Anise (Pimpinella anisum L.), a dominant spice and traditional medicinal herb for both food and medicinal purposes

Wenli Sun1,2*, Mohamad Hesam Shahrajabian1,2** and Qi Cheng1,2**

Abstract: Aromatic plants such as anise seed have a long traditional use in both folk and conventional medicine and of course in the pharmaceutical industry. Important compounds found in anise seed include estragol, p-anisaldehyde, anise alcohol, acetophenone, pinene, and limonene, but the most important volatile oil that gives the characteristic sweet, aromatic flavor to seeds is anethole. The recent studies have shown that anise seeds and essential oil have antioxidant, antibacterial, antifungal, anticonvulsant, anti-inflammatory, analgesic, gastro-protective, antidiabetic, and antiviral activities. Other important benefits of anise seeds are stimulant, carminative, expectorant, insecticide, digestive, antispasmodic, antirheumatic, antiseptic, antiepileptic, antihysteric, culinary significance, keeps the heart strong by its importance role to control the blood pressure, one of the best gas-releasing agent, eases many hormonal problems in females, hair benefits, skin benefits, and it may reduce symptoms of depression. Anise seed and its extract also use in savory dishes, baked goods, and different drinks in both ancient and modern time. Anise seeds are good source of many essential B-complex vitamins such as pyridoxine, niacin, riboflavin, and thiamin. The seeds are also important source of.

ABOUT THE AUTHORS
Dr. Wenli Sun is an assistant researcher working on related topics of allelopathic characteristics of medicinal plants, especially traditional Asian herbs, fruits and crops. She is also working on topics related to sustainable agriculture and farming. Her full profile is available in http://orcid.org/0000-0002-1705-2996

Dr. Mohamad Hesam Shahrajabian is a senior researcher of Agronomy and Biotechnology. His full profile is available in https://orcid.org/0000-0002-8638-1312

Prof. Dr. Qi Cheng, is a professor of biotechnology and his researches have connected with agrobiotechnology and agrotechnology. His full profile is available in http://orcid.org/0000-0003-1269-6386. All these scholars are researchers in Biotechnology Research Institute, Chinese Academy of Agricultural Sciences, and Nitrogen Fixation Laboratory, Qi Institute, Building C4, No. 555 Chuangye Road, Jiaxing 314000, Zhejiang, China (Corresponding author).

PUBLIC INTEREST STATEMENT
Pimpinella anisum L., is an aromatic, annual grossy herb with 30–50 cm height, white flowers and small green to yellow seeds with secondary feather like leaflets of bright green, twice pinnate. Keeping the traditional knowledge of Chinese medicine and other Asian medicine is vital requirement for not only saving traditional Chinese medicine are not only important cultural resources, but also can be used as organic products to have sustainable life. Anise seed oil contains anethol, estragole, eugenol, pseudoeugenol, methyl chavicol and anisaldehyde, coumarins, scopoleting, umbelliferon, estrals, terpene hydrocarbons, and polyacetylenes as the major compounds. The plant oil has both pharmacological and clinical effects. The pharmacological effects consist of antimicrobial, hepatoprotective, anticonvulsant, anti-inflammatory, antispasmodic, bronchodilator, estrogenic, expectorant, and insecticidal effects, and clinical effects such as nausea, constipation, menopausal period, virus, diabetes, obesity, and sedative action.
minerals like calcium, copper, potassium, iron, manganese, magnesium, and zinc. Antioxidant vitamins such as vitamin C and A can also be found in the spice. More clinical studies are necessary to uncover the numerous substances and their effects in ginseng that contribute to public health.

Subjects: Botany; Conservation - Environment Studies; Biodiversity & Conservation

Keywords: Health benefits; traditional Chinese medicine; traditional Asian medicine; clinical aspect; anethole

1. Introduction

1.1. Anise occurrence and cultivation

Traditional medicinal herbs have been used for both food and medicinal purposes, which have obvious role in maintaining human health and improving human life quality for thousands of years (Ogbaji, Li, Xue, Shahrajabian, & Egrinya, 2018; Shahrajabian, Sun, & Qi, 2018, 2019a, 2019b, 2019c; Soleymai & Shahrajabian, 2018; Soleymani & Shahrajabian, 2012a, 2012b; Soleymani, Shahrajabian, & Naranjani, 2013). China has important potential to produce aromatic and medical plants and herbs due to its various biological diversity and different climatic conditions (Chen et al., 2013; Ogbaji, Shahrajabian, & Xue, 2013; Shahrajabian, Soleymani, Ogbaji, & Xue, 2017; Yong et al., 2017). Aromatic plants such as anise seed have a long traditional use in both folk and conventional medicine and of course in the pharmaceutical industry (Abouzid & Mohamed, 2011; Ibrahim, Mattar, Abdel-Khalek, & Azzam, 2017; Sevindik, Murathan, Yamaner, & Ayvaz, 2016; Shahrajabian, Khoshkharam, Zandi, Sun, & Qi, 2019e, Shahrajabian, Sun, & Cheng, 2019f, Shahrajabian, Sun, & Qi, 2019d). Anise (Pimpinella anisum) is a herbaceous annual plant, native to Mediterranean region and primarily grown for both fruits and seeds (Zand, Darzi, & Haj Seyed Hadi, 2012). It has been reported, it is also indigenous to Iran, India, and Turkey (Kucukkurt et al., 2009). Its fruits, known also as aniseed, were used as traditional medicine in China as early as in the 5th century. Fruits of this plant contain fatty oil, proteins, carbohydrates, and cellulose fibers. In European countries, consumption of anise fruits is more than its production so the amount of imported anise fruits reached about 2,000 t in 2004 (Ullah, Mahmmod, & Honermeier, 2014). Among other countries Germany remains the largest spice importer of anise (Rapisarda, 2004). Sirisha and Sujathamma (2018) noticed that anise usually grows on dry rocky places, rocky crevices, fields, meadows, mountains pastures, and grasslands, and its seed germination in nature is very poor.

1.2. Anise classification and variation species

The Pimpinella anisum has common names in different countries such as: Anis vert (France); Anise seed (Japan); Anise and Star anise (the USA); Annesella (Italy); Anisa, Badian, Kuppi, Muhuri, Saunf and Sop (Iran and India); Boucage anis, Petit anise (North Africa), and anise (England) (Khare, 2007; Ross, 2001). Information on scientific names, common names, uses, origins, cultivation potential toxic compounds, and toxicity is shown in Table 1.

1.3. Anise nutritional composition and chemical constituents

Anethole which is used in pharmaceutical, food, perfumery, and flavoring industry, is the most important constituent of anise (Ozkan & Chalchat, 2006; Tuncturk & Yildirim, 2006). The yield and anethole content of aniseed are affected by the genotype, the ecological conditions, and especially by agricultural practices such as the irrigation, plant population, fertilizer, and planting date (Acimovic et al., 2014; Asadi-kavan, Ghorbanli, Pessaraki, & Sateei, 2009; Ozel, 2009). Apart from anethole, anise is well known for essential oil, which gives it the characteristics odor and aroma. Although, the major component of anise oil is trans-anethole (75–90%), other constituents include coumarins (umbelliferone, umbelliprenine, bergapten, and scopoletin), lipids (fatty acids, beta-armyrin, stigmasterol, and its salts), flavonoids (flavonol, flavone, glycosides, rutin, isoorientin,
| Scientific names and synonyms | Common names | Uses | Origin/Introduction to Europe | Cultivation | Potentially toxic compounds | Toxicity |
|-------------------------------|-------------|------|-------------------------------|-------------|-----------------------------|----------|
| Pimpinella anisum Linne (Umbeliferae family) | Anise, anis vert, anis seed | Carminative, antispasmodic, expectorant, insecticide, bactericide, aromatic; manufacture of preserves, liquors, and confectionery | Middle East/introduced by the Moors | Mediterranean | Anethole | Potentially toxic; relatively safe |
| Illicium verum Hooker filius; Illicium anisatum Lour (Magnoliaceae family) | Star anise, Chinese star anise, badiane | Antioxidant, antimicrobial, expectorant, analgesic, and sedative | Asia/17th century | Southeast Asia | Anethole, estragole, veranisatin A, B, and C | Toxic at high doses |
| Illicium anisatum Linne, Illicium japonicum, Illicium religiosum (Magnoliaceae family) | Japanese star anise, shikimi, shiimi | No clear medicinal effects | Asia | Southeast Asia | Anethole, Anisatins | Highly toxic (not authorized use) |

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and isovitexin), protein, and carbohydrate (Picon et al., 2010; Yamini, Bahramifar, Sefidkon, Saharkhiz, & Salamifar, 2008). It has been reported that apiaceae seed are used in food industry such as bread, biscuits, and cookies as ingredients, and in meat industry, Apiaceae are favorable spices. (Acimovic, Kostadinovic, Popovic, & Dojcinovic, 2015). Components of anise essential oil analyzed by GC-MS are shown in Tables 2 and 3. Anise methanolic extract and molecular formula is shown in Table 4. Chemical composition (%) of oleoresins of anise is shown in Table 5.

1.4. Potential health benefits, medicinal uses of anise in modern medicine industry

Seeds of anise are used as analgesic in migraine and also as carminative, aromatic, disinfectant and diuretic in traditional medicine (Amin, 2005). In some traditional texts, anise is mentioned for melancholy, nightmare, and also in treatment of epilepsy and seizure (Mirheydar, 2001). Shobha, Rajeshwari, and Andallu (2013) noticed that aniseed oil is a potent antiperoxidative and antidiabetic agent and thereby, possess a vast spectrum of applications and exploitations in the food and drug industry. Cifti, Guler, Dalkilic, and Nihat Ertas (2005) showed that anise oil has anethole as active ingredients and also eugenol, methylchavicol, anisaldehyde, and estragole. Rebey et al. (2017) revealed that aniseeds might constitute a novel source of natural antioxidants and could be used as food additive. Acimovic et al. (2014) found that drought cause a significant decrease in thousand seed weight, germination energy, and total germination as well as essential oil content.
in anise. Contrary to this finding, the content of trans-anethole was significantly higher in the dry year. Ibrahim (2008) reported that according to the traditional thinking, drinking anise by boys maybe harmful to their reproductive system. Kreyidyyeh, Usta, Knio, Markossian, and Dagher (2003) found that extracts of the aniseeds are used as medicine for their diuretic and laxative effect, expectorant and antispasmodic action, and their ability to ease gastric pain and flatulence. Ibrahim et al. (2017) reported that waste residues of anise and star anise are promising new sources of phenolic antimicrobial compounds, which offer new commercial opportunities to pharmaceutical industry. They have suggested that combination of anise waste extracts with some antibiotics leads to new choice for treatment of infectious diseases and waste extracts may act as activity modifying agent for antibiotics. Islam, Khan, Rakhshanda, Mahdi, and Chowdhury (2016)

### Table 3. Chemical composition of *Pimpinella anisum* essential oil analyzed by GC/MS (Singh, Kapoor, Singh, de Heluani, & Caralan, 2008)

| Compound          | %MS  | RI#  | Identification  |
|-------------------|------|------|-----------------|
| α-pinene          | 0.1  | 927  | MS,RI,co-GC     |
| Sabinene          | t    | 964  | MS,RI,co-GC     |
| Myrcene           | t    | 983  | MS,RI,co-GC     |
| Aα-phellandrene   | t    | 998  | MS,RI,co-GC     |
| p-cymene          | 0.1  | 1018 | MS,RI,co-GC     |
| Limonene          | 0.8  | 1023 | MS,RI,co-GC     |
| 1,8-cineole       | 0.1  | 1026 | MS,RI,co-GC     |
| Cis-β-ocimene     | t    | 1029 | MS,RI,co-GC     |
| Fenchone          | 5.0  | 1083 | MS,RI,co-GC     |
| Camphor           | 0.2  | 1138 | MS,RI,co-GC     |
| Methyl chavicol   | 2.3  | 1192 | MS,RI           |
| Endo-fenchyl acetate | 0.1 | 1224 | MS,RI,co-GC   |
| Cis-anethole      | 0.5  | 1247 | MS,RI           |
| p-anisaldehyde    | 0.5  | 1253 | MS,RI           |
| Trans-anethole    | 90.1 | 1294 | MS,RI           |
| Total             | 99.9%|      | 100%           |

Trace <0.05; # the retention index (RI) was calculated using a homologous series of n-alkanes C₈-C₁₈-GC. co-GC: coinjection with an authentic sample. Percentages are the mean of three runs and were obtained from electronic integration measurements using selective mass detector.

### Table 4. Anise methanolic extract and molecular formula

| No. | Compound name | Molecular formula |
|-----|---------------|-------------------|
| 1   | Anethole      | C₁₀H₁₂O           |
| 2   | Varidiflorene | C₁₅H₂₄             |
| 3   | Eicosane      | C₂₀H₃₂             |
| 4   | Docosane      | C₂₂H₄₆             |
| 5   | Nonadecane    | C₁₉H₃₈             |
| 6   | Pentadecane   | C₁₅H₃₀             |
| 7   | Butanoic acid | C₁₅H₂₀O₁           |
| 8   | Heneicosane   | C₂₁H₄₄             |
| 9   | Octacosane    | C₂₈H₅₆             |
| 10  | Hexadecane    | C₁₈H₃₄             |
| 11  | Cyclohexane   | C₁₆H₃₀             |

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Table 5. Chemical composition (%) of oleoresins (in various solvents) of *Pimpinella anisum* analyzed by GC/MS (Singh et al., 2008)

| Compounds              | PS2 | PS3 | PS4 | PS5 | RI#  | Identification |
|------------------------|-----|-----|-----|-----|------|----------------|
| *p*-cymene             | —   | —   | t   | —   | 1028 | MS,RI,co-GC   |
| Limonene               | t   | —   | 0.5 | t   | 1031 | MS,RI,co-GC   |
| 1,8-cineole            | —   | —   | t   | —   | 1034 | MS,RI,co-GC   |
| Cis-β-ocimene          | —   | —   | t   | —   | 1039 | MS,RI,co-GC   |
| Fenchone               | 1.2 | 0.3 | 0.9 | 0.4 | 1093 | MS,RI,co-GC   |
| Undecane               | t   | —   | —   | 0.3 | 1100 | MS,RI,co-GC   |
| Camphor                | t   | t   | t   | —   | 1149 | MS,RI,co-GC   |
| Methyl chavicol        | t   | —   | —   | 0.5 | 1201 | MS,RI         |
| Endo-fenchyl acetate   | t   | t   | t   | —   | 1226 | MS,RI         |
| *p*-anisaldehyde       | t   | —   | —   | t   | 1258 | MS,RI         |
| Trans-anethole         | 14.1| 5.7 | 19.7| 6.4 | 1295 | MS,RI         |
| Palmitic acid, methyl ester | t   | 0.3 | t   | t   | 1914 | MS,RI         |
| Palmitic acid          | 8.5 | 7.9 | 5.3 | 5.7 | 1968 | MS,RI,co-GC   |
| Palmitic acid, ethyl ester | 1.2 | —   | —   | —   | 1981 | MS,RI,co-GC   |
| Linoleic acid, methyl ester | t   | 0.7 | 0.1 | t   | 2080 | MS,RI,co-GC   |
| Oleic acid methyl ester | t   | 2.8 | 0.4 | 0.5 | 2086 | MS,RI,co-GC   |
| Oleic acid             | 57.9| 75.5| 57.5| 63.5| 2130 | MS,RI,co-GC   |
| Oleic acid, ethyl ester | 11.0| —   | —   | —   | 2146 | MS,RI,co-GC   |
| Stearic acid           | 1.9 | —   | —   | —   | 2157 | MS,RI,co-GC   |
| 2-oleoylglycerol       | 2.3 | 2.8 | 2.1 | 3.6 | —    | MS             |
| Squalene               | —   | t   | 0.2 | t   | —    | MS             |
| Octacosanal            | t   | t   | 0.4 | 0.6 | —    | MS             |
| Stigmasterol           | t   | t   | 0.4 | 0.5 | —    | MS             |

PS2: ethanol extract; PS3: methanol extract; PS4: *n*-hexane extract; PS5: petroleum benzene extract. Trace: <0.05; # the retention index (RI) was calculated using a homologous series of n-alkanes C<sub>6</sub>-C<sub>22</sub>; Φ co-injection with an authentic sample. Percentages are the mean of three runs and were obtained from electronic integration measurements using a selective mass detector.
reported that aniseed extracts showed positive antibacterial effects on only three bacteria, named, *Bacillus cereus*, *Bacillus subtilis*, and *Streptococcus pneumoniae*. They have also found that the phytochemical analysis of the aqueous extract revealed the presence of alkaloids, flavonoids, saponins, tannins, terpenoids, phenolic compounds, and cardiac glycosides. Fouda, Elewady, Shalabi, and Habouba (2014) indicated that the anise extract shows good performance as corrosion inhibitor 1 M HCl, and also the anise extract inhibits the corrosion by getting adsorbed on the

| Table 6. Oil content and fatty acid composition of anise (Alfeikaiki, 2018) |
|---------------------------------|------------------|
| Element                        | Mineral contents (%) |
| Carbon                          | 34.5              |
| Oxygen                          | 21.1              |
| Nitrogen                        | ND                |
| Aluminum                       | 20.5              |
| Bramine                         | 14                |
| Iron                            | ND                |
| Copper                          | 3.63              |
| Lanthanum                       | 5.85              |
| Palladium                       | 0.35              |
| Sulfur                          | 0.15              |
| Potassium                       | ND                |
| Magnesium                       | ND                |

| Table 7. Composition of Pimpinella anisum essential oil (%) of various origins (Saibi, Belhadj, & Benyoussef, 2013) |
|---------------------------------------------------------------|-----------------|-----------------|
| Components                                                   | Algeria         | Reported compositions |
|                                                              | Turkey          | Turkey          | Portugal        |
| Linalool                                                      | 0.3             | 0.8             | -               |
| Terpinene 4-ol                                               | -               | -               | 0.6             |
| Methyl chavicol                                              | -               | -               | 0.8             |
| α-terpinene                                                 | -               | -               | 1.0             |
| Estragol                                                     | 1.9             | 0.6             | -               |
| Anisaldehyde                                                 | -               | 0.9             | 0.5             |
| Cis-anethole                                                 | 0.5             | 0.3             | 0.1             |
| Trans-anethole                                               | 92.4            | 95.4            | 89.5            |
| Methy eugenol                                                | -               | -               | 0.6             |
| γ-himachalene                                                | 1.1             | 0.8             | -               |
| Zingiberene                                                  | 0.3             | -               | -               |
| Anesic acid                                                  | -               | 0.5             | -               |
| Anisylacetone                                                | 0.3             | -               | 0.2             |
| Anisyl alcohol                                               | -               | -               | 0.1             |
| o-isoeugenol                                                 | 1.9             | -               | 0.2             |
| Trans-Pseudoisoeugenyl-2-methybutyrate                      | -               | -               | -               |
| Butanoic acid, 2-methyl-4-methoxy-2(3-methoxyxiranyl)phenyl ester | 0.3             | -               | -               |

reported that aniseed extracts showed positive antibacterial effects on only three bacteria, named, *Bacillus cereus*, *Bacillus subtilis*, and *Streptococcus pneumoniae*. They have also found that the phytochemical analysis of the aqueous extract revealed the presence of alkaloids, flavonoids, saponins, tannins, terpenoids, phenolic compounds, and cardiac glycosides. Fouda, Elewady, Shalabi, and Habouba (2014) indicated that the anise extract shows good performance as corrosion inhibitor 1 M HCl, and also the anise extract inhibits the corrosion by getting adsorbed on the
etal surface following Langmuir adsorption isotherm. Positive antimicrobial effects produced by methanol, ethanol, and aqueous extract of aniseed are shown in Table 12. Antifungal activity of the essential oils, which expressed through the minimal inhibitory concentrations, is shown in

| Table 8. Properties of aniseed oil (Yadav, Mahadwad, Kshirsagar, & Gite, 2015) |
| Sr. no. | Parameter | Results |
| 1 | Color | Pale yellow |
| 2 | Specific gravity | 0.987 |
| 3 | Saponification value | 168.3 |
| 4 | Acid value | 2.55 |
| 5 | Iodine value | 99 |
| 6 | Refractive index | 1.55 |
| 7 | Odor | Sweet like Anethole |

| Table 9. Total phenols, carotenoids, and tannins in ethanolic extract of anise (Tolba, El-Sherif, & El-Sherif, 2012) |
| Total phenols (as mg gallic acid) | 64.63 |
| Carotenoids (mg/100g) | 23.33 |
| Tannins (mg as tannic acid) | 83.31 |

| Table 10. HPLC-analysis of polyphenolic compounds in ethanolic extracts of anise |
| Compound | Anise |
| | $R_t$ | Area (%) | ppm |
| Protocatechol | - | - | - |
| Catechin | 2.467 | 1.2923 | 3.310 |
| Pyrogallo | 2.494 | 1.4354 | 6.391 |
| Chlorogenic | 2.785 | 4.0396 | 2.875 |
| Caffeic | - | - | - |
| Vanillic | - | - | - |
| Syrinic | 3.933 | 1.0083 | 0.137 |
| Caffeine | - | - | - |
| P. coumaric | 6.090 | 0.6257 | 0.060 |
| Ferulic | - | - | - |
| Salycilic | 6.541 | 2.3829 | 1.704 |
| Coumarin | 6.679 | 1.3413 | 0.132 |
| Cinnamic | 6.447 | 0.2376 | 0.017 |
| Chrisin | 11.708 | 0.2359 | 1.285 |
| Hypersoid | 4.936 | 3.9599 | 47.103 |
| Quecettin | 7.384 | 1.2037 | 17.239 |
| Luteolin | 7.756 | 1.8574 | 159.300 |
| Kampferol | 8.757 | 0.5232 | 7.177 |
| Apegnin | 8.860 | 0.3272 | 6.880 |
| Total area of phenolic compounds | 7360.32203 |
| Total area of flavonoid compounds | 7681.33273 |
Table 11. Oil yield and fatty acid composition (%) of Tunisian and Egyptian anise (Pimpinella anisum) seeds (means of six replicates ± S.D). Values with different superscripts (a-b) are significantly different at p < 0.05 (Rebey et al., 2017).

|                          | TAS             | EAS             |
|--------------------------|-----------------|-----------------|
| Oil yield (%)            | 11.60 ± 0.03a   | 9.82 ± 0.02b    |
| Saturated fatty acid (SFA)(%) |                  |                  |
| Capric acid (C10:0)      | 0.16 ± 0.03a    | 0.11 ± 0.01a    |
| Lauric acid (C12:0)      | 0.52 ± 0.01a    | 0.44 ± 0.02a    |
| Myristic acid (C14:0)    | 0.07 ± 0.01a    | 0.02 ± 0.00a    |
| Palmitic acid (C16:0)    | 4.90 ± 0.22a    | 13.20 ± 0.09a   |
| Stearic acid (C18:0)     | 0.85 ± 0.04a    | 0.66 ± 0.01a    |
| Arachidic acid (C20:0)   | 0.07 ± 0.01a    | 0.07 ± 0.00a    |
| Total                    | 6.57            | 14.5            |
| Unsaturated fatty acid (UFA)(%) |                  |                  |
| Petroselinic acid (C18:1 Δ6) | 46.60 ± 0.22a  | 38.40 ± 0.11b   |
| Oleic acid (C18:1 Δ9)    | 21.05 ± 0.08a   | 18.47 ± 0.13a   |
| Linoleic acid (C18:2)    | 22.99 ± 0.44a   | 23.18 ± 0.22a   |
| Linolenic acid (C18:3)   | 1.07 ± 0.01a    | 0.58 ± 0.04b    |
| Total                    | 91.71           | 80.63           |

Notes: Values with different superscripts (a-b) are significantly different at p < 0.05 (means of six replicates); SFA: saturated fatty acid; UFA: unsaturated fatty acid.

Table 12. Positive antimicrobial effects (average zone of inhibition) produced by methanol, ethanol, and aqueous extract of aniseed, and that in positive controls (Islam et al., 2016).

| Extraction condition | Day of extraction | Zone of inhibition (mm) |
|----------------------|-------------------|-------------------------|
|                      |                   | Bacillus cereus | Bacillus subtilis | Streptococcus pneumoniae |
| Methanol extraction  | 2nd day           | 19.03 ± 1.53    | 18.77 ± 0.55    | 12.07 ± 1.39           |
|                      | 5th day           | 20.13 ± 0.32    | 19.27 ± 1.2     | 14.5 ± 0.65            |
|                      | 7th day           | 18.43 ± 1.15    | 15.63 ± 1.16    | 14.87 ± 0.96           |
|                      | Positive controls | 26.61 ± 0.91    | 23.44 ± 0.5     | 31.67 ± .88            |
| Ethanol extraction   | 2nd day           | 14.90 ± 0.36    | 14.01 ± 0.7     | 12.17 ± 0.12           |
|                      | 5th day           | 14.52 ± 0.95    | 12.19 ± 0.9     | 13.00 ± 0.7            |
|                      | 7th day           | 14.78 ± 0.94    | 16.08 ± 1.36    | 14.44 ± 1.17           |
|                      | Positive controls | 28.20 ± 1.3     | 23.80 ± 1.47    | 31.39 ± 1.67           |
| Aqueous extraction   | 2nd day           | 11.05 ± 0.69    | 10.83 ± 1.18    | -                      |
|                      | Positive controls | 29.56 ± 0.91    | 24.83 ± 1       | -                      |

The results represent the mean ± SD of values obtained from three independent experiments.
Antimicrobial activity of anise EO in disc-diffusion method is shown in Table 20. The major molecular compounds identified in the essential oils of cumin, clove, cinnamon, anis, and laurel using gas chromatography mass spectrometry (GC-MS) is shown in Table 21. Minimum inhibitory concentration (MIC) of anise EO is shown in Table 22. Antioxidant activity of aniseed extracts as affected by maturity stages is shown in Table 23. GC-MS chromatography of anise oil components is shown in Table 24.

Values are mean ± SEM of three replicates.

ND = not detected.

Alfa-pinene, estragole, anethole, β-Himachalene, α-Himachaelen, cyclohexene, and 2-Methoxy-5-(1-propenyl) phenol are shown in Figures 1–7.

Minimum inhibitory concentration (MIC) and minimum fungicidal concentration (MFC) of anise dried extract on different fungi species is shown in Tables 25 and 26, respectively. Biochemical reactions leading to phenylpropenes in plant and the reactions catalyzed by known enzymes is shown in Figure 8.
Uysal, Kara, Alqur, Dumlupinar, and Nuri Aydogan (2007) reported that fruits of anise use for treatment of infections, angina, bronchitis, gastritis, laryngitis, and migraine. Mohamed, Abdelgadir, and Almagboul (2015) showed that the petroleum ether, chloroform, ethyl acetate, and methanol extracts of *P. anisum* (1:10 and 2:10) were highly active (30–40 mm) against *B. subtilis*. The ethyle acetate extract exhibited moderate activity (15 mm) against *Escherichia coli* and low activity (13 mm) against *Ps. aeruginosa*. The methanol extract of *P. anisum* showed high activity (16 mm) against *E. coli*, low activity (13 mm) against *Ps. aeruginosa*, and the methanol extract have variable activity against all test organisms. Yazdani et al. (2009) concluded that anise can be a candidate for further studies due to their antifungal potencies. Rebey et al. (2019) indicated that the determination of optimal periods and provenances for antioxidant accumulation can be used to evaluate the quality of aniseeds and could be important for industries. Khudor, Jasim, Malik, and Zahra (2013) mentioned that *Pimpinella anisum* and some antibiotics by disc diffusion methods and minimum inhibitory concentration, the results showed these bacterial isolates were sensitive to the aqueous extract compared with methanol, acetone, and petroleum ether and were more sensitive to vancomycin compared with other antibiotics. Karimzadeh et al. (2012) indicated the anticonvulsant and neuroprotective effects of anise oil, likely via inhibition of synaptic plasticity. Bagdassarian, Bagdassarian, and Atanassova (2013) stated that the seeds of anise are rich in phytochemical contents, which possessed high antioxidant and antimicrobial activities and they can be used for health supplement and pharmaceutical benefits. Aydemir, Cifci, Aviyente, and Bosgelmez-Tinaz (2018) observed that trand-anethole has the potential to inhibit QS (Quorum sensing)-regulated virulence factors in *P. aeruginosa* by binding to LasR protein, similar to its natural ligand N-(3-oxododecanoyl)-L-homoserine lactone. Mahood (2012) concluded that anise oil extract can decrease signs of polycystic ovary syndrome (PCOS) in the ovarian tissue and altered concentrations of luteinizing hormone. Singh et al. (2008) stated that the antioxidant potency of anise oil and its methanol and ethanol oleoresins, can be utilized for protecting fat-containing foods. Diaz et al. (2014) stated that mixture of chamomile and star anise decrease the completion percentage of the activated carbon, delayed the appearance of diarrhea and decrease the number of evacuations in comparison with the control treatments.

| Fungi                   | Inhibition zone (mm) | Reference substance | Fluid extract | Essential oil |
|-------------------------|----------------------|---------------------|---------------|---------------|
| Yeasts                  |                      |                     |               |               |
| *Candida albicans*      | 18                   | 12 29               | Nistatin      |               |
| *C. tropicalis*         | 23                   | 11 AE              |               |               |
| *C. pseudotropicalis*   | 18                   | 10 AE              |               |               |
| *C. parapsilosis*       | 18                   | 11 30              |               |               |
| *C. krusei*             | 17                   | 11 AE              |               |               |
| *C. glabrata*           | 18                   | 0 21               |               |               |
| Geotrichum spp.         | 19                   | GPA                |               | 17            |
| Dermatophytes           |                      |                     |               |               |
| *Trichophyton rubrum*   | 21                   | 20 25              |               |               |
| *T. mentagrophytes*     | 24                   | 29 23              |               |               |
| *Microsporum canis*     | 21                   | 26 27              |               |               |
| *M. gypseum*            | 21                   | 23 21              |               |               |

* Nistatin as reference substance (0.5 mg mL⁻¹) for yeasts and ketoconazole for dermatophytes.
* GPA, growth promotion activity.
* AE, fungicidal influence of aerosol (0.7 µL cm⁻³).
| Fungi | Reference substance<sup>a</sup> (µg mL<sup>-1</sup>) | Antifungal activity | Essential oil (% V/V) |
|-------|--------------------------------|---------------------|----------------------|
|       | MIC<sup>b</sup> | MFC<sup>c</sup> | MIC | MFC | MIC | MFC |
| Yeasts  |  |  |  |  |  |  |
| Candida albicans | 0.5 | 1 | 19 | 25 | 1.00<sup>d</sup> | 2.00<sup>d</sup> |
| C. parapsilosis | 1 | 2 | 18 | 25 | 0.10<sup>d</sup> | 0.20<sup>d</sup> |
| C. tropicalis | 1 | 2 | 18 | 25 | 0.10<sup>d</sup> | 0.20<sup>d</sup> |
| C. pseudotropicalis | 0.5 | 1 | 17 | 20 | 0.20<sup>d</sup> | 0.39<sup>d</sup> |
| C. krusei | 0.5 | 1 | 20 | 25 | 0.20<sup>d</sup> | 0.39<sup>d</sup> |
| C. glabrata | 2 | 4 | nt | nt | 0.10<sup>d</sup> | 0.20<sup>d</sup> |
| Geotrichum spp. | 2 | 4 | nt | nt | 1.56<sup>d</sup> | 3.12<sup>d</sup> |
| Dermatophytes  |  |  |  |  |  |  |
| T. rubrum | 0.25 | 0.5 | 1.5 | 3 | 0.20<sup>d</sup> | 0.39<sup>d</sup> |
| T. mentagrophytes | 0.50 | 1 | 9.0 | 20 | 0.78<sup>d</sup> | 1.56<sup>d</sup> |
| M. canis | 0.25 | 0.5 | 2.5 | 5 | 0.10<sup>d</sup> | 0.20<sup>d</sup> |
| M. gypseum | 0.25 | 0.5 | 7.0 | 15 | 0.20<sup>d</sup> | 0.39<sup>d</sup> |

<sup>a</sup>Nistatin as reference antifungal against yeasts tested and ketoconazole against dermatophytes tested.
<sup>b</sup>MIC, minimum inhibitory concentration.
<sup>c</sup>MFC, minimum fungicidal concentration.
<sup>d</sup>Significantly different from fluid extract (p<0.01).
nt, not tested.
have suggested the combination of chamomile and star anise as an alternative antidiarrheal treatment. Ibrahim (2008) concluded that anise oil administration inhibited GST expression, besides decreasing testosterone, T3 and T4 hormones and inhibiting sperm counts and sperm motility. Al-Omari, Qaqish, and Al-Qaoud (2018) concluded that anise possesses immunomodulatory activity when apply orally in mice and selectively activates cell-mediated immune mechanisms. Cifti et al. (2005) indicated that anise is an annual herb indigenous to Iran, India, Turkey, and many other warm regions and it could be considered as a potential natural growth promoter for poultry. Amina, Nadia, Kahloulakhaled, Nesrine, and Abdelkader (2016) showed that the aqueous extract of *P. anisum* L. can have a corrective effect against nephrotoxicity induced by lead, so *P. anisum* L. has a beneficial impact on the kidneys intoxicated with lead acetate. Mosaffa-Jahromi et al. (2017) suggested that anise oil could be a promising choice of treatment for depressed patients with irritable bowel syndrome. Shahamat, Abbasi-Maleki, and Mohammadi Motamed (2015) concluded that *P. anisum* possesses an antidepressant-like activity similar to that of fluoxetine, which has a potential clinical value for application in the management of depression. Felsociova et al. (2015) reported that the most hopeful antifungal activity and killing effect against all tested penicillia was found to be *Pimpinella anisum* and *Origanum vulgare* L. Rattan, Satpathy, and Gupta (2014) showed that a formulation of biscuits with anise extract was prepared for enhancing the healthy beneficial usage of biscuits and nutraceutical, in conditions like cough or sore throat with a simultaneous attainment of the other health benefits. Kargozar, Azizi, and Salari (2017) stated that *Pimpinella anisum* is effective in the treatments of acute menopausal syndrome with different mechanisms.

**Table 17. Qualitative analysis of methanolic extract and various fractions (Shobha & Andallu, 2016)**

| Test                    | Me   | He  | Be  | Ea  | n-But | Aq  |
|-------------------------|------|-----|-----|-----|-------|-----|
| Carbohydrates           |      |     |     |     |       |     |
| a. Molisch test         | +    | -   | -   | +   | -     | ++  |
| b. Fehling's test       | -    | -   | -   | -   | -     | +   |
| c. Barfoed's test       | -    | -   | -   | -   | -     | -   |
| d. Benedict's test      | -    | -   | -   | -   | -     | +   |
| Amino acids             |      |     |     |     |       |     |
| a. Ninhydrin test       | +    | -   | -   | +   | -     | ++  |
| b. Hopkins-Cole test    | -    | -   | -   | -   | -     | -   |
| c. Erhlich's test       | -    | -   | -   | -   | -     | -   |
| d. Pauly's test         | -    | -   | -   | -   | -     | -   |
| e. Nitroprusside test   | -    | -   | -   | -   | -     | -   |
| Flavonoids              |      |     |     |     |       |     |
| a. Sodium hydroxide test| ++   | +   | +   | +++ | +     | +   |
| b. Sodium acetate test  | ++   | +   | +   | +++ | +     | +   |
| c. Sulfuric acid test   | ++   | +   | +   | +++ | +     | +   |
| Polyphenols and tannins |      |     |     |     |       |     |
| a. Ferric chloride test | ++   | +   | +   | +++ | +     | +   |
| b. Potassium dichromate test | ++   | +   | +   | +++ | +     | +   |
| c. Potassium ferricyanide test | ++   | +   | +   | +++ | +     | +   |
| Sapnins                 |      |     |     |     |       |     |
| a. Foam test            | +    | ++  | ++  | +   | +     | +   |
| Sterols                 |      |     |     |     |       |     |
| a. Leibermann Buchard's test | +    | +++ | +   | +   | +     | +   |
| b. Salkowski test       | +    | ++  | -   | -   | +     | +   |

Me, Methanolic extract; He, Hexane; Be, Benzene; Ea, ethyl acetate; n-But, n-Butanol; Aq, Aqueous
Barbalho et al. (2015) suggested that *P. anisum* has potential to be used to control lipid levels. Radaelli et al. (2016) suggested that the use of essential oil from anise might serve as an alternative to the use of chemical preservatives in the control and inactivation of pathogens in commercially produced food systems. Kucukkurt et al. (2009) demonstrated that aniseed could be used at 30 g/kg level in quail diets an increased antioxidant activity with glutathione (GSH) and a decreased blood malondialdehyde (MDA) levels. Abdel-Reheem and Oraby (2015) found that *Pimpinella anisum*

### Table 18. Phytoceuticals in methanolic extract and various fractions of aniseed (Shobha & Andallu, 2016)

| Sample extract | Total phenolic (mg/100 g) GAE | Total flavonoids (mg/100 g) RE | Total Flavonols (mg/100 g) RE |
|----------------|-------------------------------|-------------------------------|-------------------------------|
| Methanol       | 0.63 ± 2.3                    | 0.32 ± 0.9                    | 0.47 ± 1.9                    |
| Hexane         | 0.16 ± 2.9                    | 0.20 ± 0.5                    | 0.24 ± 0.5                    |
| Benzene        | 0.23 ± 0.6                    | 0.27 ± 1.4                    | 0.34 ± 0.3                    |
| Ethyl acetate  | 0.77 ± 0.3                    | 0.45 ± 1.6                    | 0.55 ± 0.1                    |
| n-butanol      | 0.42 ± 1.7                    | 0.15 ± 1.1                    | 0.41 ± 0.9                    |
| Aqueous        | 0.15 ± 2.1                    | 0.07 ± 1.7                    | 0.08 ± 1.4                    |

Values are mean ± SEM of three replicates.

### Table 19. Essential oil composition of Tunisian and Egyptian anise (*Pimpinella anisum*) seeds (means of six replicates ± S.D). Values with different superscripts (a-b) are significantly different at *p* < 0.05 (Rebey et al., 2017)

| Compounds* | RI<sup>a</sup> | RI<sup>b</sup> | % | % |
|------------|----------------|----------------|---|---|
| Terpene hydrocarbons | 0.13 | 0.04 | TAS | EAS |
| Linalool | 1097 | 1557 | 0.13 ± 0.01<sup>a</sup> | 0.04 ± 0.04<sup>b</sup> |
| Oxygenated monoterpenes | 0.06 | 0.02 | | |
| α-Terpinene | 1018 | 1249 | 0.06 ± 0.01<sup>a</sup> | 0.02 ± 0.00<sup>b</sup> |
| Phenylpropanoids | 95.78 | 94.99 | | |
| Anisole | 918 | 1720 | 0.97 ± 0.05<sup>a</sup> | 0.52 ± 0.03<sup>b</sup> |
| Estragole | 1197 | 1430 | 0.20 ± 0.03<sup>b</sup> | 3.74 ± 0.13<sup>a</sup> |
| Trans-anethole | 1253 | 1470 | 94.30 ± 0.01<sup>a</sup> | 90.41 ± 0.22<sup>b</sup> |
| ρ-Anisaldehyde | 1250 | 1718 | 0.17 ± 0.01<sup>a</sup> | 0.10 ± 0.07<sup>b</sup> |
| Cis-isoeugenol | 1359 | 2180 | 0.14 ± 0.01<sup>a</sup> | 0.22 ± 0.02<sup>b</sup> |
| Sesquiterpene hydrocarbons | 3.95 | 2.48 | | |
| β-Elemene | 1388 | 1465 | 0.07 ± 0.06<sup>a</sup> | 0.09 ± 2.11<sup>b</sup> |
| γ-Himachalene | 1484 | 1690 | 2.32 ± 0.04<sup>a</sup> | 1.08 ± 0.01<sup>b</sup> |
| Zingiberene | 1494 | 1672 | 0.30 ± 0.03<sup>a</sup> | 0.25 ± 0.03<sup>b</sup> |
| β-Himachalene | 1505 | 1942 | 0.12 ± 0.02<sup>a</sup> | 0.11 ± 0.01<sup>b</sup> |
| β-Bisabolene | 1506 | 1832 | 0.19 ± 0.02<sup>a</sup> | 0.85 ± 0.01<sup>b</sup> |
| Isolongifolene | 1532 | 2003 | 0.04 ± 0.00<sup>a</sup> | 0.02 ± 0.00<sup>b</sup> |
| Diepi-α-cedrene | 1575 | 2020 | 0.91 ± 0.02<sup>a</sup> | 0.08 ± 0.00<sup>b</sup> |
| Total identified | 99.74 | 97.53 | | |

Notes: Volatile compounds percentages in the same line with different letters (a-b) are significantly different at *p* < 0.05 (means of six replicates). RI<sup>a</sup> order of elution in apolar column (HP-5); RI<sup>b</sup> order of elution in polar column (HO Innowax), MS: mass spectrum.
essential oil residuals have high inhibitory effect for *Salmonella typhi*, *Enterococcus faecalis*, *Staphylococcus aureus*, *E. coli*, and *Micrococcus luteus*. Pavela (2014) stated has the essential oil from *Pimpinella anisum* fruits and trans-anethole were toxic for *Daphnia magna* (62–92% mortality) and significantly reduced it fertility at high concentrations (35–50 µL mL\(^{-1}\)) and long exposure (48 h). However, no negative effect on *Daphnia* mortality or fertility was found at shorter exposure times (6 h) and lower concentrations (20 µL mL\(^{-1}\)). Womeni, Djikeng, Tiencheu, and Linder (2013) found that the powder of *Pimpinella anisum* has a special potent antioxidants for stabilization of crude soybean oil. Changizi-Ashtiyani et al. (2017) observed that the simultaneous use of ethanolic extract of *P. anisum* during gentamicin (GM) administration is recommended to reduce its nephrotoxicity effects. Barbalho et al. (2015) reported that *P. anisum* has potential to be used to control lipid levels. Kadan, Rayan, and Rayan (2013) noted that anise could be one of the foods that attribute to cancer prevention and treatment. It could be a natural source of novel anticancer compounds with anti-proliferative and apoptotic properties. Bekara et al. (2015) observed that aniseed aqueous extract was effective in reducing the level of some of biochemical parameters and ameliorate behavior of intoxicated rats by lead. Nahidi, Kariman, Simbar, and Mojab (2012) concluded that *P. anisum* is effective on the frequency and severity of hot flashes in postmenopausal women. Hosseinzadeh, Tafaghodi, Abedzadeh, and Taghiabadi (2014) stated that *P. anisum* aqueous and ethanolic extracts can increase milk production in rats. Sharifi, Kiani, Farzaneh, and Ahmadzadeh (2008) reported that anise is commercially cultivated in Iran and has been used in medicinal applications; moreover, their oil can be effective for protection of fresh fruits facing fungi and its essential oil can be considered as a potential, broad spectrum and safe substitute of chemical agents. Ashraffodin Ghoshergir et al. (2015) showed the effectiveness of anise in relieving the symptoms of postpartum depression. Shirzadi, Abbasi-Maleki, and Zanbouri (2017) noted that *P. anisum* ethanolic extract is effective in suppression of morphine physical dependence and further studies are needed to find out the responsible constituents and also the exact mechanisms of actions. Niksokhan, Hedarieh, Najafifard, and Najafifard (2015) observed that 250 and 300 mg/kg of hydroalcoholic extract of *P. anisum* seed significantly increased the duration of open arm ledges and decreased the duration of closed arm ledges in maze; in addition, this treatment resolved anxiety and relieved anxiety in rats. Nikfarjam, Bohmami, and Heidari-Soureshjani (2016) decribed that *Pimpinella anisum* is one the most important native medicinal plants of Iran with anti-anxiety properties. Amini, Tajabadi, Khani, Labbafi, and Tavakoli (2018) identified components of the essential oils and obtained results showed that *Pimpinella anisum L.* showed the most fungitoxic activity on the storage pests. The pharmacological effect of anise is shown in Table 27.

## Table 20. Antimicrobial activity of *P. anisum* EO in disc-diffusion method (30 µl/disc) (Abdel-Reheem & Oraby, 2015)

| Microorganism         | Inhibition zones in mm |
|-----------------------|------------------------|
|                       | *P. anisum* oil | Corn oil | Streptomycin |
| *Staphylococcus aureus* | 15           | 0        | 19          |
| *Streptococcus pyogenes* | 12           | 0        | 17          |
| *Escherichia coli*     | 15           | 2        | 19          |
| *Salmonella typhi*     | 17           | 1        | 20          |
| *Pseudomonas aeruginosa* | 10         | 0        | 15          |
| *Enterococcus faecalis* | 16           | 0        | 18          |
| *Micrococcus luteus*   | 14           | 3        | 20          |
| *Candida albicans*     | 10           | 1        | ND          |

ND= not detected.
Table 21. The major molecular compounds identified in the essential oils of cumin, clove, cinnamon, anis, and laurel using gas chromatography mass spectrometry (GC-MS) (Sergio, Fabiola, Guadalupe, Blanca, & Leon, 2013)

| Compound          | Cumin (Cuminum cyminum) | Clove (Eugenia cyryophyllata) | Cinnamon (Cinnamomum verum) | Anis (Pimpinella anisum) | Laurel (Laurus nobilis) |
|-------------------|--------------------------|-------------------------------|-------------------------------|--------------------------|-------------------------|
| α-Pinene          | ×                        |                               |                               |                          |                         |
| Limonene          | ×                        |                               |                               | ×                        |                         |
| γ-Terpinene       | ×                        |                               |                               |                          |                         |
| Cuminaldehyde     | ×                        |                               |                               |                          |                         |
| Alcohol cuminic   | ×                        |                               |                               |                          |                         |
| Eugenol           | ×                        |                               |                               |                          |                         |
| Caryophylene      | ×                        |                               | ×                              | ×                        |                         |
| Acetate of eugenyle | √                      |                               |                               |                          |                         |
| Chavicol          | ×                        |                               |                               |                          |                         |
| Carene            | ×                        |                               |                               | ×                        |                         |
| Cinnamaldehyde    | ×                        |                               |                               |                          |                         |
| Geranial          | ×                        |                               |                               |                          |                         |
| β-Myrcene         | ×                        |                               |                               | ×                        |                         |
| Germancrene       | ×                        |                               |                               |                          |                         |
| Eucalyptol        | ×                        |                               |                               |                          |                         |
| Ocimene           | ×                        |                               |                               |                          |                         |
| Trans-anethol     | ×                        |                               |                               |                          |                         |
| Cis-anethol       | ×                        |                               |                               |                          |                         |
Table 22. Minimum inhibitory concentration (MIC) of *Pimpinella anisum* EO (Abdel-Reheem & Oraby, 2015)

| Microorganism         | *P. anisum* oil | Corn oil | Streptomycin |
|-----------------------|----------------|----------|--------------|
| *Staphylococcus aureus* | 3.0            | N        | 1.5          |
| *Streptococcus pyogenes* | 4.0            | N        | 1.0          |
| *Escherichia coli*     | 2.5            | 10.0     | 1.5          |
| *Salmonella typhi*     | 2.0            | N        | 1.5          |
| *Pseudomonas aeruginosa* | 3.0            | N        | 1.5          |
| *Enterococcus faecalis* | 2.0            | N        | 1.0          |
| *Micrococcus luteus*   | 2.0            | 9.0      | 1.5          |
| *Candida albicans*     | 4.0            | N        | ND           |

ND = not detected, N = bacteria not effected at any concentration.

Table 23. Antioxidant activity of aniseed (*Pimpinella anisum L.*) extracts as affected by maturity stages (Rebey et al., 2015)

| Antioxidant assays | DPPH (IC\textsubscript{50} \textmu g/mL) | Chelating ability (IC\textsubscript{50} mg/mL) | Reducing power (EC\textsubscript{50} \textmu g/mL) |
|--------------------|----------------------------------------|----------------------------------------------|-----------------------------------------------|
| Turkey             |                                        |                                              |                                              |
| Immature           | 103.45                                 | 108.8                                        | 1234.28                                       |
| Intermediate       | 42.97                                  | 57.81                                        | 947.05                                        |
| Mature             | 18.97                                  | 12.46                                        | 684.73                                        |
| Serbia             |                                        |                                              |                                              |
| Immature           | 153.18                                 | 122.76                                       | 982.27                                        |
| Intermediate       | 58.04                                  | 68.09                                        | 687.41                                        |
| Mature             | 20.18                                  | 10.89                                        | 565.11                                        |
| Egypt              |                                        |                                              |                                              |
| Immature           | 103.02                                 | 130.55                                       | 1080.39                                       |
| Intermediate       | 62.17                                  | 68.51                                        | 764.22                                        |
| Mature             | 16.77                                  | 13.17                                        | 618.82                                        |
| Tunisia            |                                        |                                              |                                              |
| Immature           | 96.21                                  | 97.34                                        | 1154.33                                       |
| Intermediate       | 35.27                                  | 52.84                                        | 755.88                                        |
| Mature             | 12.87                                  | 9.23                                         | 523.47                                        |

Table 24. GC-MS chromatography of anise oil components (Obaid, Al Janabi, & Taj-Aldin, 2017)

| No. | Compound             | Rt (min) | M. Weight | Area  |
|-----|----------------------|----------|-----------|-------|
| 1   | Alfa-pinene          | 5.61     | 136       | 0.63  |
| 2   | Estragole            | 13.81    | 148       | 3.7   |
| 3   | Anethole             | 15.99    | 148       | 18.54 |
| 4   | B- HIMACHALENE       | 20.9     | 204       | 8.5   |
| 5   | Aα-HIMACHALENE       | 21.87    | 204       | 6.6   |
| 6   | cyclohexene          | 22.84    | 82        | 2.01  |
| 7   | 2-Methoxy-5-(1-     | 31.05    | 164       | 2.93  |
2. Conclusion

The followings conclusion could be drawn for the discussions. *Pimpinella asnisum* L. is an aromatic, annual grassy herb with 30–50 cm height, white flowers and small green to yellow seeds with secondary feather like leaflets of bright green, twice pinnate. Due to all positive characteristics, such as antidiabetic, hypolipidemic, antioxidant activities, anticancer, and antimicrobial properties, both seeds and essential oils of anise is promising for safe use as super food supplements and raw constituents in the both pharmaceutical and food industries. Keeping the traditional knowledge of Chinese medicine and other Asian medicine is vital requirement for not only saving traditional
Figure 5. α-Himachaelen.

Figure 6. Cyclohexene.

Figure 7. 2-Methoxy-5-(1-propenyl) phenol.
Table 25. Minimum inhibitory concentration (MIC) of *P. anisum* dried extract on different fungi species (Yazdani et al., 2009)

| Fungi species       | 64 | 32 | 16 | 8 | Control |
|---------------------|----|----|----|---|---------|
| Aspergillus niger   | -  | -  | -  | - | -       |
| Candida albicans    | +  | +  | +  | - | -       |
| Microsporum canis   | +  | +  | +  | - | -       |
| Epidermophyton fluccosum | + | +  | +  | - | -       |
| Trichophyton mentagrophytes | + | +  | +  | - | -       |

+ = Positive inhibition, - = Negative inhibition

Table 26. Minimum fungicidal concentration (MFC) of *P. anisum* dried extract on different fungi species (Yazdani et al., 2009)

| Fungi species       | 256 | 128 | 64 | 32 | 16 | 8 | 4 | Control |
|---------------------|-----|-----|----|----|----|---|---|---------|
| Aspergillus niger   | -   | -   | -  | -  | -  | - | - | -       |
| Candida albicans    | +   | -   | -  | -  | -  | - | - | -       |
| Microsporum canis   | +   | +   | -  | -  | -  | - | - | -       |
| Epidermophyton fluccosum | + | +  | +  | - | - | - | - | -       |
| Trichophyton mentagrophytes | + | +  | +  | - | - | - | - | -       |

+ = Positive inhibition, - = Negative inhibition

Figure 8. Biochemical reactions leading to phenylpropenes in plants. The reactions catalyzed by known enzymes are indicated (Koeduka, Baiga, Noel, & Pichersky, 2009).
Chinese medicine as the important cultural resources, but also using organic products to have sustainable life. Anise seed oil contains anethol, estragole, eugenol, pseudoeugenol, methyl chavicol and anisaldehyde, coumarins, scopoletin, umbelliferon, estrols, terpene hydrocarbons, and polyacetylenes as the major compounds. The plant oil has both pharmacological and clinical effects. The pharmacological effects consist of antimicrobial, hepatoprotective, anticonvulsant, anti-inflammatory, antispasmodic, bronchodilator, estrogenic, expectorant and insecticidal effects, and clinical effects such as nausea, constipation, menopausal period, virus, diabetes, obesity, and sedative action. More clinical studies are necessary to uncover the numerous substances and their effects in ginseng that contribute to public health.

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### Author details
Wenli Sun
E-mail: sunwenli@caas.cn
Mohamad Hesam Shahrajabian
E-mail: hesamshahrajabian@gmail.com
Qi Cheng
E-mail: chengqi@caas.cn

1 Biotechnology Research Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, China.
2 Nitrogen Fixation Laboratory, Qi Institute, Building C4, No.555 Chuangye Road, Jiaxing, Zhejiang 314000, China.

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