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Chinese star anise (*Illicium verum*) and pyrethrum (*Chrysanthemum cinerariifolium*) as natural alternatives for organic farming and health care- A review

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Abstract

Botanical insecticides keep attracting more attention from environmental and small farmers worldwide as they are considered as a suitable alternative to synthetic insecticides. The outstanding properties of pyrethrum include rapid action, low mammalian toxicity, broad spectrum of activity, lack of insect immunity, lack of persistence and of course effective insect repellent. Pyrethrum is a natural insecticide which has many properties, but the most important are rapid action, very low toxicity for mammalian, lack of insect immunity, broad of activity, lack of persistence and quick degradation by UV-sunlight and very effective insect repellent. Using natural pesticide may lead to organic farming, and advantage of organic farming is more beneficial to biodiversity and the environment, which reduces dietary exposure to pesticides. Chinese star anise has anti-bacterial and anti-fungal characters. It is useful in treatment of diseases like asthma, bronchitis and dry cough. One of its most compounds is Shikimic acid which is used as a drug in curing influenza and flu virus. It also consists of Linalool which is good for overall health because of its anti-oxidants characters. Its seeds are good source of minerals like calcium, iron, copper, potassium, manganese, zinc, and magnesium. The seeds are a great source of essential B-complex vitamins such as pyridoxine, niacin, riboflavin and thiamin. Chinese star anise is also a good source of anti-oxidant vitamins such as vitamin-C and vitamin-A. The essential oil of Star anise contains anethole which has shown several functional properties including antimicrobial, antioxidant, hypoglycemic, hypolipidemic and oestrogenic properties. Star anise primarily contains anethole and fatty oil. Its essential oil has a sweetish, burning flavor and a highly aromatic odor. Organic farmers may use these two ancient Chinese herbs which can lead to industrial sustainability.

Keywords: Chinese Star Anise, Pyrethrum, Eastern Alternative.

Introduction

Pyrethrum (*Chrysanthemum cinerariifolium*)

The interest in sustainable agriculture has increased in recent years. The demand for plant-derived pesticides are less toxic both to mammals and to the environment (Soleymani et al., 2011; Shahrajabian et al., 2013; Soleymani et al., 2016; Shahrajabian et al., 2017; Ogbaji et al., 2018; Shahrajabian et al., 2018; Soleymani et al., 2018; Shahrajabian et al., 2019). Insecticidal pyrethrins are extracted from the achenes within the flower heads (Grdisa et al., 2009), and represent the economically most important natural pesticide which are neurotoxins effective against a wide range of insect species, and is broadly applied in private homes, gardens, stables and organic agriculture, because they have environmentally friendly properties (Yang et al., 2014). It was discovered about 200 years ago in central Asia. During the Napoleonic wars (1804-1815) it was used to control flea and body lice infestations by French soldiers. The white Chrysanthemum flower (pyrethrum) has been mentioned in early Chinese history. It is believed to have passed into Europe along the Silk Road. The first record of the pyrethrum was 2000 years ago at the time of China's Chou Dynasty, then the flowers were traded along ancient Silk Road and was grown in the Dalmatian region. Although the earliest notes of the Chrysanthemum flowers in early Chinese history, it is believed that the flower passed into Europe along the Silk Road. The term pyrethrum refers to the dried and powdered flower heads of a white-flowered, daisy-like plant belonging to the *Chrysanthemum* genus. Pyrethrum could be used by municipal utilities as organic or integrated with conventional crop cultivation because of its natural origin and high biocide effect. The pyrethrum has been used mainly for protection of cereal

products, vegetables and animals, and could also be used to protect human habitats and animals against insects. There are some possible uses: the first is spraying the fine dry pulp of flowers and the other spraying their extract. The second form is incense sticks to protect against mosquitoes causing malaria (Toth et al., 2012). Pyrethrum is a white flower headed, tufted perennial herbaceous plant possessing deeply lobed leaves, with numerous and fibrous shallow root system (30 cm). The plant has numerous fairly rigid stems that grow up to 50 to 80 cm in height with blue-green deeply divided leaves that are covered on both sides by a dense woolly material. Pyrethrum requires rich soils in phosphorous, calcium and magnesium with a minimum soil pH of 5.6. The appropriate situation is fertile and well-drained soils with reasonably good texture and structure. This crop is spring sown, with its first harvest occurring approximately 15 months after establishment and up to three subsequent annual harvests thereafter (Vaghefi et al., 2016).

The *pyrethrins* properties such as insect flushing, excitation, quick knockdown, rapid degradation and low mammalian toxicity are desired in short term grain protection. However, there is a need for reapplication or additional application when a long-term storage period is required. Chesang et al. (2017) concluded that increased proportion of unstabilized pyrethrins in combination with diatomaceous earth offer grain protection comparable to the commercial chemical grain protectants. Pyrethrins can be separated into two groups of three ester compounds: pyrethrin I and II. The pyrethrin I fraction contains chrysanthemic acid products, including pyrethrin I, cinerin I, and jasmolin I. The pyrethrin II fraction is derived from pyrethric acid made up of pyrethrin II, cinerin II, and jasmolin II (Casida, 1980; Casida, 1990; Elliot, 1995). Pyrethrins also have the advantage over other synthetic insecticides due to its ability to rapidly break down upon exposure to light and air. It is also quickly metabolized and can be used in the production of organic farm products. They generally considered as non-polluting (Casida, 1990; Elliot, 1995). Roncevic et al. (2014) found that the roots of pyrethrum plants are characterized by a combination of loadings of iron, aluminium, nickel, chromium, strontium, and barium, while the stems, leaves, and flowers showed more contributions from sodium, potassium, calcium, magnesium, phosphorus, sulphur, manganese and copper. They have also observed that microelements such as copper, aluminium, and iron were more readily transferred into natural insecticide extracts. Duchon et al. (2009) suggested that pyrethrum maybe a potential candidate for the impregnation of mosquito nets and textiles in areas, where resistance to pyrethroids has become problematic. Rehman et al. (2014) stated that pyrethroids are broadly classified into first and second generation pyrethroids. The first generation (Type 10 pyrethroids are less toxic to mammals than the second generation (Type II) pyrethroids.

Chinese star anise (*Illicum verum*)

Star anise (*I. verum Hook. f.*) is a medium-sized evergreen tree which is native to southwest of China. It is also widely cultivated in the subtropical and tropical areas of Asia (Elmasry et al., 2018). 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 (Wang et al., 2011). De et al. (2001) reported that 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 (Acimovic et al., 2017). *Illicium verum Hook. f*. mainly grows in the provinces of Guangxi, Guangdong and Yunnan, covered nearly 80% in the world (Yan et al., 2002). This plant also has been reported to possess anti-bacterial, anti-cancer and of course anti-inflammatory characteristics (Yang et al., 2010). Kang et al. (2013) reported that Chinese anise star can alleviate inflammatory responses and is a common flavor in medicinal tea, cough mixtures and pastilles. Star anise is classified in the division Magnoliohpyta, class Magnoliopsida, sub-class Magnoliidae, order Austrobaileyales, family Illiciaceae. The plant is widely distributed in the central and southern parts of the Japanese archipelago (Yoshikawa et al., 2018). Japanese star anise looks very similar to Chinese star anise in its dried form but that is where the similarity ends. The Japanese star anise is extremely toxic and is not edible in any form (Yoshikawa et al., 2018). Recently concern has been raised regarding adulteration effect of Chinese star anise with Japanese star anise (Scharge et al., 2013). The fruit is also most toxic, followed by the seed, root, leaf and bark. Howes et al. (2009) explained that the volatiles desorbed from the pericarps of the toxic *I. anisatum* (Japanese star anise) were characterized by the presence of asaricin, methoxyeugenol, and two other eugenol derivatives, and none of which were detected in any other species examined. 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 (Vecchio et al., 2016). 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 (De et al., 2001). 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 (Ismaiel et al., 2016). Verghese (1998) also claimed that, 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 (De et al., 2001). It has been reported that (E)-Anethole, limonene, linalook, and α-pinene are major components of the essential oil of *I. verum* (De et al., 2002). Also, it is used as medicine to cure cough, toothache and sinusits, used as an anit-fungal agent and food preservative (Angami et al., 2017). De et al. (2001) found that 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

Table 1. Economic and medicinal importance of Chinese star anise.

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 oil 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 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.

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 are in fevers, scabies, constipation and insomnia. Vecchio et al. (2016) noted that Pimpinella anisum (anised or green anise) and *Illicium verum* (Chinese star anise or star anise) are both under the name of anise, but each one presents different functional and botanical characteristics. Both Chinese star anise and anise have been widely used in Iranian traditional medicine for antimicrobial effects (Yazdani et al., 2009). It has not only studied for its advantages in food and medicinical science (Ohira et al., 2009), but also it has been studied for its essential oil which is biologically active for both fumigating and repelling *S. zeamais*, Blattella germanica, Lasioderma serricorne, Sarocladium oryzae, Callosobruchus chinensis, and Aedes aegypti (Dana and Wej, 2006). Gholivand et al. (2009) reported that the dried star anise fruit is almost composed of 49 compounds, which may include trans-anethole (81.40%), limoene (6.50%), chavicol (2.10%), and also ani-saldehyde (1.81%). Li et al. (2013) 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, and into 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. Ismail (2018) mentioned that 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 (Wang et al., 2011). Parsa et al. (2012) reported that 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. They have also found that the oil of star anise is stimulant, stomachic, carminative, mildy expectorant and diuretic. Aly et al. (2014) mentioned that its fruit is an important traditional Chinese medicine as well as a commonly used spice. The Chinese star anise also facilitates birth and increases the libido, as well as relieves menopausal discomforts. Its oil is applicant in rheumatism as recommended by some folk remedies. Sripongpun (2008) stated that the crude extract of Chinese star anise can be applied as an optional control of house fly at breeding sites. Evidence indicate that anethole is natural bioactive compound with multiple beneficial effects in human health such as anti-inflammatory, anticancer, chemopreventive, neuroprotective, spasmolytic, hypotensive, antithrombotic, immunomodulatory, and antidiabetic. It offers a safe approach in treatment of several chronic diseases, especially in skin and lung inflammatory disorders, cancer, type 2 diabetes and neurological diseases. Wei et al. (2014) suggested that *I. verum* fruit extracts and trans-anethole can potentially be developed as a grain protectant to control stored-product insect pests. Li et al. (2013) also found that *I. verum* which is one of the most important Chinese herb, has possess insecticidal activity against *S. zeamais* and *Cryptolestes pusillus Schnoherr*. Other studies have indicated that the essential oil of *I. verum* has repellent and fumigant actions on *S. Zeamais*, Blattella germanica (Change and Ahn, 2001), Lasioderma serricorne, Sitophilus oryzae, Callosobruchus chinensis (Kim et al., 2003), and Aedes aegypti (Dana and Wej, 2006). Yang et al. (2010) introduced *I. verum* as natural anti-microbials for the treatment of antibiotic pathogens. Abdallah et al. (2013) investigated the antiviral activity of anise oil against bovine herpes virus type 1- (BHV-1) in cell culture and they found that anise oil is non-toxic to MDBK cells upto 100 ug/ml, and also inhibited the growth and development of BHV-1. Sung et al. (2012) recommended star anise in the treatment of inflammatory diseases. Alhajj et al. (2015) indicated that Chinese star anise could be used as a natural additive to improve the immune responsiveness and performance of broiler chickens. One of the most important character of *I. verum* is digestive aid, which may make the nursing mothers

promote breast milk production. It has the anti-bacterial and anti-fungal affection of astham, bronchitis, and dry cough, refreshed the breath, and ensure a good sleep (Ashraf et al., 2012). Fagundes et al. (2014) concluded that anethole in the essential oil of *Illium verum Hook* can be identified and determined by GC-MS, NMR and UV-VIS, and a superior HPLC method has been developed for the determination of the compound in rat plasma. Zhang et al. (2015) have examined the characteristics aromatic constituents of star anise, and they have confirmed forty seven compounds, with trans-anethole, estragole, and anisaldehyde the main aroma components. The content of trans-anethole was the highest (75.76%), followed by linalool (1.44%), Limonen (1.01%), and 4′-methoxypropiophenone (0.72%) were the lowest. Economic and medicinal importance of Chinese star anise is presented in Table 1.

Shikimic acid which extracted from *I. verum* is one of the main ingredients in the antiviral drug Tamiflu used to fight avian influenza (Ohira et al., 2009; Borah, 2015). *I. verum* has been reported to possess antioxidant properties (Chempakam and Balaji, 2008) as well as significant anticancer potential (Shu et al., 2010). Antioxidant properties may be recommended in enhancing shelf life of products such as spices (Prakash et al., 2011). Natural antioxidants are known to protect cells from damage induced by oxidative stress, which is generally considered to be a cause of ageing, degenerative disease, and cancer (Ringman et al., 2005). Dinesha et al. (2014) concluded that the extracts of star anise exhibited effective prevention ability against H_2O_2 induced cell death and DNA protection. These activities of extracts may be due to the presence of polyphenols, proteins and flavonoids in star anise extracts. Chouksey et al. (2013) observed that the extracts of *I. verum* possess potent central nervous system (CNS) depressant action and anxiolytic effect without interfering with motor coordination. Park et al. (2015) suggested that treatment with *Illicium verum* maybe the basis of a novel therapeutic strategy for hyperlipidemia-antherosclerosis. Ritter et al. (2014) also found that anethole which has been found in both star anise and anise exerts a peripheral ant-nociceptive effect without causing sedation. They did propose anethole as an interesting therapeutic alternative in inflammatory and painful diseases. Li et al. (2017) showed that *I. verum* fruit extracts exhibit considerable potential for *M. persicae* control programs. Lenora et al. (2016) concluded that commercial use of star anise could be an alternative for the management of water hyacinth, contributing to solve environmental and economic problems caused by it. Zhou et al. (2016) have found that star anise extracts showed significant inhibitory effects on aerobic bacteria counts. Besides, star anise extracts showed antimicrobial activity against amine producers. Peng et al. (2016) have suggested that the SJYB extractives of *I. verum* had a function in activating the acquired immune response and a huge potential in biomedicine. Diaz et al. (2014) have found that the mixture of star anise and chamomile decreased the completion percentage of the activated carbon, delayed the appearance of diarrhea and decreased the number of evacuations in comparison with the control treatments. They have finally proposed that the combination of chamomile and star anise can be used as an alternative anti-diarrheal treatment. Yadav and Bhatnagar (2007) indicate that the treatment with star anise rescues the tumor burden, lowers oxidative stress and increases the level of phase II enzymes, which may contribute to its anti-carcinogenic. Both the essential oil from Chinese star anise fruit and trans-anethole are major constituents and exhibit potent inhibitory effect against all test fungi indicating that most of the observed anti-fungal properties was due to the presence of trans-anethole in the oil, which could be developed as natural fungicides for plant disease control in fruit and vegetable preservation (Huang et al., 2010; Vecchio et al., 2016).

Conclusion

Pyrethrum (*Tanacetum cineraiifolium*) is a perennial in the Astraceae that has been widely used for pyrethrin production. Pyrethrins are the active ingredients derived from the natural insecticide pyrethrum, and pyrethroids are synthetic or manufactured versions of pyrethrins. The active constituents of Pyrethrins are, Pyrethrin I, Cinerin I, Jasmolin I, Pyrethrin II, Cinerin II and Jasmolin II. The combined usage of pyrethrin I and II have significant influence for pest control. Pyrethrins are natural products and permitted in organic agriculture because they are degraded by sunlight and changes in pH, into non-toxic products, which are immobile in soil. Pyrethrum which is a natural insecticide has many properties, but the most important are raid action, very low toxicity for mammalian, lack of insect immunity, broad of activity, lack of persistence and degraded quickly by UV in sunlight and very effective insect repellent. Organic farmers can use pyrethrins as an insecticide for fruit and vegetable crops. Pyrethrum can control pests in a difficult battle in a natural way.

Star anise (*Illicium verum Hook. f*.) is one of the most famous evergreen trees, which has originally distributed in tropical and sub-tropical areas of Asia, especially China. It is famous in traditional Chinese medicine as well as traditional Asian medicine. It has been reported that (E)-Anethole, limonene, linalool, and α-pinene are major components of the essential oil of *I. verum.* The most important compounds of Chinese star anise are α-Pinene, β-Pinene, Myrcene, α-Phellandrene, 3-Carene, α-Terpinene, p-Cymene, Limonene, Trans-Ocimene, Cis-β-Ocimene, γ-Terpinene, Terpinolene, Linalool, γ-Terpineol, 4-Terpineol, α-Terpineol, Estragole, Cis-Anethole, Trans-Anethole, α-Cubebene, β-Clemene, Caryophyllene, Bergamotene, Δ-Cardinene, and α-Cadinol. Star anise is one of the many species that contains bioactive compounds as well as a number of phenolic and flavonoid compounds, having antioxidant, preservative and antimicrobial properties. Star anise considered as the main source of shikimic acid, which is the most important ingredient of Tamiflu drug. Chinese star anise has anti-bacterial and anti-fungal characters, and is useful in treatment of diseases like asthma, bronchitis and dry cough. It is also has a good effect on sleep. One of its most compounds is Shikimic acid which is used as a drug in curing influenza and flu virus. It consists of Linalool which is good for overall health because of its anti-oxidants characters.

Conflicts of Interest

All authors declare no potential conflicts of interest.

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