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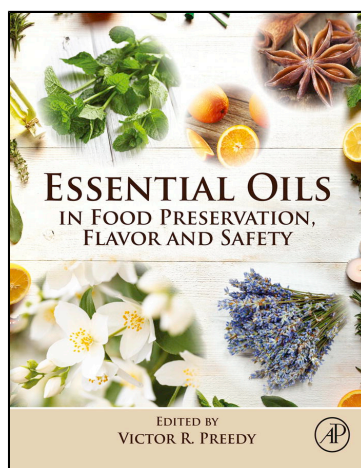
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## Chapter 21

# Angelica (*Angelica glauca* and *A. archangelica*) Oils

Rajesh K. Joshi

Regional Medical Research Centre (Indian Council of Medical Research), Department of Phytochemistry, Belgaum, Karnataka, India

## List of Abbreviations

**FDA** Food and Drug Administration

**FEMA** Flavour and Extract Manufacturers Association

**GRAS** Generally recognized as safe

**NDBR** Nanda Devi Biosphere Reserve

## INTRODUCTION

Essential oils are complex mixtures of volatile compounds, used as additives to protect food materials against microbial aggression and as a flavor to enhance taste. The oils from plant material can prevent unfavorable antioxidant–prooxidant balance from appearing in the food. High-altitude floras are known for their great medicinal value in curing various diseases and for their use as food supplements. Alpine floras have unique properties for producing secondary metabolites compared to temperate-region plants and vice versa.

A plant can be considered as a system where many biochemical reactions occur. The secondary metabolites are the product or byproduct of biosynthesis, where several factors alter the synthetic route, including soil, climate, rainfall, altitude, grazing frequency, and amount of sunlight, causing the plant to produce different metabolites. Based on the geoclimatic distribution of the flora, botanicals may be consumed by local residents to cure disease, and some plants are frequently used in food preparation.

The genus *Angelica* is an important medicinal and aromatic plant used in traditional medicine to cure various diseases. *Angelica glauca* (Figures 1 and 2) grows at high altitudes in the Himalayan region of India; it is locally known as *chora* or *gandrayan*. The plant is a prioritized medicinal plant of western Himalaya and ranks third on the list of 52 medicinal plants prioritized for consultation and conservation (Sastry and Chatterjee, 2000). *Angelica archangelica* (Figures 3 and 4) seed oil was granted generally recognized as safe (GRAS) status by the Flavor and Extract Manufacturers Association in 1965 and is approved by the US Food and Drug Administration for food use (GRAS). The Council of Europe (1970) included *A. archangelica* seed oil in the list of substances, spices, and seasonings deemed admissible for use with a possible limitation of the active principle in the final product. Both the plants are extensively used in traditional medicines for various treatments as well as in a variety of food recipes, but little scientific information is available on its biological activities, especially of essential oils.

## BOTANICAL ASPECTS

*Angelica glauca* Edgew. (syn: *Angelica nuristanica*), (Figures 1 and 2) belonging to the family Apiaceae, is commonly known as Smooth Angelica. It is distributed in the north-temperate, arctic regions and New Zealand. In India, this plant is found from Kashmir to Simla at an altitude range of 8000–10,000 ft. This plant is considered to be crucially endangered in the Himalayan region and needs to be conserved. *Angelica glauca* is an aromatic, glabrous herb that grows up to 1–2.5 m high. The leaves are one-, two-, or three-pinnate, toothed, and usually large. The umbels are compound, with many rays and few, narrow, or absent bracts. The bractlets are small. The calyx-teeth are obsolete; petals are obovate, emarginated, white, or lurid-purple. The fruit is ovoid or ellipsoid, dorsal and intermediate are not prominent; carpels are complanate and broadly marginate; furrows are 1-2-vittate; and carpophores 2-partite. The seed is much compressed dorsally and the inner face is plane concave or almost grooved (Hooker, 1879).

*Angelica archangelica* Hoff. (syn: *Angelica officinalis*) (Figures 3 and 4) is commonly known as angel's herb, root of the holy spirit, and garden angelica. It is distributed in north temperate regions. In India, this plant is found from Kashmir at



**FIGURE 1** *Angelica glauca* inflorescence with seeds. Source: <http://planttaxonomy.blogspot.in/2011/01/angelica-glauca.html>



**FIGURE 2** *Angelica glauca* aerial parts. Source: <http://www.ayurvediccommunity.com/Botany.asp?Botname=Angelica%20glau>



**FIGURE 3** *Angelica archangelica* inflorescence. Source: [https://farm2.staticflickr.com/1068/4724445244\\_39a193fc55\\_b.jpg](https://farm2.staticflickr.com/1068/4724445244_39a193fc55_b.jpg)





**FIGURE 4** *Angelica archangelica* aerial parts with inflorescence. Source: <http://botany.csdl.tamu.edu/FLORA/schoepke/ang-ar-1.jpg>

an altitude range of 8000–13,000 ft, in Jogi at an altitude of 11,000 ft, and in Sikkim and Lachen at an altitude range of 10,000–11,000 ft. This plant is a tall and perennial herb. The leaves are two- to three-pinnate; the ultimate pinnae is toothed and usually large. The umbels are compound, with many ray and few, small, or absent bracts. The bracteoles are many, linear, or obsolete. The calyx-teeth is obsolete in Indian species. The petals are white and ovate. The fruits are ellipsoid, subquadrate, or oblong. The carpels are dorsally compressed and lateral ridges are winged or acute, dorsal and intermediate narrower. The seed is much compressed dorsally and the inner face is plane (Hooker, 1879).

## USAGE AND APPLICATIONS

Traditionally, *A. glauca* is used in medicines, aromatic spices, and condiments. The roots of this plant are also used by the local people for giving the flavor of celery to their food. Local inhabitants of Tibet and Nanda Devi Biosphere Reserve consume large quantities of *Dongcha*, which is prepared with the powder of *A. glauca* and *Pleurospermum angelicoides* rhizomes mixed with *Allium* leaves and salt. They also use the decantant of root stock of *A. glauca* and *P. angelicoides* boiled in water to treat stomach pains and headaches (Kandari et al., 2007).

The roots of the *A. glauca* are also used for seasoning curry (Collet, 1921). In the Kumaun and Garhwal regions of Uttarakhand, as well as other parts of India, the roots are used in dal or curry flavoring to enhance taste. The majority of the roots are used for the preparation of horse gram recipes by the people of Uttarakhand during the winter season. This herb is given to women after the delivery of a baby for vitality and strength.

*Angelica glauca* has high global and domestic demand for the preparation of various drug formulations. *Angelica* has a long history of medical, magical, and culinary tales to its credit. In traditional medicine, *A. glauca* is used in the treatment of dyspepsia, constipation, infantile atrophy, dysentery, menorrhagia, and rinderpest. The roots of *A. glauca* in the powdered form are used traditionally in different remote areas of the Uttarakhand region, where a primary health care system is not available. The roots are used for the treatment of stomach trouble in children, for vomiting, as a cardiac stimulant, and for gastric disorders and constipation.

*Angelica archangelica* has been used primarily as a digestive, as a tonic, for flatulence (Boon and Smith, 1999), and especially for mild cramping in gastrointestinal disturbances (Blumenthal, 2000). In folk medicine, *A. archangelica* is also used as an antiseptic, expectorant, diuretic, and antiemetic, as well as for toothaches, wounds, rheumatism, skin rashes, fever, and headache (Bhat et al., 2011). This plant is a good remedy for cold, cough, pleurisy, wind, colic, and disease of the urinary organs, although it should not be given to the patients who have a tendency toward diabetes, as it causes an increase of sugar in the urine (Bhat et al., 2011).

*Angelica archangelica* is used extensively in the liquor industry for flavoring, such as in benedictine, boonekamp, and chartreuse (Blumenthal, 2000; Boon and Smith, 1999). *Angelica archangelica* is commonly used in Chinese medicine for

cerebral diseases and in traditional formulation/recipes for the treatment of typhus fever, typhoid, and chronic rheumatism. Both plants are extensively used in traditional medicines for various treatments, as well as in a variety of food recipes.

## USAGE AND APPLICATIONS IN FOOD SCIENCE

### Antioxidant Activity

The essential oil of *A. glauca* exhibited good DPPH radical scavenging activity, showing 93.4% inhibition, as well as 45.05% inhibition of peroxidation (Irshad et al., 2011). The essential oil of *A. glauca* can be used for the preservation of food materials. The IC<sub>50</sub> value of *A. archangelica* oil (3.89  $\mu$ L/mL) has strong antioxidant potential (Prakash et al., 2014) and thus can help in the inhibition of oxidative deterioration in food products.

### Antimicrobial Activity

Studies on disk diffusion and the minimal inhibitory concentration of *A. glauca* essential oil demonstrated inhibition of the growth of bacteria and fungi (Irshad et al., 2011). In one report, the essential oil of *A. glauca* exhibited in vitro antifungal activity (Irshad et al., 2012). The essential oil of *A. archangelica* showed activity against eight mold species, including some aflatoxigenic *Aspergillus flavus* strains. The oil of *A. archangelica* can be used to protect agri-food items during storage and processing in the food industry (Prakash et al., 2014).

The essential oil obtained from the roots of *A. archangelica* showed good antimicrobial activity against microorganisms such as *Clostridium difficile*, *Clostridium perfringens*, *Enterococcus faecalis*, *Eubacterium limosum*, *Peptostreptococcus anaerobius*, and *Candida albicans*, with minimum inhibitory concentration values of 0.25, 0.25, 0.13, 0.25, 2.25, and 0.50% v/v, respectively (Fraternali et al., 2014). The essential oil of *A. archangelica* showed moderate antibacterial activity against *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Bacillus subtilis*, *Micrococcus luteus* (Gram-positive), *Escherichia coli*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa*, and *Proteus mirabilis* (Gram-negative) bacterial strains. There was only a small difference between the power of activity against Gram-positive and Gram-negative bacteria, with minimal inhibitory concentrations ranging from 0.62 to 1.25 mg/ml and 1.25–2.5 mg/ml, respectively (Skalicka-Wozniak et al., 2011). Thus, the essential oils of *A. glauca* and *A. archangelica* can be used as food additives for food preservation.

### Insecticidal Effects

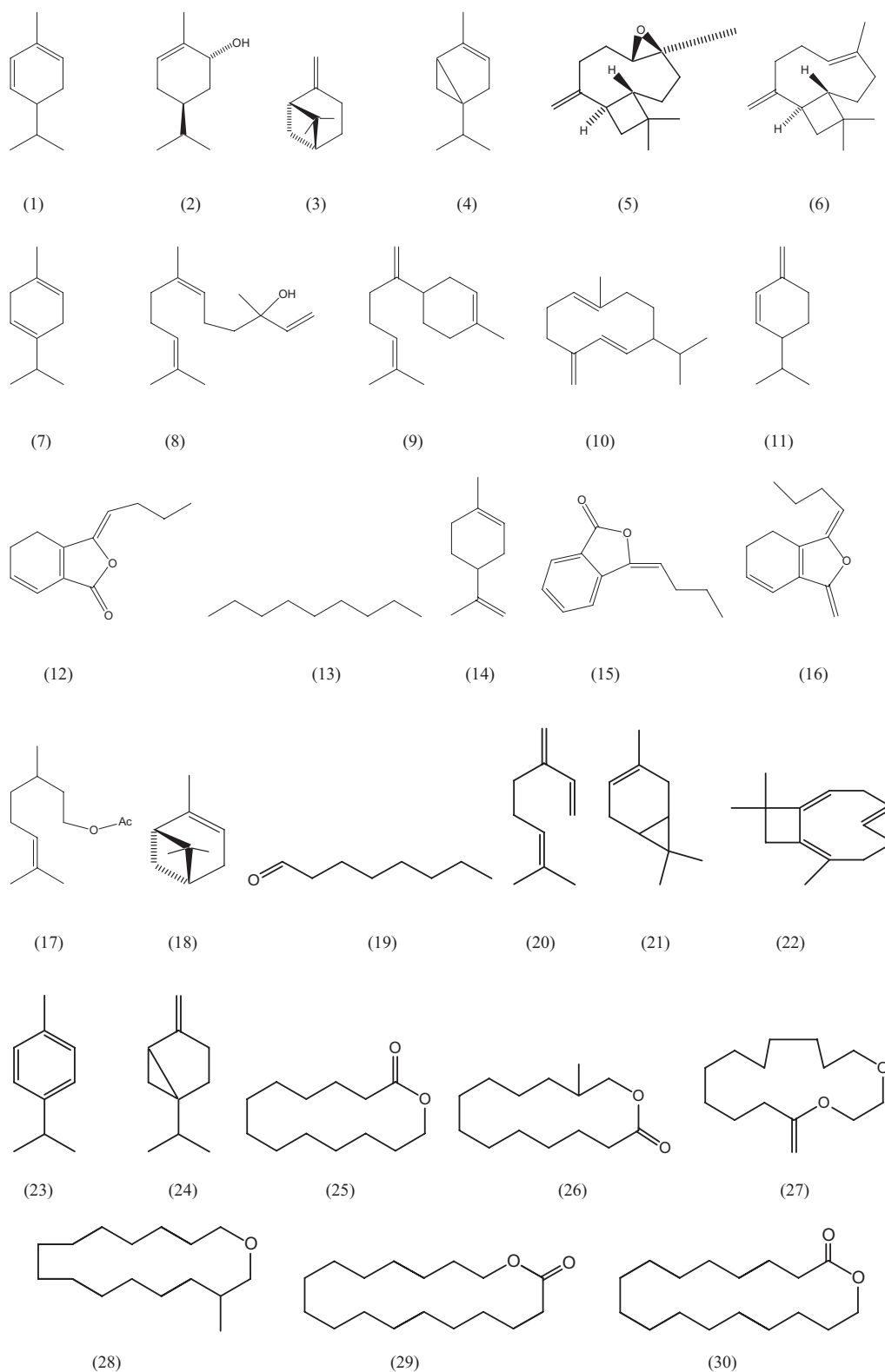
The essential oil from *A. glauca* roots showed antifeedant activity against *Spodoptera litura*, a major lepidopteran pest, at concentrations of 0.01%, 0.1%, 1%, 2.5%, and 5%. The oil of *A. glauca* exhibited significant antifeedant activity (100% protection at 5% of either; 60% and 95% protection at 2.5% of the respective oils) (Sharma et al., 1990). The essential oil obtained from the seeds of *A. archangelica* showed chronic and acute toxicity, antifeedancy, and growth inhibition of *Spodoptera littoralis* larvae. Significant acute toxicity was caused only by the essential oil (LD<sub>50</sub> 96  $\mu$ g/larva) producing growth inhibition (Pavela and Vrchotova, 2013).

### Major Chemical Compounds of the Essential Oil of *Angelica glauca*

The chemical constituents of *A. glauca* essential oil were analyzed by gas chromatography coupled with mass spectrometry (GC/MS) and gas chromatography equipped with flame ionization detector (GC-FID). The major essential oil components of  $\alpha$ -phellandrene (1), *trans*-carveol (2),  $\beta$ -pinene (3), thujene (4), caryophyllene oxide (5),  $\beta$ -caryophyllene (6),  $\gamma$ -terpinene (7), nerolidol (8),  $\beta$ -bisabolene (9), and germacrene D (10) have been reported in aerial parts of *A. glauca* (Agnihotri et al., 2004). In the roots, the main compounds  $\beta$ -phellandrene (11), (Z)-ligustilide (12) (Kaul et al., 1996), methyl octane (13), limonene (14),  $\beta$ -phellandrene (11),  $\beta$ -pinene (3), (Z)-3-butyldiene-phthalide (15), (Z)-ligustilide (12), (E)-ligustilide (16), and citronellyl acetate (17) (Thappa et al., 2005) have been reported (Figure 5).

### Major Chemical Compounds of the Essential Oil of *Angelica archangelica*

The chemical constituents of *A. archangelica* essential oil were analyzed by GC/MS and GC-FID. The major components were  $\alpha$ -pinene (18), octanal (19),  $\beta$ -myrcene (20),  $\delta$ -3-carene (21), limonene (14),  $\gamma$ -terpinene (7),  $\alpha$ -humulene (22), germacrene D (10) (Pasqua, 2003),  $\beta$ -phellandrene (11), *p*-cymene (23), and sabinene (24) (Wedge et al., 2009). The seed (fruit) oil contains  $\beta$ -phellandrene (11),  $\alpha$ -pinene (18), germacrene D (10),  $\alpha$ -phellandrene (1), sabinene (24) (Nivinskiene et al., 2005), tridecano-13-lactone (25), 12-methyltridecano-13-lactone (26), tetradecano-14-lactone (27),



**FIGURE 5** Structure of the major constituents of *Angelica glauca* and *Angelica archangelica* essential oils: (1)  $\alpha$ -phellandrene; (2) *trans*-carveol; (3)  $\beta$ -pinene; (4) thujene; (5) caryophyllene oxide; (6)  $\beta$ -caryophyllene; (7)  $\gamma$ -terpinene; (8) nerolidol; (9)  $\beta$ -bisabolene (10) germacrene D; (11)  $\beta$ -phellandrene; (12) (*Z*)-ligustilide; (13) methyl octane; (14) limonene; (15) (*Z*)-3-butyldiene-phthalide; (16) (*E*)-ligustilide; (17) citronellyl acetate; (18)  $\alpha$ -pinene; (19) octanal; (20)  $\beta$ -myrcene; (21)  $\delta$ -3-carene;  $\alpha$ -humulene (22); *p*-cymene (23); sabinene (24); tridecano-13-lactone (25); 12-methyltridecano-13-lactone (26); tetradecano-14-lactone (27); 14-methylpentadecano-15-lactone (28); hexadecano-16-lactone (29); heptadecano-17-lactone (30).

14-methylpentadecano-15-lactone (28), hexadecano-16-lactone (29), and heptadecano-17-lactone (30) (Lopes et al., 2004) from the essential oil of *A. archangelica* (Figure 5).

## SUMMARY POINTS

- *Angelica glauca* and *A. archangelica* are medicinal plants that grow at high altitudes.
- Both the plants are used as flavoring ingredients in a variety of foods.
- Secondary volatile compounds are present in the *Angelica* oils.
- *Angelica* oils possess antioxidant and antimicrobial activity.
- *Angelica* oil can use as a food additive and preservative.

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