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REVIEW ARTICLE

Pimpinella Anisum and *Illicium Verum*: The Multifaceted Role of Anise Plants

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Abstract: The role of dietary active compounds in human nutrition is an important area of investigation in the field of nutritional science. In this perspective, functional foods play a relevant role, offering a new kind of health tool that promises specific effects related to particular food components. Anise plant has a long cultural tradition in various countries all over the world, both as food and as drug. The essential oil of anise, extracted from the dry ripe fruits of *Illicium verum* and *Pimpinella anisum*, contains anethole, an active chemical compound that showed several functional properties including antimicrobial, antioxidant, hypoglycemic, hypolipidemic and oestrogenic properties.

To date, studies conducted on the properties of anise, demonstrated the efficacy of the plant in the improvement of physiological condition in human and the possibility to exploit the active compounds of anise for the treatment of several chronic diseases. The aim of this review is to collect data on anise in order to evaluate its pharmacological properties.

Keywords: Anethole, Anise, Antioxidant, Functional properties, *Illicium verum*, *Pimpinella Anisum*.

INTRODUCTION

The role of dietary active compounds in human nutrition is an important area of investigation in the field of nutritional science. Nowadays, the demand for foods and beverages improving the health status has increased worldwide, due to the rise of healthcare costs and the desire for a higher quality of life [1]. In this perspective, functional foods play a relevant role, offering a new kind of health tool that promises specific effects related to particular food components [2]. The first definition of functional food was introduced in 1980 in Japan and it was referred to processed foods that support specific body functions, in addition to their nutritional properties [3]. Nowadays, there is no universally accepted definition of functional food but several organizations gave their own explanation. The Institute of Medicine of the US National Academy of Sciences defined functional food as the food that encompass potentially healthful products, including any modified food or food ingredient that may provide a health benefit beyond its nutrient content. In Korea, functional foods are defined as dietary supplement with the purpose to supplement the normal diet, marketed in measured doses such as in pills [4]; for the European Commission's Concerted Action on Functional Food Science in Europe (FuFoSE), functional foods have beneficial actions on one or more body functions beyond adequate nutritional effects and act by improving state of health and well-being and/or by reducing the risk of disease [1]. For centuries plant-based medicines have been used traditionally for the treatment of a wide range of diseases, including gastrointestinal [5] disorders such as dyspepsia, gastritis and peptic ulcer [6, 7]. Nowadays,

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phytotherapy compounds are used as an alternative treatment option, because they may offer advantages in terms of safety, tolerability, and costs, improving patient compliance especially in chronic disorders and long-term treatments [8]. Anise is an example of plant used for different purposes all over the world, because of its healthy and functional properties. *Pimpinella anisum* (green anise or aniseed) and *Illicium verum* (star anise or Chinese star anise) are both identified under the name anise, but each one presents different botanical and functional characteristics. Both plants are commonly used in Iranian traditional medicine as antimicrobial [9]; *P. anisum* is used in Turkey for its stomachic, carminative and appetizing effects [10] and in Egyptian medicine for the treatment of respiratory diseases [11]. Furthermore, *I. verum* has long been used in traditional Chinese medicine with the actions of dispelling cold and relieving pain [12].

The aim of the present paper is to describe the traditional use, the phytochemical characteristics and the pharmacological properties of *P. anisum* and *I. verum*, presenting the multifaceted role of these medicinal plants, used in the traditional culture of several countries.

Botany and Plant Description

I. verum Hook. f. is classified in the division Magnoliophyta, class Magnoliopsida, subclass Magnoliidae, order Austrobaileyales, family Illiciaceae. The plant is a medium sized tree, 8-15 m tall and 30 cm depth. The bark is white to bright grey. Leaves are 6-12 cm long, alternate, simple, leathery, entire, shining, glabrous, usually crowded in bundles at the end of the branches. Flower is large, bisexual, 1-1.5 cm in diameter, white pink to red or greenish yellow, axillary and solitary. Fruit is capsule like, aggregate is star shaped. Each arm is seed pod. Fruits are picked before they ripe and dried. Seeds are shiny brown or reddish with high oil content [13, 14]. Flowers bloom from March to May, and the fruits ripe from September to October.

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 [12].

P. anisum L., is classified in the division Magnoliophyta, class Magnoliopsida, subclass Rosidae, order Apiales, family Apiaceae (also known as Umbelliferae). It is an herbaceous annual plant with stem about one foot high, erect, smooth, slightly branched. Leaves are numerous, lower ones are cordate and cuneate-lobed, middle ones are pinnate-lobed, and upper ones are trifid. The flowers are small and white, the fruits are oval, striate with five ridges, with a few scattered hairs of a peculiar greenish tint. *P. anisum* is endemic in Asia Minor, Egypt (where it is used since ancient times as aromatic herb), and Greece, certain areas of Europe (Spain, Italy, Germany, Southern Russia) and South America. It is cultivated in Turkey, Russia, South Africa, Latin America, and Brazil. Anise fruits, which are commercially called "seeds", are used as flavorings and crude drug. The essential oil from anise fruits is used in food processing, perfumes, toothpaste, and in medicine [15].

Chemical Constituent and Use of Anise

The essential oil (anisi aetheroleum) extracted from steam distillation of ripe fruits of both *I. verum* and *P. anisum* [16] contains trans-anethole from 80% to 95% or more (responsible for its characteristic taste and smell, as well as for its medicinal properties [17, 18]), followed by chavicol methyl ether (estragole), anisaldehyde and cis-anethole [19].

P. anisum composition includes, in addition, coumarins (umbelliferone, umbelliprenine, bergapten, and scopoletin), lipids (fatty acids, beta-amyrin, stigmaterol and its salts), flavonoids (flavonol, flavone, glycosides, rutin, isoorientin, and isovitexin), proteins and carbohydrates [17]. *P. anisum* is well known as a carminative and an expectorant, and it is also used to decrease bloating, especially in pediatric patients. At higher doses, it is used as an antispasmodic and antiseptic [17, 18], and *in vitro* studies have also reported an antimicrobial action [17].

The fruits of *I. verum* contain, besides volatile oil, resin, fat, tannin, pectin and mucilage [20], making the plant efficacious in the treatment of dyspeptic complaints, catarrhs of the respiratory tract [21], rheumatism and otalgia. The fruits are also used for their antiseptic, digestive, diuretic, and deodorant properties [22]. *I. verum* is also used as aromatic spice for food and cosmetic preparations, representing an ingredient of the traditional five-spice powder (a mixture of star anise, clove, cinnamon, pepper and fennel) of Chinese cooking, especially for meat and soup [20]; the seeds are used in baked goods and confections [23] and in the West, *I. verum* is added in fruit compotes and jams and in the manufacture of anise-flavoured liqueurs (anisette) [20].

Anti-oxidant Effect

Free radicals, in particular the reactive oxygen species -ROS- have been shown to cause cellular injury and have been considered as one of the most important factors in the etiology of various diseases like diabetes mellitus, cancer and stroke. Free radicals determine damage to cellular DNA and are the precursors of carcinogenesis. A substantial amount of data from epidemiological studies indicate that diet has positive impact on the multistage process of chemical carcinogenesis [24]. In scientific literature, several studies demonstrated the influence of anise and *I. verum* on cells oxidation, showing the beneficial effect of anethole on the interruption of carcinogenesis [25]. Yadav *et al.* demonstrated that treatment with star extracts reduced the mean nodular volume as well as the development of nodules in the liver of rats with induced carcinogenesis, and that the nodule incidence was significantly lowered after star treatment in rats [26]. Gulcin *et al.* evaluated the antioxidant properties of water and ethanolic extracts of *P. anisum*, comparing the activities with synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and α -tocopherol. Both extracts of *P. anisum* showed strong antioxidant activity, reducing superoxide anion scavenging, hydrogen peroxide scavenging, and metal chelating activities compared to BHA, BHT, and α -tocopherol [27].

Antibacterial Activity

Numerous wild plants show antimicrobial properties, particularly in blocking the bacterial reproduction and their development. The antibacterial effects of the individual components of anise oil varied depending upon their chemical structure, functional groups and configuration as well as doses used. Singh *et al.* showed that the antibacterial activity of *P. anisum* can be exploited against *Stafilococco aureus* responsible for bases, sepsis and skin infection; *Streptococcus haemolyticus* causing infection of the throat and nose; and *Bacillus subtilis* responsible for infection in immune compromised patients. The oil can also be used to control *Pseudomonas aeruginosa* which causes hospital acquired infection; *Escherichia coli*, responsible for urinogenital tract infections and diarrhea; *Klebsella* spp and *Proteus vulgaris* [28]. These results are confirmed by Abu-Darwish, showing the antibacterial activity of anise by demonstrating that the plant has a relevant role against clinical and standard strains of *S. aureus* and *E. coli* [29]. Anise plant, thanks to its active compounds, could be used in pharmaceutical preparations as natural antibiotics.

Effect on Gastrointestinal Disorder

The beneficial effects of anise in the treatment of gastrointestinal disorder are reported in several studies. Al Mofleh and coworkers demonstrated the antacid action of the plant, showing that anise suspension enhances ethanol-induced gastric wall mucus depletion in rats, confirming the ability of anise to prevent and/or ameliorate the effects of damaging agents on gastric mucosa [30].

Furthermore, the methanol extract of *P. anisum* seeds inhibits the *in vitro* growth of *Helicobacter pylori*, the gram-negative bacterium which represents an etiological factor for gastrointestinal disorders, representing a potential compound useful in the treatment of gastric diseases [5].

Estrogenic Effect

P. anisum has been used as estrogenic agents for millennia especially due to the anethole, which is considered the active estrogenic agent. Albert-Puleo in his study demonstrated the estrogenic role of the plant, which increase the milk secretion, promote menstruation, facilitate birth, alleviate the symptoms of the male climacteric, and increase libido [31]. The estrogenic role of anise is also showed by Nahidi and colleagues, which demonstrated, in a double blind clinical trials on 72 postmenopausal women, that the consumption of 300mg of anise extract for 4 weeks, leads to significant reduction in hot flash frequency, caused by the decrease and cessation of estrogen secretion [32].

Effect on Glucose Absorption and Diabetes

The effect of *P. anisum* oil on glucose absorption was studied by Kreydiyyeh *et al.* The study showed that the oil added to the perfusion buffer and administered in rats' jejunum increase significantly the absorption of glucose from the small intestine.

The absorption mechanism is due to the stimulation of the $\text{Na}^+ \text{-K}^+$ ATPase, mediated by *P. anisum* oil, which increases the sodium gradient that gears the mucosal glucose transport [33].

The role of anise in people affected by diabetes is reported in a work of Rajeshwari and colleagues. They showed

that the administration of 5 gr per day of anise seed powders for 60 days decrease the fasting blood glucose, the serum cholesterol and triglycerides, and improve the serum high density lipoprotein (HDL) in type 2 diabetes patients. The antidiabetic and hypolipidemic activities exhibited by the seeds are a result of the synergistic action of the bioactive compounds present in the seeds, and demonstrate the possible use of anise seed in the treatment of hyperglycemia [34].

Effect on Constipation

In a randomized clinical trial conducted on 20 patients with chronic constipation, the laxative effect of a phytotherapeutic compound containing *P. anisum* L., *Foeniculum vulgare* Miller, *Sambucus nigra* L., and *Cassia augustifolia* was investigated.

The two endpoints of the study were the measurement of the colonic transit time and the number of evacuation per day. The results revealed the laxative effect of phytotherapeutic compound compared to the placebo, demonstrating the use of this compound as a possible cure for constipation [35].

Other Effects

In 1985, Reiter *et al.* describe the effects of volatile oil of this plant on the relaxation of the tracheal isolated muscles of guinea pig [36] and after them, the antispasmodic effect of anise's compounds was evaluated in several other studies. An example of a latest study on antispasmodic effect was conducted by Tirapelli and coworkers, which demonstrated the reduction of anococcygeus smooth muscle contraction in rat induced by acetylcholine, due to three hidroalcoholic extract of *P. anisum* at different concentration (40%, 60% and 80%) [37]. The effect demonstrated by this study justifies its use in the folk medicine as an antispasmodic agent. Despite the healthy effect of *P. anisum* and *I. verum* demonstrated by scientific literature, that conferred to the plants the characteristic of "harmless medicine", some cases of intoxication were registered. The major part of these cases, among infants and child, were reported because the *I. verum* tea is often used in various cultures for the treatment of infant colic pains. In particular, the toxicity is due to the contamination of *I. verum* by Japanese star anise or *Illicium anisatum* L, which contains several neurotoxins (anisatin, neoanisatin, and pseudoanisatin) causing serious neurologic and gastrointestinal symptoms [38]. Furthermore, the effect of *I. anisatum* on people exposed to the substance contained in the contaminated beverage was really serious, consisting of signs of acute-onset irritability, jitteriness, clonus or myoclonus, increased deep tendon reflexes, nystagmus, vomiting, and seizures [39]. In this perspective, the knowledge of the effect of eventual contamination of herbal teas with Japanese star anise is a cardinal point to prevent such events.

CONCLUSION

Anise belongs to a family of spices with a long history. In addition to their traditional uses, *P. anisum* and *I. verum* have multiple applications in botany, chemistry and pharmacology. Several studies were performed to identify the chemical compounds and the pharmacological properties of the plant demonstrating that its action is mostly due to anethole, the major component of essential oil, which showed a great scientific interest worldwide. In this paper the antimicrobial and antioxidant effects of anise were reported. Furthermore, the review also revealed the use of plant as gastric protector, oestrogenic agent and its employment in the treatment of diabetes due to its hypoglycemic and hypolipidemic effects. Considering the multifaceted activity and the beneficial properties of anise, the plant could be used for the control and the cure of several human diseases. Despite anise has a broad spectrum of pharmacological effects, very few clinical studies were performed on this plant. In future, the identification of active compounds of this plant which can lead to the synthesis of new drugs is necessary, as well as clinical trials, for the evaluation of the beneficial effects of *P. anisum* and *I. verum* in human models.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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