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A REVIEW ON AROMA PROFILE OF *CINNAMOMUM* SPECIES IN NORTH AND NORTH EAST INDIA

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ABSTRACT

Cinnamomum genus belonging to the family Lauraceace comprises of evergreen trees and shrubs. Over 250 species of *Cinnamomum* have been reported all over the world which are distributed in tropical and subtropical regions of North America, Central America, South America, Asia, Oceania, and Australia. *Cinnamomum* species have been mentioned in the Bible and have been used in Ayurvedic medicine since time immemorial. Most of the *Cinnamomum* species are aromatic and many of them are used as spices and herbal drugs daily by people all over the world. *Cinnamomum* oils contain cinnamaldehyde, cinnamic acid, and cinnamate as major constituents. The oil shows antioxidant, anti-inflammatory, antidiabetic, antimicrobial, anticancer activity and reported to have been used for lipid-lowering, and cardiovascular-diseases. Twenty six species of *Cinnamomum* are found in India, out of which 12 are from north east and south India. The leaves, panicle and bark of *Cinnamomum* species have aromatic oils. In north India, the important *Cinnamomum* species are *C. tamala*, *C. verum*, *C. glanduliferum*, *C. sulphuratum*, *C. bejolghota*, *C. camphora*, *C. impressinervium*, *C. glaucescens*, *C. champokianum* and *C. pauciflorum*. The present review highlights the various species of *Cinnamomum* found in north and north east India with their distribution and aroma profile.

KEYWORDS: *Cinnamomum* species, distribution, essential oil profile, north India

INTRODUCTION

The genus *Cinnamomum* belonging to the family, Lauraceae comprises of evergreen aromatic trees and shrubs. The leaves and bark are a rich source of aromatic oils. Over 250 species of the genus are distributed in south Asia, China and Australia. Twenty six species of *Cinnamomum* are found in India, of which 12 are from north east and south India.[1] About

60% of the world trade of cinnnamon is from Sri Lanka which produces the best quality of cinnamon bark. [1] The leaves are thick, leathery, dark green, narrow, pointed, oval in shape and characterized by a layer of wax, making them glossy in appearance.[2] The bark of various *Cinnamomum* species is one of the most important and popular spice. Additionally it is used for medicinal purpose also. Cinnamon is mainly used in the aroma and essence industries due to its fragrance.[3]

The essential oil of cinnamon consists of cinnamaldehyde and *trans*-cinnamaldehyde, that are responsible for the fragrance and various biological activities observed in cinnamon. It has also been used to treat diarrhoea and other problems of the digestive system. It shows high antioxidant activity. Cinnamon also shows pharmacological effects in the treatment of type II diabetes and colon cancer. Further, it is also added to flavor chewing gums as it contains mouth refreshing effects. Cinnamon is a coagulant and prevents bleeding, besides increasing the blood circulation in the uterus and advances tissue regeneration. This plant plays a vital role as a spice, and also has important biological activities, including antimicrobial, antifungal, antioxidant, and antidiabetic.[4]

Cinnamon is being used as an anti-inflammatory, antitermitic, nematicidal, mosquito larvicidal, insecticidal, antimycotic and anticancer agent from a long time. It is traditionally used as tooth powder and to treat toothaches, dental problems, oral microbial and bad breath.[4] The essential oil of *Cinnamomum tamala* has great antibacterial, antioxidant, antidiabetic, antimicrobial and many more properties.[5] *Cinnamomum glanduliferum* shows antimicrobial activity and is used as a stimulant and carminative.[6] *Cinnamomum bejolghota* has been used for the treatment of cough, cold, toothache, liver complaints, diabetes, gall stones and as a mouth freshener. Further, its leaves have been in use among some of the ethnic societies for preparation of a special kind of rice-beer. Studies have shown that it has antihyperglycemic, *in-vivo* antioxidative and anthelmintic activity.[7] *Cinnamomum camphora* shows analgesic, antiseptic, antispasmodic, antipruritic, anti-inflammatory, anti-infective, anti-fungal, rubefacient, contraceptive, mild expectorant, nasal decongestant and cough suppressant properties. The wood and leaves have analgesic, antispasmodic, odontalgic, rubefacient, stimulant activities. The infusion of *Cinnamomum camphora* is in the treatment of colds and diseases of the lungs. Due to its antimutagenic effect, it is effective in a number of human cancers. Essential oil of this species is anthelmintic, antirheumatic, antispasmodic, cardiotonic, carminative, diaphoretic, sedative and tonic. It is used for treating joint and

muscle pains and is also used in aromatherapy.[8] Due to its immense benefits on human health, we here present a review on the taxonomy, distribution, aroma profile and medicinal importance of *Cinnamomum* species present in north India.

Taxonomy and description of *Cinnamomum* species

Taxonomical Hierarchy

Kingdom - Plantae Subkingdom - Viridiplantae
Infrakingdom - Streptophyta
Superdivision - Embryophyta
Division - Tracheophyta
Subdivision - Spermatophytina
Class - Magnoliopsida
Order - Laurales
Family - Lauraceae
Genus - *Cinnamomum*

Distribution, aroma profile and botanical description of some *Cinnamomum* species found in north India

***Cinnamomum verum* Bertch. & Presl (True cinnamon)**

It is called true Cinnamon or Sri Lankan cinnamon and also called as *Cinnamomum zeylanicum* Blume. These trees are mainly propagated by seeds. The trees are small to medium usually up to 20 – 40 ft. Leaves are oblong, ovate shaped, dark glossy green and with a three prominent nerves from the base, leathery and approximately 7–20 cm in length. Flowers of *C. verum* are small, yellow in colour, paniculate. The fruits are black, pulpy, aromatic and elliptical with single seed. *Cinnamomum verum* is mostly cultivated in Sri Lanka, Malagasy Republic and Seychelles. It has originated in the central hills of Sri Lanka. In India, it is grown in Kerala. It is found in north east of India also. The ideal temperature for growing cinnamon is between 20-30°C and rainfall between 1250 to 2500 mm.[9] The basic component of the oil from Srilanka was eugenol (74.9%).[10] The major components in the petiole essential oil of cinnamon from Hyderabad were (*E*)-cinnamaldehyde (33.0%), eugenol (17.3%), linalool (16.9%) and (*E*)-cinnamyl acetate.[11] The leaf oil of *C verum* from Fiji islands was rich in eugenol (86.02 %), (*E*)-caryophyllene (5.70 %) and linalool (2.30 %).[12] Major components in the Malayasian cinnamon were methyl (*E*)-cinnamate (84.0%), benzyl benzoate (11.1%).[13] A report from Cotonou revealed the presence of (*E*)-cinnamaldehyde

(37.6%), cinnamyl acetate (23.7%), cinnamyl benzoate (16.4%) as major constituents in the fresh leaves of *C. verum*.[14] The major compounds in the *C. zeylanicum* oil were (*E*)-cinnamaldehyde (68.95%), benzaldehyde (9.94%) and (*E*)-cinnamyl acetate (7.44%).[15] The essential oil from Malaysia was rich in cinnamaldehyde.[16] Quality evaluation for the essential oil of *C. verum* leaves at different growth stages was investigated by Li et al. and observed that eugenol was the major constituent of the oil at earlier growth stage.[17] The major components of *C. verum* essential oil were cinnamaldehyde (56.3%), cinnamyl acetate (7.1%) and β-phellandrene (6.3%) from south Korea.[18] The major and minor constituents in the oil of *C. verum* investigated from north India, have been shown in the Table 1.

Table 1: Essential oil composition of *Cinnamomum verum* from north India.

S. No.	Collection	Plant part	Oil yield (%)	Major Constituents	Chemotypes	Minor constituents	Reference
1.	Assam, India			α-Linalool (60.73 %), α-pinene (10.54%), β-pinene (10.42 %)	α-Linalool (1)/ α-pinene (2)/ β-pinene (3)	Eugenol, cinnamaldehyde	[19]
2.	Delhi, India	Dried leaves	1,2	*trans*-Sabinene hydrate (29.8%), (*Z*)-β-ocimene (17.9%), germacrene A (11.3%)	*trans*-Sabinene hydrate (4)/ (*Z*)-β-ocimene (5)/ germacrene A (6)	α-Gurjunene (4.7%), myrcene (4.6%), α-pinene (3.1%), β-sabinene (2.3%)	[20]
3.	Assam, India	Fresh leaf Stem bark	1.4 (v/w) 0.5 (v/w)	Eugenol (70.6%), α-phellandrene (14.9%) α-Terpineol (47.2%), p-cymene (9.7%), 1,8-cineole (6.8%), α-phellandrene (6.6%)	Eugenol (7)/ α-phellandrene (8) α-Terpineol (9), p-cymene (10), 1,8-cineole (11), α-phellandrene (8)	p-Cymene (2.5%), α-pinene (2.3%), 1,8-cineole (1.3%), eugenol acetate (1.2%), benzaldehyde (1.1%), linalool (1.1%) Terpin-4-ol (3.2%), α-pinene (3.8%), β-pinene (1.6%), linalool (1.2%), myrcene (1.1%), α-terpinene (1.1%), caryophyllene (1.1%)	[21]
4.	Gorakhpur Uttar Pradesh	Dried leaves	2.2	Eugenol (66.1%)	Eugenol (7)	Spathulenol (4.8%), viridiflorene (2.4%), methyl eugenol (1.9%), aromodendrene (1.5%)	[22]
5.	Jeolikot, Uttrakhand	Fresh leaves	1.2 (v/w)	(*E*)-Cinnamaldehyde (79.4%), linalool (5.4%)	(*E*)-Cinnamaldehyde (12) / linalool (1)	(*E*)-Cinnamyl acetate (3.7%). β-pinene (1.3%), α-copaene (1.0%),	[23]
6.	Nainital district, Uttarakhand	Fresh leaves	0.1 (w/w)	(*E*)-Cinnamylacetate (10.0-22.7%), linalool (5.7-16.2%), (*Z*)-cinnamaldehyde (1.0-7.1%),	(*E*)-Cinnamylacetate (13)/ (*Z*)-cinnamaldehyde (14) / linalool (1)	α-Pinene (1.4-3.1%), camphene (1.8-4.0%), benzaldehyde (2.3-4.1%), salisyladehyde (1.6-3.2%), 3-phenyl propanal (1.3-2.5%),	[24]

						bornyl acetate (0.1-1.3%), (*Z*)-cinnamyl acetate (0.6-1.0%), coumarin (1.0-3.6%), β-copaen-4α-ol (0.6-2.5%)	
7.	Uttarakhand	Fresh aerial part	-	Linalool (52.5%), (*E*)-cinnamaldehyde (26.4%) from Munsyari Camphor (25.5 and 44.0%), linalool (24.7 and 29.8%), (*E*)-cinnamaldehyde (30.4 and 14.3%) from Lohaghat and Champawat Linalool (22.2 and 28.0%), (*E*)-cinnamaldehyde (44.6 and 25.0%), cinnamyl acetate (15.1 and 3.5%) from Pithoragarh and Tanakpur Eugenol (65.0%) from Pantnagar	Linalool (1) / (*E*)-cinnamaldehyde (12) Camphor (15) / linalool (1) / (*E*)-cinnamaldehyde (12) Linalool (1) / (*E*)-cinnamaldehyde (12) / cinnamyl acetate (14) Eugenol (7)	1,8-Cineole (4.2%) - Caryophyllene oxide (4.1%), (*E*)- Cinnamaldehyde (3.8%), (*E*)-cinnamyl acetate (2.6%), *epi*-cubenol (2.9%)	[25]
8.	Chandigarh Botanical garden,	-	0.35	Methyl eugenol (46.65%), eugenol (26.70%), (*E*)-	Methyl eugenol (16) / eugenol (7) / (*E*)-cinnamyl	Cinnamaldehyde (2.16%), ascabin (3.16%)	[26]

	Chandigarh			cinnamyl acetate (12.48%), β-Caryophyllene (6.26%)	acetate (14) / β-caryophyllene (17)		
9.	Selaqui Dehradun, Uttarakhand	Dried leaves	0.l1-1.6 volume by w eight(v/w)	Cinnamaldehyde (42.5-59.3%), cinnamylacetate (3.12-35.27%), linalool (0.16-30.0%)	Cinnamaldehyde (12)/ cinnamylacetate (13)/ linalool (1)	-	[27]
10.	Dehradun, Uttarakhand	Leaves	-	Cinnamaldehyde (37.9%), *cis*-linalool oxide (30.0%), linalool (7.7%), cinnamyl acetate (5.4%	Cinnamaldehyde (12)/ *cis*-linalool oxide (18) / linalool (1) / cinnamyl acetate (13)	Benzaldehyde (3.2%), 1,8-cineole (3.2%), 3-phenyl propanal (1.7%), bornyl acetate (1.5%), p-cymene (1.1%),	[28]
11.	Northern India	Fresh leaves	1.2 to 3.9 (w/w)	Eugenol (41.8-91.4%), eugenyl acetate (0.0-47.1%)	Eugenol (7) / eugenyl acetate (19)	α-Phellandrene (0.6-2.5%)	[29]
12.	Ghnda Maujpur, Delhi	Dried leaves	2.3	Eugenol (74.4%), isoeugenol (21.1%)	Eugenol (7) / isoeugenol (20)	β-Elemene (1.1%), acetyl eugenol (1.2%)	[30]
13.	Nainital, Pithoragarh, Champawat, Almora, Tehri, Pauri, Rudraprayag and Chamoli	Shade dried leaves	0.4-1.2 (v/w)	Cinnamaldehyde (60.1-82.0%) in 13 populations Cinnamyl acetate (18.4-42.3%), cinnamaldehyde (28.2-55.0%) in 3	Cinnamaldehyde (12) Cinnamyl acetate (13)/ cinnamaldehyde (12)	Cinnamyl acetate (1.4-11.1%), benzaldehyde (1.9-3.2%), β-pinene (0.3-1.0%), 1,8-cineole (0.2-2.5%), caryophyllene oxide (0.4-1.2%) Benzaldehyde (1.3-3.7%), β-pinene (0.1-0.9%), 1,8-cineole (0.1-3.5%), caryophyllene oxide (0.5-	[31]

				populations Linalool (46.4-62.0%), cinnamaldehyde (7.7-30.8%) in 6 populations Cinnamaldehyde (44.4-61.7%), linalool (22.7-30.2%) in 13 populations	 Linalool (1) / cinnamaldehyde (12) Cinnamaldehyde (12)/ linalool (1)	0.7%) Benzaldehyde (0.5-1.7%), β-pinene (0.3-2.4%), 1,8-cineole (0.2-3.7%), caryophyllene oxide (0.7-1.6%) Benzaldehyde (0.6-2.0%), β-pinene (0.5-1.4%), 1,8-cineole (0.3-2.6%), caryophyllene oxide (0.5-1.7%)	
14.	Arunanchal Pradesh	Shade dried leaves	1.2% (v/w)	Eugenol (60.2%),α - phellandrene (11.7%), β - phellandrene (7.2%)	Eugenol (7) / α - phellandrene (8) / β - phellandrene (21)	α-pinene (2.8%), elixene (1.8%), *cis*-caryophyllene (1.6%), myrcene (1.5%), limonene (1.4%)	[32]

The structure of major components of *C. verum* is shown in Fig. 1.

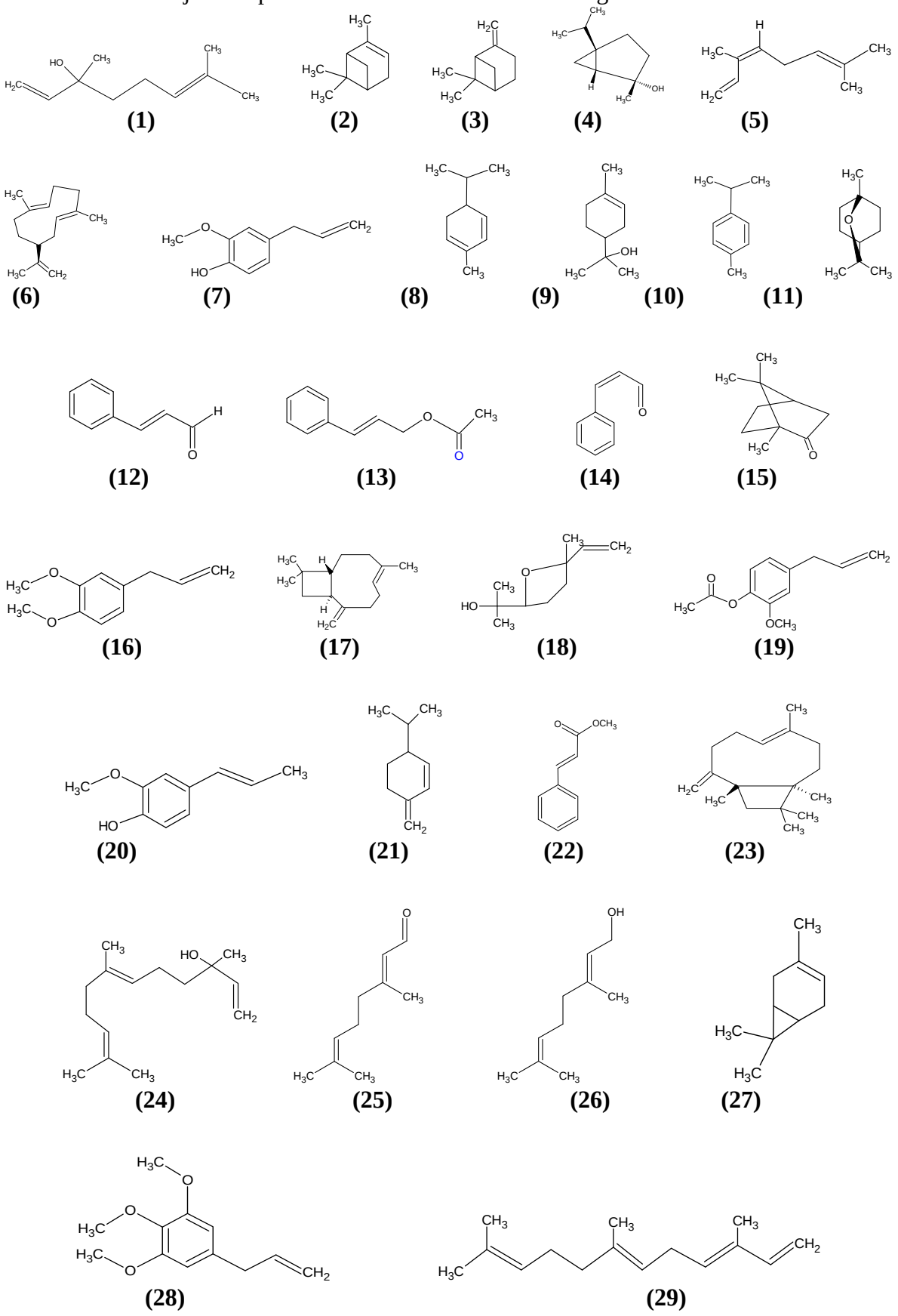

Fig. 1: Structure of major constituents present in *Cinnamomum* species from north India.

***Cinnamomum tamala* (Buch.-Ham.) T. Nees & C.H. Eberm**

This species is local to India and is reported to have originated in the Himalayas. It is cultivated in the Indian subcontinent, Indo-China region, Bangladesh and Nepal. In tropical and sub-tropical Himalayas, it is distributed upto an altitude of 900-2500m. It also occurs in Meghalaya, Assam, Jammu and Kashmir, Himachal Pradesh and Uttarakhand. *Cinnamomum tamala* is planted in Khasi and Jaintia Hills, Garo Hills, Mikir Hills, Manipur and Arunachal Pradesh and in limited areas in Nainital (Uttarakhand) and Kanfra districts (Himachal Pradesh).[33,34] The tree has a height up to 7.5 m with crisscross branching, trunk up to 95 cm girth, bark rough, dark grey to reddish brown in colour. Leaves are12.5-20 cm long, 5-7.5 cm wide at the centre, 3 converging nerves from base to apex, young leaves are pink, petiole 7.5-13 mm long, margin entire, apex acute or acuminate, both surfaces smooth, stomata paracytic, odour is aromatic, taste is slightly sweet, mucilaginous and aromatic.[35] *Cinnnamomum tamala* leaves have clove like taste and pepper like odour. Essential oil composition of fresh and dried leaves of *C. tamala* has been analyzed by Chowdhury et al.[36] The major constituents were eugenol (75.3% and 68.0%) and spathulenol (10.1% and 12.7%). In north India, various chemotypes of *C. tamala* exist which are different in their essential oil composition. The different chemotypes of *C. tamala* are shown in Table 2.

Table 2: Essential oil composition of *Cinnamomum tamala* from north India.

S. No.	Collection	Plant part	Oil yield (%)	Major Constituents	Chemotypes	Minor constituents	References
1.	CIMAP, Pantnagar, Uttrakhand	Fresh aerial parts	-	(*E*)-Cinnamyl acetate (58.5%), (*E*)-cinnamaldehyde (10.9%), linalool (7.4%)	(*E*)-Cinnamyl acetate (13)/ (*E*)-cinnamaldehyde (12) / linalool (1)	-	[25]
2.	Mizoram, Northeast India	Stem bark	0.9	Methyl cinnamate (81.9%)	Methyl cinnamate (22)	*trans*-Cinnamaldehyde (4.0%), linalool (3.9%), styrene (2.4%), benyl benzoate (1.1%)	[37]
		Leaves	2.1	Linalool (67.6%), methyl cinnamate (17.3%)	Linalool (1)/ methyl cinnamate (22)	α-Pinene (2.7%), hexanol (2.1%), β-phellandrene (2.0%), benyl benzoate (1.2%), β-pinene (1.1%)	

***Cinnamomum glanduliferum* (Wall) Meissn**

Cinnamomum glanduliferum is a small tree up to 1.5 m girth and is widely distributed in central Himalayas and Khasi hills.. The leaves are 7.5 - 12.5 cm long, alternate and elliptic or lanceolate and flowers are yellowish green. In northeast India, *C. glanduliferum* is found naturally in both the plains and hills up to an altitude of 1200 m *C. glanduliferum* is locally known as 'Gondsoroi tree.' Almost all parts of *C. glanduliferum* are aromatic. There are a very few reports on the essential oil composition of *C. glanduliferum* (Table 3).

Table 3: Essential oil composition of *C. glanduilferum*.

S. No.	Collection	Plant part	Oil yield (%)	Major Constituents	Chemotypes	Minor constituents	Reference
1.	-	-	-	1,8-Cineole (16.8%), caryophyllene oxide (6.0 %), camphor (8.3%), linalool (10.7%), α-terpineol (6.0%)	1,8-Cineole (11)/ caryophyllene oxide (23)/ camphor (15)/ linalool (1)/ α-terpineol (9)	-	[38]
2.	Arunchal Pradesh	Fresh leaves	0.4	(*E*)-Nerolidol (52.2 %), caryophyllene oxide (6.0%)	(*E*)-Nerolidol (24)/ caryophyllene oxide (23)/	β-pinene (1.0%), linalool (1.0%)	[39]
3.	Champawat, Uttarakhand	Fresh leaves	0.7 (v/w)	1,8-Cineole (41.42 %), α-terpineol (9.40 %)	1,8-Cineole (11)/ α-terpineol (9)	Sabinene (4.2%), limonene (2.0%), terpinen-4-ol (1.7%)), α-terpinene (1.7%), α-phellandrene (1.6%), linalool (1.3%)	[6]

***Cinnamomum sulphuratum* Nees**

It is a small to medium sized tree, about 8m tall with 70 cm. girth found in the southern western Ghats of India, north Cachar hills of Assam and northeast India. It is one of the 12 endemic south Indian species of *Cinnamomum*. Bark of *C. sulphuratum* is smooth, reddish brown outside, dull red inside, and has strong aromatic smell. Berries are oblong ellipsoid, 11.5 cm, smooth, hairless, seated on about 1 cm across cup-shaped fleshy disc.[40] Existence of four chemotypes *of C. sulphuratum* such as linalool-type, citral and cinnamaldehyde-type, methyl cinnamate-type and cinnamaldehyde-type have been reported from Northeast India. Nath et al. reported 92.7% linalool followed by geranial (2.2%) and cirotronellol (1.47%) in leaf oil from north-east India.[41] The bark is used as medicine and also for preparing agarbatti

(incense sticks). It is traded at local and regional levels and inter-state trade is practiced. *Cinnamomum sulphuratum* is one of the most highly traded medicinal plants sourced from tropical forests. Leaves of different species of *Cinnamomum* are used as substitute to tejpatta (kind of aromatic spicy leaves). On account of easy availability and similarity in flavor, different parts of *C. sulphuratum* are in use as substitutes for commercial cinnamon derived spices. The different chemotypes of *C. sulphuratum* have been given in Table 4.

Table 4: Chemotypes of *C. sulphuratum* from north India.

S. No.	Collection	Plant part	Oil yield (%)	Major Constituents	Chemotypes	Minor constituents	Reference
1.	Northeast India	Fresh leaves	0.6	Linalool (92.7%)	Linalool (1)	Geraniol (2.2%), citronellol (1.5%)	[19]
2.	Assam, India	Leaf	0.6	Geranial (27.8%), geraniol (23.2%), neral (17.6%)	Geranial (25)/ geraniol (26)	Linalool (3.0%), β-pinene (2.4%), bomyl acetate (2.0%), limonene (1.7%), 6-methyl-5-hepten-2-one (1.4%), α-Pinene (1.2%), myrcene (1.1%)	[42]
		Bark	0.2	(*E*)-Cinnamaldehyde (65.6%), (E)-cinnamyl acetate (5.4%)	(*E*)-Cinnamaldehyde (12)	Tetradecanal (4.6%), borneol (1.9%), α-terpineol (1.7%), 1,8-cineole (1.6%), β-bisabolene (1.5%), α-copaene (1.5%), ar-curcumene (1.3%), β-caryophyllene (1.3%), terpinen-4-ol (1.3%), caryophyllene oxide (1.0%)	
3.	Northeast, India	Leaf	-	Cinnamaldehyde (50.0%)		-	[43]
		Stem bark		Cinnamaldehyde (64.3%)			

***Cinnamomum bejolghota* (Buch.-Ham.) Sweet**

Cinnamomum bejolghota {syn. *C. obtusifolium* (Roxb.) Nees} is a moderate to large sized evergreen, aromatic tree, distributed in the central and outer parts of eastern Himalayas up to an altitude of 2100 m. The plant is found commonly in evergreen to mixed deciduous forests of Meghalaya, particularly near the bank of stream between the altitudes of 650-1250 m. The

plant is a middle sized evergreen tree, 6-8 m tall. Bark is brownish-white, brittle, inside creamish white, turning darker-brown on exposure, 4-8 mm thick. Leaves are alternate, sub-opposite or opposite, narrowly oblong to oblong-elliptic-lanceolate or ovate-lanceolate, apex obtusely acute to rarely acute. Panicle pseudo-terminal, axillary to solitary axillary, slender, pale yellowish-green, minutely pubescent, glabresent, usually equal to the leaves or slightly shorter, upto13.5 cm long, sub-equal, ovate-elliptic-lanceolate, silky on both surfaces. Stamens 3+3+3, 1.5-1.75 mm long, pale yellowish-green, anther 4-locular, introrse, silky pubescent to villous, glands of whorl 111 yellow, attached 1/3 of the base of the filament. Staminode are 3, pale yellowish-green, 1.5 mm long, broadly sagittate head, villous, filament greenish white. Pistil 2 mm long, ovary globose, pale green, silky puberolous, stigma capitates.[44] Choudhury et al. reported the essential oil composition of leaves of this plant collected from the Jorhat and Sibsagar districts in Assam, India.[45] The major constituents were linalool (35.8% and 52.2%), 1,8-cineole (14.3% and 6.0%) and bicyclogermacrene (9.9% and 6.6%).[45] Baruah and Nath reported the composition of panicle and bark oil of *C. bejolghota* collected from Assam. Linalool (65.0%) and α-phellandrene (8.9%) were the major components in the panicle oil along with 1,8-cineole (3.9%), α-pinene (3.4%), β-phellandrene (3.0%), β-pinene (2.6%), β-caryophyllene (2.6%), (*Z*)-methyl isoeugenol (2.1%) and α-farnesene (1.9%) as minor constituents.[46] The predominant components in the bark oil were α-terpineol (23.3%), linalool (14.4%), p-cymene (13.9%) and α-pinene (5.3%) while (*E*)-methyl cinnamate (3.1%), β-caryophyllene (2.9%), terpenen-4-ol (1.7%), (*E*)-cinnamaldehye (1.5%), eugenol (1.5%), α- phellandrene (1.5%), β-pinene (1.4%) and (*Z*)-methyl isoeugenol (1.1%) were the minor components.

***Cinnamomum camphora* (L.) J. Presl**

Camphor Tree is native to China, Japan, Korea, Taiwan, and adjacent parts of East Asia. It is now cultivated in many parts of the world. Camphor Tree is found in India in the states of Karnataka, Kerala, West Bengal, Assam, Tamil Nadu and Uttar Pradesh. *Cinnamomum camphora* is a medium to large sized evergreen tree, up to 40 m tall with a diameter of about 3 m. The leaves have a glossy, waxy appearance and smell of camphor when crushed. The leaves are alternately arranged in long stalk and have three distinct yellowish veins. Camphor tree can be easily identified by the distinctive odor of crushed leaf. The bark of *C. camphora* is yellow or brown with vertical grooves. Flowers are bisexual, creamy white in colour, hermaphroditic, one ovary, locular, one ovule, pendulous or basal, definite stamens and

minute embryo. The fruit is round, one-seeded, fleshy drupe, 7-8 mm wide and become purple-black at maturity. This tree flowers in the month of April- May.[8]

Cinnamomum camphora grown in Taiwan and Japan is normally very high in linalool, often between 80 and 85%. In India and Sri Lanka, the high camphor chemotype is dominant. *Cinnamomum camphora* grown in Madagascar, is high in 1,8 cineole (averaging between 40 and 50%).[8] The major compounds in the leaf oil of *C. camphora* were camphor (18.5%), eucalyptol (16.5%), linalool (11.9%) and 3,7-dimethyl-1,3,7-octatriene (11.1%) while the major constituents in the twig essential oil were eucalyptol (17.2%), camphor (13.2%) and 3,7-dimethyl-1,3,7-octatriene (11.47%). The major components in the seed oil of *C. amphora* were eucalyptol (20.9%), methyleugenol (19.9%), linalool (14.7%) and camphor (5.5%).[47] According to Guo et al.[48], the bark oil of *C. camphora* from China was rich in D-camphor (51.3%), leaf oil was rich in D-camphor (40.5%), linalool (22.9%), 1,8-cineole (11.3%) and fruit oil was rich in safrole (29.0%), D-camphor (28.1%) and linalool (12.8%). In an another report from China, the main components of *C. camphora* leaves essential oil were D-camphor (40.5%), linalool (22.9%) and cineole (11.3%).[49] Fresh leaves of *C. camphora* Chvar. Borneo were rich in d-borneol (81.6%).[50] Table 5 presents the chemical composition of *C. camphora* from north India.

Table 5: Chemical constituents in the oil of *C. camphora* from north India.

S. No.	Collection	Plant part	Oil yield (%)	Major Constituents	Chemotypes	Minor constituents	References
1.	Naukuchiatal, Uttarakhand	-	1.2 (v/w)	Camphor (81.5%)	Camphor (15)	1,8-Cineole (2.6%), p-cymene (2.3%), a-pinene (1.4%), a-humulene (1.3%), camphene (1.1%)	[23]
2.	Pantnagar, Uttarakhand, India	-	-	Camphor (82.4%)	Camphor (15)	-	[25]

***Cinnamomum impressinervium* Meissn.**

Cinnamomum impressinervium is an aromatic tree found at an altitude of 1500 to 2500 m.[51] Table 6 shows the chemical composition of *C. impressinervium* oil from north India.

Table 6: Essential oil composition of *C. impressinervium*.

S. No.	Collection	Plant part	Oil yield (%)	Major Constituents	Chemotypes	Minor constituents	Reference
1.	Northeast India	Fresh wild leaves	1.8	Eugenol (83.2%), δ-3-carene (7.2%)	Eugenol (7)/ δ-3-carene (27)	Limonene (2.3%), α-pinene (1.2%), eugenol acetate (1.0%)	[52]
		Fresh cultivated leaves	2.0	Eugenol (88.3%)	Eugenol (7)	Limonene (4.1%), δ-3-carene (1.6%), eugenol acetate (1.1%)	

***Cinnamomum glaucescens* (Nees) Meissn**

Cinnamomum glaucescens, a large-sized evergreen tree species is native to the tropical Himalayan regions of India and Nepal. It occurs naturally both in the hills and plains up to an altitude of 1200 m. All parts of the plant are aromatic. The wood oil of *C. glaucescens* is rich in safrole, myristicin and elemicin.[53] Berries of this plant also yield Sugandha kokila oil of commercial value.[54,55] The essential oil of the total fruits of *C. glaucescens* from Nepal was rich in 1,8-cineole (13%), methyl cinnamate (14%) and α-terpineol (7%) while pericarp oil was dominated by 1,8-cineole (56%) and α-terpineol (10%).[55] The essential oil of *C. glaucescens* has been investigated by Baruah and Nath (Table 7).[39]

Table 7: Essential oil composition of *C. glaucescens*.

S. No.	Collection	Plant part	Oil yield (%)	Major Constituents	Chemotypes	Minor constituents	Reference
1.	Assam, India	Leaf	0.4	α-Phellandrene (32.8%), α-farnesene (11.8%), 1,8-cineole (5.6%), α-pinene (5.3%)	α-Phellandrene (8)/ α-farnesene (28)/ 1,8-cineole (11)/ α-pinene (2)	Terpeniol (2.4%), β-pinene (2.1%), β-caryophyylene (2.0%)	[57]
		Panicle	0.2	Linalool (65.0%), α-phellandrene (8.9%)	Linalool (1)/ α-phellandrene (8)	1,8-Cineole (4.0%), α-pinene (3.4%), β-phellandrene (3.0%), β-pinene (2.6%), β-caryophyllene (2.6%), (*Z*)-methyl isoeugenol (2.1%), α-farnesene (1.9%)	
		Stem bark	0.1	α-Terpineol (23.3%), linalool (14.4%), p-cymene (13.9%), 1,8-cineole (6.9%), α-pinene (5.3%)	α-Terpineol (9)/ linalool (10)/ p-cymene (10)/ 1,8-cineole (11)/ α-pinene (2)	(*E*)-Methyl cinnamate (3.1%), β-caryophyllene (2.9%), (*E*)-cinnamaldehyde (1.5%), eugenol (1.5%), α-phellandrene (1.5%), β-pinene (1.4%), (*Z*)-methyl isoeugenol (1.1%)	

***Cinnamomum champokianum* Baruah & S.C. Nath**

Cinnnamomum champokianum is a moderated sized evergreen tree up to 6-7m height. The bark of the tree is brownish white, 5-10mm thick. The leaves are aromatic, green, pale green below, shining above and arranged in alternate manner. Flowers are pale yellow and 6-7mm long. Flowering occurs in March-May and fruits in June-September.[57] Essential oil evaluation of *C. champokianum* has been studied by Baruah and Nath (Table 8).[57]

Table 8: Essential oil composition of *C. champokianum*.

S. No.	Collection	Plant part	Oil yield (%)	Major Constituents	Chemotypes	Minor constituents	Reference
1.	Arunanchal Pradesh	Leaves	0.4	Elemicin (92.9%)	Elemicin (29)	Methyl eugenol (4.9%)	[56]

***Cinnamomum pauciflorum* Nees**

Cinnamomum pauciflorum Nees. is an important spice crop from north east India.[58,59] It is an aromatic shrub attaining a height of 1.5–5.0 m, found wild in eastern Himalayas, particularly in north-eastern region up to an altitude of 1800 m. In North-East India, it grows in Arunachal Pradesh, Assam Hills, Manipur, Meghalaya and Nagaland. Its bark, mature leaves and root bark possess the warm, pungent and sweet taste. Cinnamaldehyde has been reported as the only major component in the essential oils of *C. pauciflorum* (Table 9). Its stem bark is used as a substitute of true cinnamon by the local tribal people of Meghalaya and is sold in the local markets as ‘dalchini’ or ‘deinglorthia’.

Table 9: Essential oil composition of *C. pauciflorum*.

S. No.	Collection	Plant part	Oil yield (%)	Major Constituents	Chemotypes	Minor constituents	Reference
1.	North east India	Shade dried leaves Shade dried stembark Shade dried rootbark	4.0 1.1 5.2	Cinnamaldehyde (94.0%) Cinnamaldehyde (85.1%) Cinnamaldehyde (92.4%)	Cinnamaldehyde (12)	-	[60]
2.	Meghalaya, India	Shade dried leaves	4.0 (w/w)	(*E*)-Cinnamaldehyde (89.8%)	(*E*)-Cinnamaldehyde (12)	Linalool (2.6%), (*Z*)-cinnamaldehyde (1.2%), α-pinene (1.0%)	[61]
3.	Northeast India	Leaves	4.0	(*E*)-Cinnamaldehyde (94.0%)	(*E*)-Cinnamaldehyde (12)	Linalool (2.3%)	[62]

Many herbal remedies have been used in various medical systems for the treatment and management of different diseases. Literature review on cinnamon revealed that it mainly contains essential oils and important compounds like cinnamaldehyde, eugenol, cinnamic acid and cinnamate. It has been reported to possess good anti-inflammatory, anti-oxidant, anti-ulcer, anti-microbial, anti-diabetic, memory enhancer and many other activities.[63] Drugs obtained from plant sources are playing an important role in today's world. Herbal drugs come with practically no side effects if taken in proper doses and under the guidance of a qualified health practitioner. Various species of *Cinnamomum* are now being increasingly used to treat various types of diseases. The present review attempts to highlight distribution, botanical description, uses and chemical constituents of various species of *Cinnamomum* found in north India.

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