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Star Anise: A review on benefits, biological activities and potential uses

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Abstract

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. Traditional uses of *Illicium verum* are evidenced from south and west Asia, where it has been consumed for a number of disorders. Several bioactive constituents such as sesquiterpenes, phenylpropanoids, lignans, flavonoids and other compounds have been recognized from *Illecium verum*. 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). Current review highlights the information relating to the botany, conventional uses, phyto-chemistry and pharmacology together with the toxicology of *Illicium verum*.

Key words: Star anise, anethol, essential oil, shikimic acid

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1. Botany

1.1. Introduction

Star anise (*Illicium verum*) is an evergreen small medium sized tree from the plant family Illiciaceae [1]. 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. 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). The origin, source and growing conditions have an impact on plant uses. The star anise has a wide variety of uses, depending upon origin and growing conditions, which will be explored in more detail below.

1.2. History

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. 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. 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 [2].

1.3. Demography/Location

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. It should be protected from low temperature. Star anise grows in following countries: China, Japan, Laos, Philippine, Indonesia, Vietnam and Jamaica. 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). The star anise production in China in 2015-2016 was 95,000 tons as compared to 2014-2015 when it was 93,800 tons and in 2013-2014 94,500 tons, respectively. It has been transported to the dry and low temperature areas.

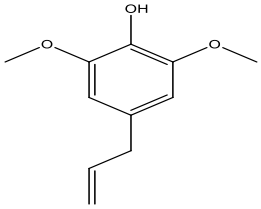
1.4. Botany, Morphology, Ecology

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

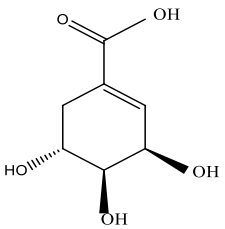
pink to dim red, bisexual, axillary or subterminal, and are 1.5–4 cm, in diameter. The petals seven to twelve, extensively elliptic to broadly ovate. The carpals are 10 mm long, boat shaped, hard and wrinkled, containing a seed. The anthars have 1–1.5 mm length. The fruit is star-shaped with reddish brown color comprising of six to eight follicles that are arranged in a whorl. The seeds are shiny and brittle brown, compressed and smooth [1-3]. Star anise grows in warm subtropical atmosphere. It is cold sensitive. Star anise just develops in zones where the temperature does not fall beneath 15 ºF (- 10 ºC). Star anise should be kept in a nursery in winter for growth. Star anise is propagated by seeds or cuttings. Seeds are proliferated best when temperature goes around 65 – 70 ºF (18 – 20 ºC). Seeds can sow in pots as well as outside. Seeds should be watered often to keep them wet and ensure the pot has drainage holes in the base to remove excess water.

2. Chemistry

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 [4-10]. This scented volatile oil is chiefly comprises of trans-anethol and shikimic acid (3,4,5-trihydroxy-1-cyclohexene-1-carboxylic acid) (Fig.1). 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 [11-12].



Anethol



Shikimic acid

Figure 1. Structures of important compounds found in star anise essential oil

3. 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.

4. 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 CO_2 extraction (SFE) [13-14]. 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 [11]. 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 (Wang et al., 2011). The supercritical CO_2 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.

5. 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 [12].

6. Uses

Star anise has many uses ranging from culinary to religious. It is grown around temples and on graves by Japanese. It is believed that when star anise is put in four directions on altar, it gives power. It is considered to be associated with good luck. More often the whole star or part of it is used in the recipe, right for Chinese tea eggs. Star anise is also used as flavoring in confectionery. Star anise is a main ingredient used in Indian curries and stews. Star anise is added in biryani to enhance its flavor. The major ingredient of garam masala is star anise. It has been utilized in soups in Vietnamese and also used in making masala chai in India [15]. It has lot of medicinal uses. It improves digestion and has been used as additive to improve the taste of traditional medicines. This is a versatile plant which can be used for internal as well as external applications. For example it is used internally for colic, flatulence, menstruation disturbances, whooping cough, liver diseases and tuberculosis. Star anise is inhaled externally to treat respiratory tract blockage. It has been utilized as a part of a tea as a solution for colic and stiffness, and the seeds are very effective because they improve digestion if they are chewed after meal. It is useful for stomach related sicknesses. It is used in, 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 etc.

7. Pharmacological uses

The essential oil of *Illicium verum* has been shown in studies to have pharmacological uses. Numerous medicinal activities shown by essential oil of star anise include: antispasmodic, expectorants, aromatic, antiseptic, diuretic, anti-inflammatory, stimulant, as well as diaphoretic properties.

7.1. Antimicrobial activity

Star anise has been observed to have excellent antimicrobial properties. Trans-anethol is a principal component of star anise which exhibit antiparasitic, antiviral, antibacterial and antifungal properties [16]. The antifungal activity of this plant has been identified *in vitro* by using spore germination inhibition assay, vapor contact assay, and mycelial radial growth inhibition assay. IC_{50} values of the star anise oil against mycelar growths of eleven plant pathogenic fungi observed to be in the range of 0.07 to 0.25 mg/ml while for all other tested parasitic fungi these IC_{50} values were observed from 0.06 mg/ml to 0.25 mg/ml. Agar diffusion method is taken as a standard method to identifying *in vitro* anti septic activities of the isolated anethole. The results of a study conducted in 2010 demonstrated that the supercritical CO_2 and ethanol extracts of *I. verum* exerted substantial antibacterial activity against 67 clinical drug-resistant isolates, including *Pseudomonas aeruginosa and Acinetobacter baumannii* etc [17]. The antimicrobial compounds from *I. verum* including shikimic acid and the flavonoid quercetin were also identified in this study. The antibacterial activity of methanol extract and decoction of *I. verum* fruits against anaerobic and aerobic bacteria was also performed in vitro using the standard disc diffusion method. Researchers examined the antimicrobial activity (in-vitro) of decoction and methanolic extracts of *I. verum* against various anaerobic bacteria including *Porphyromonas gingivalis, Eikenella corrodens, Actinomyces odontolyticus, Veilonella parvula, Peptostreptococcus Micros* and *Capnocytophaga gingivalis*. Only *Eikenella corrodens* showed susceptibility to the methanolic extract (MIC of 256mg/L) and decoction (512 mg/L) of *I. verum*. In addition to this, moderate anti-HIV properties were shown by the compounds (phenylpropanoids, 26-methyl ester and 26-dioic acid) isolated from the roots of *I. verum*.

7.2. Insecticidal activity

For the identification of insecticidal activity of star anise, the direct contact methods were applied against fruit flies (*Drosophila melanogaster*). The methanol extract of star anise yielded (E)-anethole as the key constituent that is mainly responsible for this activity. (*E*)-anethole caused 80.3% mortality at 0.159 mg/cm^2 at 1 and 3 days treatment in a filter paper diffusion mehod. Incredible insecticidal activity has also been obtained against *Lasioderma serricorne*, (tobacco beetle) adults with methanol extracts of star anise, using filter paper diffusion method. The tested extract acted rapidly at a rate of 3.5 mg/cm^2, causing 100% mortality after 1 day treatment. Insecticidal properties have also been found in volatile oil of star anise against larva and adults of *T. castaneum* (*Tribolium castaneum*), *Botrytis cinerea* and *Callosobruchus chinensis* [18-19]. The efficacy of star anise oil was also determined against golden snail with100% at 10–20 ppm.

7.3. Anticancer activity

The human body has numerous natural set ups to deal with free radicals; in any case, it has additionally been demonstrated that eating nutritional items rich in cancer preventing agent can enhance innate protection. Diseases induced by free radicals and nicotine can be cured by star anise because it has anti-carcinogenic agents. The anticancer action is because of flavonoids, resveratrol and curcumin.

They additionally have exhibited remedial potential, including cell-defensive anti-inflammatory, and DNA protective properties. This spice also has positive effect on DNA damage, which can be a trigger for cancer, as well as on cancer cell migration [20].

7.4. Antiviral activity

Star anise has a powerful antiviral activity. The chemical, Shikimic acid, present in star anise is responsible for antiviral action of this plant. Shikimic acid shows this activity well when it is mixed with another compound called quercetin, (a cancer prevention agent. A mixture of these two chemicals averts flu. The mixture of these two chemicals can cure flu as well. This mixture is also being tested by researchers of China and Taiwan for the treatment of bird flu.

7.5. Anti-inflammatory activity

Acute inflammation protection is a normal, protective process that helps body to deal with infections. Star anise is being used in inflammation disorders. Star anise anti-inflammatory action was identified in mice by xylene-induced auricle edema. For identification of anti-inflammatory action digestion systems of mice was separated and then xylene was injected. Intestinal muscle pressure and contraction was diminished. It was noticed that the auricle swelling of mouse by injecting xylene, decreased the threshold pain the torsion body of mice. The star anise extracts of 10 and 20 mg rough drugs·mL^{-1}, clearly decreased the contractility of mice intestinal smooth muscles in 15 min after under the effect of acetylcholine and barium chloride. So it is concluded that aqueous extract of star anise has analgesic and anti-inflammatory effects on mice intestinal smooth muscles [21].

7.6. Anti-diarrheal activity

In different countries of world diarrhea is serious health issue. The disease can be cured by herbal medication. So star anise is used in the treatment of diarrhea. A study of gastrointestinal action of the blend of chamomile and star anise is carried out in mice, and the rate of activated carbon through the intestinal tract of the animal is measured. The different mixtures were prepared with a 50:50 proportion of the herbs, and are administrated at Mix-10, 20, 40 and 80 (mg/kg) orally. It was examined that blend 40 and blend 80 diminished the rate of carbon activated lessened the appearance of looseness of the bowels and diminished the quantity of evacuations. This study recommends that mixture of chamomile and star anise can be utilized as an alternative anti-diarrheal treatment [22].

7.7. Anti-fungal activity

The anti-fungal activity of star anise was tested against *F. solani* (Fusarium solani) and *F. graminearum and F. oxysporum*. Complete inhibition (100%) was examined by using 100ppm concentration of star anise due to high antifungal action. The growth of *F. verticillioides* is also completely inhibited at 200 ppm concentration [23].

7.8. Analgesic, sedative and convulsive activity

The oral administration of star anise extract (methanolic) exhibited strong hypothermic activity at a concentration of 3g/kg and writhing inhibition (23%) at 500mg/kg. Ethyl acetate extract showed hypothermic activity in mice at the concentration of 100mg/kg. However, lethal toxicity and convulsions were observed at higher concentration (500mg/kg). Three compounds including veranisatins A, B, and C were isolated from the extracts of star anise. Lethal toxicity was caused by these compounds at an oral dose of 3mg/kg, but at lower doses (0.5 mg/kg) strong hypothermic effect was shown without toxicity. Veranisatin A was further examined for its sedative and analgesic activities. Oral administration of this compound showed potential analgesic activity in mice at a concentration of 0.1 mg/kg [1].

8. Toxicity and safety

Star anise (*Illicium verum*) is a famous spice and safe food. Some investigations reported that it might be contaminated with Japanese star anise which is highly toxic. Therefore, it is necessary to distinguish its fruits from other species of genus *Illicium.*

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