It is used in a variety of dishes from beverages to deserts and savory stews. The essential oil of star anise is utilized as a scent in cleansers, beauty care products, aromas, and toothpaste, and to mask undesirable smells in medication products. Star anise has been utilized widely in Chinese cooking and in Indian dishes, it is a principle constituent of 'garam masala (Boota *et al.,* 2018).

Star Anise as A Natural Income Resource

Although, its commercial cultivation and marketing is still at infant stage, yet it serves as a good source of household income for rural poor. Due to its high demand, locals collect dry fruits from wild and sold to middle men. The dried fruits are sold at a rate of Rs. 150-200/- per kg which vary according to market demand. Henceforth, awareness on its economic importance to motivate local people for commercial cultivation, management, conservation and domestication of the species is necessary not only to increase the income but to meet the market demand. Apart from its economic importance, cultivation of the species in agroforestry system having a potential for afforestation of degraded land and social forestry programme with community participatory management will further enhance rural economy to sustain and its conservation (Angami *et al*., 2021).

Taste

Star anise has a very strong, distinct flavor that is warm, sweet, and spicy, similar to licorice, fennel seed, clove, and anise seed, of course. Although the flavor of star anise is generally thought of as sweet, it is commonly used in savory dishes; it pairs well with citrus, onions, poultry, beef, cinnamon, nutmeg, and ginger and should be used in small quantities (Moncel, 2023).

How to Buy

When shopping for star anise, Cardoz suggests looking for pods that are whole, with the star shape intact instead of broken into pieces. “You want it to be whole because that shows you it's been cared for, it's not leftover pieces that they put in a bag and are selling to you,” says Cardoz. When stored in a cool, dry, dark place, whole star anise will last about one year, while ground star anise will last about six months before losing its flavor. Most spice and international markets carry star anise, usually in both whole and ground form. Ground star anise can be found in the spice aisle of most grocery stores. Given that star anise has a very powerful flavor, it can be much easier to control it by buying the whole pods and grinding them yourself (Maggio, 2023).

Cooking

In most Asian and South Asian cuisines, star anise is used to flavor vegetables, meats, and soups like Vietnamese Phở Saigon. The spice also has baking applications, and can be found as an ingredient in pumpkin spice blends. It’s also often used in mulled wines. For Cardoz, star anise is very much a part of her usual cooking. “I don't use it ground as much as I use the whole pods,” she says. “I'll normally use it if I'm making a pilau, a biryani, or a rich meat curry. I find the sweet, earthy, musky flavors lend themselves more to heavy sauces, gravies, and curries.” (Maggio, 2023). It has a milder flavour that works better in recipes, calling for a subtle licorice taste rather than the well-known Chinese star anise. Indian star anise lends a delicate aroma to masalas and spice blends without overpowering the overall flavour, which makes it a popular ingredient in traditional Indian cooking. It is sometimes used for possible digestive benefits in Ayurvedic practices, which adds to its role in herbal remedies. The climatic and soil variations among India’s regions account for spice flavour and aroma variations (Thomas, 2024).

Whole vs. Ground

Whole and ground star anise are used differently in cooking. The whole pods are added to braised dishes, soups, and stews to infuse flavor and are removed at the end of cooking. Ground star anise powder is used similarly to other ground spices. Powdered star anise begins to lose its flavor shortly after it is ground up, so the best method is to buy whole star anise and grind it as needed. The pods and seeds can be ground together (Moncel, 2023).

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