Cinnamomum: review article of essential oil compounds, ethnobotany, antifungal and antibacterial effects

Abstract
Aromatic as well as medicinal plant species have played important roles in the lives of tribal people living in the Himalaya by providing products for both food and medicine. This review presents a summary of ethnonotanical, antibacterial, antifungal and volatile compounds of essential oils of some Cinnamomum species from the Nepal, Assam, Karnataka, and Indian Himalaya. This review illustrates the various prospective of cinnamon and its use in daily life.

Keywords: Cinnamomum, ethnonotabotany, antifungal, antibacterial, essential oil, India, food and medicine

Introduction
Spices played an important role in the history of exploration and development, are no longer luxury items of great cost. With the advent of refrigeration, there is less demand in the west to preserve and flavour foods at home, but they are widely used by the meat, sauce, canning, frozen food industries, and food manufacturing industry generally. They are also used in the cosmetic and perfumery industries, including its use in soap and toothpaste. Spices, or their essential oil, are of some importance in the preparation of liqueurs and cordials. They are also used in various ayurvedic and allopatic medicine. Bakers use it liberally in cookies and in hot drinks. Cinnamomum are said to be among the oldest spices Cinnamomum has fragrant, sweet and warm taste. Commercial essential oil production industry used several aromatic plant species for extracting high quality essential oil. Cinnamon is a highly valued spice whose bark is widely used as a spice. It is mainly used in cookery as a spice and by various industries for foodstuff, flavouring agent for fragrance and essence perfumes, and medicinal products. 

Cinnamon stands out of all spices in its “warmth” and ranks as second to pepper. As spices, cinnamon is considered one of the finest sweet spices.

It is indigenous in Sri Lanka, which still produces the largest quantity and best quality, mainly in the form of quills. This genus contains evergreen trees or shrubs belongs to Lauraceae family contain around 250 species in tropical and subtropical regions, mostly in Asia and some in South and Central America, and Australia however, in Himalayan region only eight species i.e. Cinnamomum bejolghota (Buch.-Ham.) Sweet, Cinnamomum camphora (L.) J. Presl, Cinnamomum glanduliferum (Wall.) Meisn, Cinnamomum glaucescens (Nees) Hand.-Mazz., Cinnamomum impressivulum Meisn., Cinnamomum parthenoxylon (Jack) Meisn., Cinnamomum tamala (Buch.-Ham.) Nees and Eberm., and Cinnamomum zeylanicum Breny are found Imani et al., reported noticeable improvement in digestion, as well as appetite stimulating properties in recent research. In another report, Vangalapati et al., reported that in ancient Egypt cinnamon was used for beverage flavouring, as well as to treat illnesses. Moreover, it has been frequently used in savoury cuisines, Persian sweets soups and pickles. In conventional Chinese medicine, cinnamon has been used as a potential neuroprotective agent, as well as a potent medicine for the control and treatment of type 2 diabetes mellitus. Cinnamomum species are commercially valuable source of camphor, cinnamaldehyde and safrol oil in the world. This review presents a summary of Cinnamomum species from the Indian Himalaya, Nepal, and Bhutan, focusing on their ethnobotanical uses with the volatile compounds.

Methodology
The current review was conducted using a complete and organized search of the available literature on the medicinal plant cinnamon by using the keywords: essential oil, Himalaya, India, Nepal, Assam, Karnataka, and Indian Himalaya. The searches were performed using various databases, including PubMed (http://www.ncbi.nlm.nih.gov/pubmed), Science Direct (http://www.sciencedirect.com/), Scopus (http://www.scopus.com/), Scirus (http://www.scirus.com/), and Google Scholar (http://www.scholar.google.com/).

Distribution
Sri Lanka is the major Cinnamon growing country along with Seychelles, Madagascar and India. Best quality of cinnamon bark, mainly as quills is produced by Sri Lanka. Sri Lanka and Seychelles have approximately 24,000 ha and 3400 ha area under cultivation producing around 12,000 t and 600 t cinnamon respectively. Cinnamon leaf oil is mostly produced in these countries, though the bark oil is distilled mostly in the importing countries. Sri Lankan export is to the tune of around 120 t of leaf oil and 4–5 t of bark oil.

Cultivation of cinnamon
Around 27,000-35,000 annual tons cinnamon is globally produced. It is mostly raised in China, Seychelles, Madagascar and Sri Lanka; additionally, it’s cultivated on a little scale in Vietnam and India. It’s a hardy plant in terms of its suitability for its cultivation in various weather conditions. The optimal temperature for the cultivation of cinnamon ranges between 20 to 30°C, with a yearly rainfall ranging between 1250 to 2500 mm. Cinnamon is usually propagated by dried seed and vegetative propagation (Table 1).
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Antifungal and Antimicrobial

Table 1 Ethnopharmacological uses, essential oil compositions, and any biological activities of the essential oils of Cinnamomum species

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Ethnopharmacology</th>
<th>Antifungal and Antimicrobial</th>
<th>Essential oil</th>
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<tr>
<td>C. camphora (L.) J. Presl</td>
<td>Bronchitis, cold, congestion, diarrhea, dysentery, edema, influenza, flatulence, metabolic and heart problems, gynecological problems</td>
<td>leaf oils: antifungal activity against Choanephora cucbitorum and antibacterial activity against Pasterella multicida and Aspergillus niger. Leaf oil from Nepal had shown notable allelopathic activity, cytotoxic activity against MCF-7 human breast tumor cells, and insecticidal activity (Choaoborus plumicornis, Pieris rapae, Drosophila melanogaster, Solenopsis invicta x richteri). Camphor has shown antibacterial activity against the respiratory pathogen Haemophilus influenza.</td>
<td>Essential oil chemotypes: (1) camphor, (2) linalool, (3) 1,8-cineole, (4) nerolidol, and (5) borneol. Leaf oil from Pantnagar, Uttarakhand: camphor (82.4%) (Agarwal et al., 2012) from Nukuchiatl, Uttarakhand: camphor (81.5%). From Hetauda, Makwanpur, Nepal: camphor (36.5%), camphene (11.7%), limonene (9.0%), sabinene (6.3%), β-pinene (6.3%).</td>
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<td>C. glanduliferum (Wall.) Mean.</td>
<td>Root: wounds and toothache; Leaves: used as stimulant, carminative, and to treat coughs and colds; Analgesic, antiseptic, astringent, and carminative properties; Seed: cold, cough, toothache and taenias, muscular swellings, seed oil in treating muscular spasm, joint pain and body aches; Bark: kidney trouble.</td>
<td>Leaf oil sample of northern India, rich in 1,8-cineole (41.4%), α-pinene (20.3%), and α-terpinol (9.4%), was found to have antibacterial activity against Gram-positive bacteria (Micrococcus luteus) and Gram-negative bacteria (Escherichia coli, Pseudomonas aeruginosa, and Aeromonas salmonicida). The high concentration of 1,8-cineole likely contributes to its efficacy against coughs and colds. 1,8-Cineole has shown clinical efficacy as a mucolytic and spasmolytic as well as beneficial effects in inflammatory airway diseases such as asthma and chronic obstructive pulmonary disease (COPD).</td>
<td>Leaf oil from northern India: 1,8-cineole (41.4%), α-pinene (20.3%), α-terpinol (9.4%), germacrone D-4-ol (6.1%) and α-thujene (5.10%).</td>
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<td>C. tamala (Buch.-Ham.) Nees and Eberm.</td>
<td>Leaves: stomach problems; spice and flavoring agent.</td>
<td>Root essential oil from Nepal, insecticidal (Culex pipiens, Solenopsis invicta richteri). Leaf oil from Munsyari, Uttarakhand, antibacterial (Salmonella enterica, Escherichia coli, Pasturella multocida); leaf oil from Logaghat, antibacterial (Pasturella multocida).</td>
<td>Root essential oil from Hetauda, Makwanpur, Nepal: camphor (35.0%), linalool (10.6%), p-cymene (8.5%), α-cymene (6.8%), and 1,8-cineole (6.1%). Leaf oil from Jeolikote, Uttarakhand: (E)-cinnamaldehyde (79.4%), (E)-cinnamyl acetate (3.7%), linalool (5.4%). Leaf oil from Munsyari, Uttarakhand: linalool (52.5%), (E)-cinnamaldehyde 6.4%, 1,8-cineole (4.2%). Leaf oil from Lohaghat, Uttarakhand: linalool (29.8%), camphor (44.0%), (E)-cinnamaldehyde (14.3%). Leaf oil from Champawat, Uttarakhand: linalool (24.7%), camphor (25.5%), (E)-cinnamaldehyde (30.4%). Leaf oil from Pannagar, Uttarakhand: eugenol (65.0%). Leaf essential oil from Uttarakhand: (E)-cinnamaldehyde (35.8–62.3%), (E)-cinnamyl acetate (4.7–22.7%), linalool (5.7–16.2%).</td>
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<td>C. glaucescens Hand.-Mazz.</td>
<td>In Manipur, India, the powdered bark is used to treat kidney trouble.</td>
<td>Fruit oil from Hetauda, Makwanpur, Nepal, nematicidal (Caenorhabditis elegans, LCS0 = 151 g/mL), insecticidal (Culex pipiens, Reticulitermes virginicus). Fruit oil from Lucknow, India, insecticidal (Callosobruchus chinensis), antifungal (Aspergillus flavus).</td>
<td>Fruit essential oil from Hetauda, Makwanpur, Nepal: methyl (E)-cinnamate (40.5%) 1,8-cineole (24.8%), -terpinol (7.4%). Commercial fruit essential oil from Nepal: methyl (E)-cinnamate (14%) 1,8-cineole (13%), -terpinol (7%). Leaf oil from northeast India: elemicin (92.9%).</td>
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<td>C. bejolghota (Buch.-Ham.) Sweet</td>
<td>Bark and its infusions used to treat cough, cold, toothache, liver complaints, diabetes, gall stones and as mouth freshener; bone fracture and wounds.</td>
<td>Panicle oil from Jorhat area of Assam: Linalool (65.00%), α-phellandrene (8.90%), 1,8-cineole (3.96%), α-pinene (3.40%), β-phellandrene (3.00%), α-pinene (2.55%), β-caryophyllene (2.55%), (2)-methyl isoeugenol (2.05%) and α-farnesene (1.93%). Stem bark oil from Jorhat area of Assam: α-pinene (23.30%), linalool (14.40%), p-cymene (13.90%), α-pinene (5.30%), 1,8-cineole (6.85%) and (E)-methyl cinnamate (3.06%), β-pinene (1.40%), α-phellandrene (1.46%), terpinen-4-ol (1.70%), (E)-cinnamaldehyde (1.50%), eugenol (1.50%), β-caryophyllene (2.85%) and (2)-methyl isoeugenol (1.05%).</td>
<td>Panicle oil from Jorhat area of Assam: Linalool (65.00%), α-phellandrene (8.90%), 1,8-cineole (3.96%), α-pinene (3.40%), β-phellandrene (3.00%), α-pinene (2.55%), β-caryophyllene (2.55%), (2)-methyl isoeugenol (2.05%) and α-farnesene (1.93%). Stem bark oil from Jorhat area of Assam: α-pinene (23.30%), linalool (14.40%), p-cymene (13.90%), α-pinene (5.30%), 1,8-cineole (6.85%) and (E)-methyl cinnamate (3.06%), β-pinene (1.40%), α-phellandrene (1.46%), terpinen-4-ol (1.70%), (E)-cinnamaldehyde (1.50%), eugenol (1.50%), β-caryophyllene (2.85%) and (2)-methyl isoeugenol (1.05%).</td>
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| C. zeylanicum    | Ground cinnamon is used in diarrhoea and dysentery; for cramps of the stomach, gastric irritation;  | Buds volatile oil: α-bergamotene (27.38 %), α-copaene (23.05 %), α-humulene (6.19 %), δ-cadinene (5.97 %), tetradeanol (4.27 %) and viridiflorene (3.29 %). Leaf oil: Linalool (85.7 %), α-caryophyllene (2.4 %), (E)-cinnamaldehyde (1.7 %), α-terpinenol (1.1 %), (E)-cinnamyl acetate (0.9 %). Fruit stalks oil: (E)-cinnamyl acetate (36.59 %), (E)-caryophyllene (22.36 %), α-humulene (5.49 %), (+)-cadinol (4.90 %), δ-cadinene (4.70 %), and α-copaene (0.32 %). Flower oil: (E)-cinnamyl acetate (41.98 %), trans-α-bergamotene (7.97 %), carvone (7.29 %), α-cadinol (6.35 %), tetradeconal (5.05 %) and globulol (3.80 %).
| Breyn           | Bark from Lucknow, antibacterial S. aureus (Gram positive) and E. coli (Gram-negative), anticancer and apoptotic activity against human breast cancer cell line MDA-MB-231. |

Discussion and Conclusion

IUCN red listed twenty-four Cinnamomum species. Cinnamomum are facing great pressure and threat because of economic activities, especially manual picking of bark and fruits as spice and for their medicinal value. Due to the unregulated use and overexploitation, its number is steadily decreasing. If the necessary conservation measures are not adopted, the species could become extinct. Genetic diversity data are important for conservation and management of rare and endangered species. Maintenance of genetic diversity is essential to the long term survival of the tree species without which there may be a risk of its extinction because of lack of adaptive ability. Cinnamon possess immunomodulatory, antioxidant, antiviral, lowering blood cholesterol, antimicrobial, lipid-lowering, antihypertension, anti-inflammatory, antitumor, gastroprotective, anti-diabetic, neuroprotective and blood purifying properties. Therefore, future conservation and sustainable management programmes for the Cinnamomum species are an urgent priority.

Acknowledgments

None.

Conflicts of interest

The author declares that there is no conflict of interests concerning this paper.

References


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