SYSTEMATICS AND DIVERSITIES OF *CINNAMOMUM* SPECIES USED AS "CINNAMON" SPICE IN NORTH-EAST INDIA

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ABSTRACT

A systematic census of *Cinnamomum* species used as "cinnamon" spice in Northeast India was conducted during 1994-1997. Fourteen taxa with variable phenotypic and odoriferous characters were collected. On critical study with emphasis to their morphology, foliar epidermal and venation characters these taxa revealed to be comprising of seven species namely *C. assamicum* Nath & Baruah, *C. bejolghota* (Buch.-Ham.) Sweet, *C. cassia* Blume, *C. iners* Reinw., *C. pauciflorum* Nees, *C. sulphuratum* Nees and *C.verum* Presl. For each taxon latest botanical names alongwith its synonyms, taxonomic citations, morphological descriptions (variant, if any), phenology, occurrence, distribution, uses and significant foliar epidermal and venation characters have been appended. A taxonomic key to differentiate the taxa, formulated on the basis of evaluated characters, has also been provided.

INTRODUCTION

Cinnamon is one of the most important and commercially valuable tree spices used for flavouring food stuff since antiquity (Sennanayaka & Wijesekera, 1989). It is the dried stem bark reportedly obtained from several *Cinnamomum* species like *C. verum* Presl, *C. cassia* Blume, *C. burmanii* Blume and *C. loureirii* Nees (Rethinum & Editon, 1991), of which *C. verum* Presl (syn. *C. zeylanicum* Blume) is the genuine source and known in trade as "True or Ceylon Cinnamon". Cinnamon is also used in traditional system of medicines for the treatment of rheumatism, neuralgia, headache, toothache, dyspepsia, flatulence, diarrhoea, neusea, remitting, menorrhagia, gonorrhoea, tuberculosis and enteric fever (Baruah, 2000). Cinnamaldehyde is the

main active ingredient of cinnamon responsible for its characteristic aroma and spicy taste, and extensively used in perfumery and flavour industries (Lawrence, 1967). Cinnamon is cultivated commercially in many countries like India, Seyechellies, Ghana and Malagasy Republic. However, Sri Lanka is the largest producer and exporter of cinnamon in the World (Sennanayaka & Wijesekera, 1989).

While conducting an ethnofloristic survey of the *Cinnamomum* species growing in North-East India during 1994-1997, we observed that a wide variety of stem bark with variable odoriferous characters belonging to a number of *Cinnamomum* species have been in use amongst the local people of the region as cinnamon spice. Few of them are even sold in the local markets under the name. However, there appears to be no such study from the region to explore these resources of *Cinnamomum* species in relation to their systematics and sustainable use. The present study, therefore, attempts to bring into the light the correct identities and diversities of *Cinnamomum* species associated with the name of cinnamon spice among the people in north-eastern part of India.

MATERIALS AND METHODS

The survey work was conducted during the period from 1994 to 1997, covering many areas of North-East India. The areas/localities taken into account for the survey activities are presented in Table 1. Information and specimens were collected on the basis of interviews with the people both from local markets and villages. People having imperial knowledge have also been taken into the field necessarily for collecting the specimens.

Table 1. Survey areas/localities of the *Cinnamomum* species used as Cinnamon spice in North-East India.

North-East States	Survey areas/localities
Arunachal Pradesh	Tawang, Bomdila, Itanagar, Pasighat and Khonsa
Assam	Dibrugarh, Naharkatiya, Sivasagar, Jorhat, Nambor Reserve Forest, Kaziranga, Lumding, Marigaon, Diphu, Maibong, Mahur, Haflong, Mangaldoi, Dhekiajuli, North-Lakhimpur, Guwahati and Gouripur
Manipur	Imphal
Meghalaya	Shillong, Borapani, Nonghpoh, Cherrapunjee and Jarain
Mizoram	Zobwak Forest
Nagaland	Yaongyimson and Dimapur
Tripura	Agartala

The specimens were identified consulting the relevant literatures (Kurz, 1877; Hooker, 1885; Kanjilal *et. al.*, 1940; Balakrishnan, 1983; Kostermans, 1983; Haridasan & Rao, 1987; Nath & Barua, 1994) and the herbaria of the Botanical Survey of India, Eastern Circle (ASSAM), Shillong and Central National Herbarium, Howrah (CAL), followed by their critical studies in respect of foliar epidermal and venation characters following the methods of Baruah & Nath (1999) and Singh *et. al.* (1995), respectively. All the specimens collected are preserved at the herbarium of Regional Research Laboratory (CSIR), Jorhat (Assam), India.

RESULTS

The taxa found to be associated with the people in North-East India as cinnamon spice are described in the following enumeration. For each taxon, taxonomic citations, morphological features (variant, if any) with phenology, occurrence, distribution, uses and significant foliar epidermal and venation characters have been provided. A key to distinguish the taxa is also given key to the species.

ENUMERATION

Cinnamomum bejolghota (Buch.-Ham.) Sweet, Hort. Brit. ed. 1. 334.1827; Balak. Fl. Jowai 2: 402. 1983; Haridn. & Rao, Forest Fl. Meghalaya 2: 720. 1987. *Laurus bejolghota* Buch.-Ham. in Trans. Linn. Soc. 13: 559. 1822. *L. obtusifolia* Roxb. Fl. Ind. 2: 302 .1824. *Cinnamomum obtusifolium* (Roxb) Nees in Wall. Pl. As. Rar. 2 : 561. 1902; Brandis, Ind. Trees 553, 716. 1906; Kanjilal *et al.* Fl. Assam 4: 56. 1940.

Variant I (RRLJ 1600)

A robust, evergreen tree, 25-30ft high. Bark grey, rough, blaze aromatic. Leaves opposite to subopposite, firmly coriaceous, aromatic, shining above, dark green, glabrous, pale below with frequently distributed microscopic papillae, broadly obovate-elliptic to oblong-elliptic or oblong, apex obtuse to bluntly acute, base cuneate to decurrently acute, 5-12x15-20 cm, triplinerved. Petiole rather stout, smooth, cylindrical or slightly flattened above, 0.8-1.7 cm long. Panicle spreading, sub-terminal to axillary, stout, pale yellowish-green, minutely pubescent to puberulous, glabrate with age, usually exceeding the leaves or slightly shorter, upto 19 cm long. Flowers 6 mm long, pale yellow; pedicel 3 mm long; perianth 3+3, sub-equal, 2.5-3 mm long, ovate-elliptic-lanceolate, silky on both surfaces; stamens 3+3+3, 1.5-2 mm long, pale yellowish-green; anther 4-locular,introrse, whorl 3rd extrorse, silky pubescent to villous, glands of whorl 3rd yellow, attached 1/3 of the base of the filament; staminodes 3, pale yellowish -green, 1 mm long, head broadly sagittate, villous; pistil 2 mm long; ovary globose, silky puberulous. Fruits upto 1.3 cm long, ellipsoid or subglobose.

Phenology: Flowering : January to April; Fruiting : May to August.

Ocurrence, distribution and uses : Common in evergreen to mixed deciduous forests throughout the areas of survey upto an altitude of 1200 m.

Stem bark possessing a spicy taste and odour is used as a kind of 'cinnamon' spice by the hill tribes, particularly the Nagas in Nagaland and even sold in the local markets as 'cinnamon'. Sometimes, this is also used for adulteration of the true cinnamon of commerce. Dried bark powder mixed with honey is given as a good remedy for cold and cough by the Kuki tribe of Manipur. Decoction of bark is used by the Garo tribe in Meghalaya for the treatment of urinary problems like burning sensation of the urinary tract. The bark, either raw or in the form of decoction, is used as mouth freshner by the Garo's and Khasi's in Meghalaya.

Significant foliar epidermal and venation characters: Unicellular, profusely distributed, papillate hairs present on lower surface; stomata/mm^2 35 and stomatal index 16.23; vein endings are either dichotomously forked once or simple, veinlet entering and termination number more, average frequency of areole/mm^2 3.53, veinlet entering present.

Variant II (RRLJ 1603)

A moderate-sized, evergreen tree, attaining a height of 20-22 ft. Bark brownish-white, mild aromatic. Leaves opposite or subopposite or alternate on the same twig, coriaceous to firmly coriaceous, aromatic, shining above, green, pale green below, glabrous above but sparsely distributed microscopic, unicellular, simple, piliform hairs present on lower surface, narrowly

elliptic-obovate-lanceolate, rarely broadly elliptic-lanceolate, apex obtusely acute to rarely acute or shortly acuminate, base cuneately acute to rarely obtuse or rounded, 4-9x8.5-25 cm, triplinerved; petiole rough, slightly concave above, 0.7-1.5 cm long. Panicle pseudoterminal, axillary to solitary axillary, lax-flowered, not spreading, stout, purple-brown to pale green, minutely pubescent, glabrate with age, shorter or equal to the leaves, upto 10 cm in length. Flowers 6-7 mm long, pale yellow; pedicel 3-4 mm long; perianth 3+3, 3-3.5 mm long, oblong-lanceolate, bluntly acutish, silky tomentose on both surfaces; stamens 3+3+3, 2-2.5 mm long, pale yellowish-green; anther 4-locular, introrse, whorl 3rd extrorse, filaments minutely silky puberulous; pistil 2 mm long; ovary ellipsoid, silky pubescent, style thickish, stigma peltate. Fruits upto 1 cm long, ellipsoid to oblong (Fig. 1).

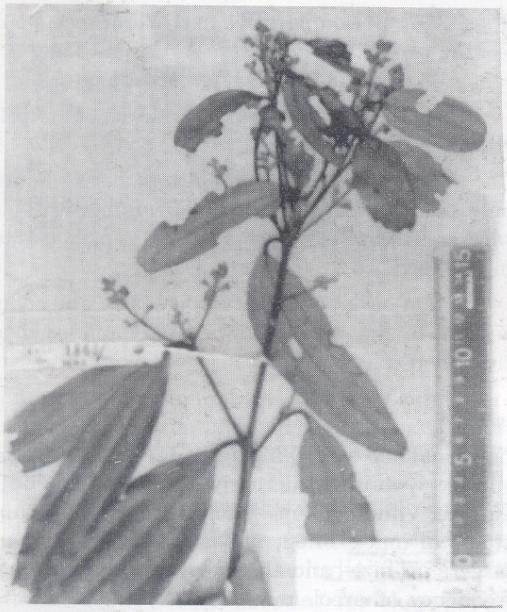


Fig. 1. Herbarium specimen of *C. bejolghota* Variant II, Scale = 15 cm.

Phenology: Flowering : March to May; Fruiting : June to September.

Occurrence, distribution and uses: Very rarely found in evergreen to mixed deciduous forests in the upper Brahmaputra valley region of Assam. It is also seen in the homestead gardens of some people in this region.

Stem bark is used as 'Cinnamon' spice for flavouring food stuffs.

Salient foliar epidermal and venation characters: Simple, unicellular and filiform hairs present in lower surface; stomata/mm^2 644 and stomatal index 19.00; average frequency of areole/mm^2 6.47.

Note: Morphological as well as foliar epidermal and venation characters, however, indicate the taxon a separate identity other than *C. bejolghota*.

Variant III (RRLJ 1847)

A middle-sized, evergreen tree, 20-25 ft tall. Bark aromatic. Leaves alternate, subopposite or opposite on the same twig, stiffly coriaceous, aromatic, shining above, glabrous, pale below, each epidermal cell on lower surface represented by papillae, narrowly oblong to oblong-elliptic-lanceolate or ovate-lanceolate, apex obtusely acute to rarely acute, base cuneate to decurrently acute, 1.8-5x4.5-14 cm, triplinerved. Panicle pseudo-terminal, axillary to solitary axillary, slender, pale yellowish-green, minutely pubescent, glabrate with age, usually equal to the leaves or slightly shorter, upto 13.5 cm. Perianth segments subequal, ovate-elliptic-lanceolate, silky on both surfaces; stamens 3+3+3, 1.5-1.75 mm long, pale yellowish-green; anther 4-locular, introrse, whorl 3rd extrorse, silky pubescent to villous; glands of whorl 3rd yellow, attached 1/3 of the base of the filament; staminode 3, pale yellowish-green, 1.5 mm long, broadly sagittate head, villous, filament greenish-white; pistil 2 mm long; ovary globose, pale green, silky puberulous, stigma capitate.

Phenology: Flowering : March to May; Fruiting : Not observed.

Occurrence, distribution and uses: Common in evergreen to mixed deciduous forests of Meghalaya, particularly near banks of stream, between the altitude 650-1250 m.

Stem bark possessing a spicy taste and odour more or less similar to that of 'Cinnamon of commerce', is used as cinnamon spice. Decoction obtained from stem-bark is also used by some Khasi people in Meghalaya for the treatment of urinary problems like burning sensation of urinary tract. Some people belonging to Khasi and Garo tribes in Meghalaya, however, use the stem-bark as mouth freshner either raw or in the form of decoction.

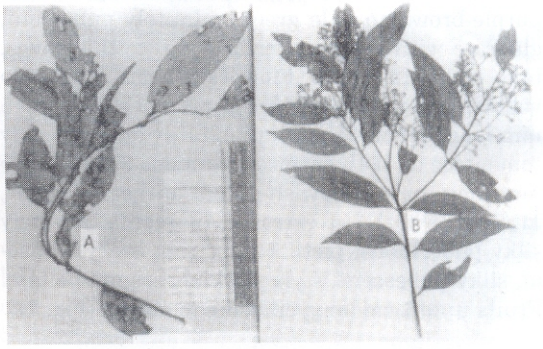
Note: This taxon has been named as *C. bejolghota* (Buch.-Ham.) Sweet var. *jarainum* A. Baruah & S.C. Nath (Baruah & Nath, 2001b).

Salient foliar epidermal and venation characters: Each lower epidermal cells repesented by papillate hair; stomata/mm^2 31 and stomatal index 1.13; vein endings are simple, veinlet entering and termination number less, average frequency of areole/mm^2 6.07.

Cinnamomum cassia Blume, Bijdr. 570. 1826; Hk. f. Fl. Brit. India 5: 130. 1885.

Variant I (RRLJ 1626)

A moderate sized, evergreen tree, 20-25 ft high. Bark rough, aromatic, smell and taste like that of "cinnamon" spice. Leaves alternate, sub-opposite or opposite on the same twig, coriaceous, aromatic, smell and taste like that of stem bark, shining above, dark green, glabrous, pale beneath with sparsely distributed microscopic unicellular hairs, elliptic-oblong to oblong-lanceolate, apex acute to acuminate, acumen upto 2.5 cm long, base decurrently acute, 2.4-4.2x6.5-18 cm, triplinerved; petiole slightly concave above, 0.8-1.2 cm long. Panicle terminal to axillary, lax, upto 10 cm long, pale yellow; pedicel 5-5.5 mm long; perianth 3+3, oblong-lanceolate, pale creamish-white, silky puberulous on both surfaces, 4 mm long; stamens 3+3+3, pale yellow, silky tomentose, whorl I & II 3 mm long; whorl 3rd 3.5-4 mm long; anther 4-locular, introrse, whorl 3rd extrorse, glands of whorl 3rd yellowish, attached 1/3 of the base of the filament; staminode 3, 1 mm long, tomentose to villous, head yellow, sagittate; pistil 3-3.5 mm long, tomentose, stigma capitate, style stout, ovary globose (Fig. 2A).



Figs. 2A & B. Comparative herbarium specimens of the variants of *C. cassia* : A. Variant I and B. Variant II, Scale = 15 cm.

Phenology: Flowering : March to April; Fruiting : May to August.

Occurrence, distribution and uses: Found only in evergreen forests of Mizoram with very rare occurrence between altitude from 800-1300 m.

Stem-bark possesses a spicy taste and odour similar to that of cinnamon spice and used as cinnamon spice.

Salient foliar epidermal and venation characters: Epidermal cells are pentagonal to polygonal and their walls highly sinuous on upper surface, while moderately sinuous on lower surface; number of stomata/mm^2 456 and stomatal index 14.02; upper epidermal cells are larger in size and less in number; average frequency of areole/mm^2 24.33, veinlet entering present.

Variant II (RRLJ 1782)

A moderate-sized evergreen tree similar to that of Variant I, in respect of its morphological characters including phenology. However, the

aromatic leaves and stem-bark possessing odour and taste comparatively mild in nature in comparison to the Variant I (Fig. 2B).

Occurrence, distribution and uses: Found only in the homestead gardens at few places in Jorhat district of Assam.

Stem-bark possesses a flavouring taste and odour and used as cinnamon spice.

Salient foliar epidermal and venation characters: Epidermal cell wall and their nature are similar to that of Variant I; number of stomata/mm^2 442 and stomatal index 14.42; upper epidermal cells are larger in size and less in number; average frequency of areole/mm^2 14.30, veinlet entering present.

Cinnamomum iners Reinw. in Blume, Bijdr. 570. 1826; Meissn. in DC. Prodr. 15(1): 19. 1864; Nees in Wall. Pl. As. Rar. 2. 287. 1831. *C. griffithii* Meissn. in DC. Prodr. 19. 1864. *C. gracile* Miquel. in Ann. Mus. Bot. Lugd. Bot. 1: 259. 1864.

An evergreen tree, upto 30 ft high. Bark greyish-brown, 5-15 mm thick, fibrous, aromatic. Leaves opposite to subopposite or alternate at the same twig, coriaceous, faint aromatic, pale green, glabrous above with sparsely distributed, microscopic, unicellular, simple, filiform hairs beneath, oblong to narrowly elliptic-oblong, apex blunt or scarcely pointed, base decurrently acute, 2.5-6x8.5-1 cm, triplinerved; petiole 1-1.2 cm long, concave above. Panicle almost equal to the leaves or slightly longer than, solitary to axillary subterminal, pale yellowish, spreading, slender, silky tomentose, glabrate with age, upto 12 cm long. Flowers 7-8 mm long, creamish-white; pedicel 5 mm long. Perianth 3+3, subequal, outer 2.5x1.25 cm, inner 2.5x1 cm, elliptic-lanceolate but narrow at the base with long silky hairs, rest portion of both suraces silky tomentose; stamens 3+3+3, 1.5-2 mm long; anther 4-locular, introrse, whorl 3rd extrorse, filaments silky, puberolous, glands of whorl 3rd attached 1/3 of the base of the filament; staminodes 3, 1.5 mm long, with sagittate-acutish head, filament silky puberulous; pistil 2 mm long, pale green, stigma peltate, ovary elliptic-oblong, silky puberulous (Fig. 3).

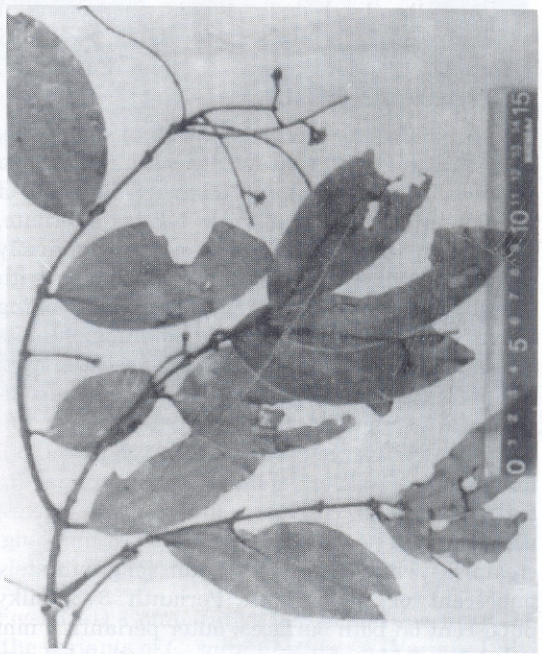


Fig. 3. Herbarium specimen of *C. iners*, Scale = 15 cm.

Phenology: Flowering : November to January; Fruiting : March to July.

Occurrence, distribution and uses: Found rarely in the evergreen forests of Karbi-anglong district of Assam between the altitude 200-430 m.

Stem-bark possessing a mild spicy odour and taste more or less similar to 'cinnamon of commerce', is used as adulterant of cinnamon.

Salient foliar epidermal and venation characters: Epidermal cells are pentagonal to polygonal with their walls highly sinuous in upper surface, while moderately sinuous in lower surface; unicellular, simple and filiform hairs present in lower surface; stomata/mm^2 625 and stomatal index 20.90; average frequency of areole/mm^2 9.07, veinlet entering present.

Cinnamomum pauciflorum Nees in Wall. Pl. As. Rar. 2: 75. 1831; Hk. f. Fl. Brit. India. 5: 129. 1886; Gamble, Man. Ind. Timb. 562. 1902; Brandis, Ind. Trees. 533. 1906; Kanjilal *et. al.* Fl. Assam 4: 57. 1940; Balak. Fl. Jowai 2: 407. 1983; Haridn. & Rao, Forest Fl. Meghalaya 2: 722. 1987.

A handsome, evergreen shrub to small tree, upto 12 ft. high. Bark grey with streaks of brown on stem, aromatic, smell and taste like that of "cinnamon", thin, 2 mm thick. Leaves alternate, subopposite or opposite on the same twig, firmly coriaceous, aromatic, smell and taste similar with stem-bark (tender leaves not aromatic), shining above, dark green, pale below, glabrous, elliptic-ovate or ovate-elliptic to oblong- lanceolate, apex acuminate to caudate-acuminate, base decurrently acute to rounded or sub-cordate, 1.5-5 x 2.5-14.5 cm, triplinerved; petiole concave above, 5-9 mm long. Panicles solitary, sub-terminal to axillary, upto 5 cm long, shorter than leaves, peduncle with 2-3 flowers. Flowers 7-8 mm long, creamish- white; pedicels 4-5 mm long, minutely pubescent or puberulous. Perianth 3+3, silky pubescent on both surfaces, outer perianth 3 mm long, obovate-lanceolate, inner perianth 2.5-3 mm long, minutely puberulous to pubescent; anther 4-locular, introrse, whorl 3rd extrorse, valve and locule oblong-lanceolate, glands of whorl 3rd yellow, attached 1/3 of the base of the filament; staminodes 3, 1 mm long, minutely puberulous to pubescent, head sagittate with pointed apex and rounded base; pistil 3.5 mm long, stigma capitate, ovary ovoid, minutely puberulous. Fruit globose, seated on the truncate toothed accresent base of the perianth. Fruit setting is poor (Fig. 4).

Phenology: Flowering : March to May; Fruiting : June to September.

Occurrence, distribution and uses: Sporadically found in evergreen forests in many areas of Meghalaya, Assam, Arunachal Paradesh, Manipur and Nagaland at an altitude between 810-1250 m.

Fig. 4. Herbarium specimen of *C. pauciflorum*, Scale = 15 cm.

Stem-bark possessing an odour and taste similar to that of the 'cinnamon spice'. It is sold in the local markets under the name of cinnamon, particularly by the Khasi's in Meghalaya. The stem-bark in the form of decoction is also used for medicinal purpose by the Khasi's in Meghalaya as cardiotonic and antispasmodic. Decoction obtained from the bark is, however, used by the Kuki tribe in Manipur for the treatment of stomach disorders.

Salient foliar epidermal and venation characters: Epidermal cells tetragonal to polygonal with moderately sinuous walls in upper surface and slightly sinuous walls in lower surface; stomata/mm^2 802 and stomatal index 24.00; average frequency of areole/mm^2 37.53, veinlet entering absent.

Cinnamomum sulphuratum Nees in Wall. Pl. As. Rar. 2 : 74. 1831; Hk. f. Fl. Brit. India. 5: 132. 1886; Kostermans in Bull. Bot. Surv. India. 25 (1-4) : 114. 1983; Nath & Barua in J. Econ. Taxon. Bot. 18 : 211. 212. 1994.

Variant I (RRLJ 1255)

A medium to larged-sized tree, 30-35 ft. high. Bark smooth, aromatic, odour and taste like "cinnamon" spice, 4-8 mm thick. Leaves opposite to subopposite or alternate on the same twig, aromatic, smell like "linalool type-sweet basil", thinly coriaceous to coriaceous, glabrous, ovate-elliptic to elliptic-lanceolate or elliptic, apex shortly acuminate to rarely acute, base acute to cuneatly acute, variable in size, 1.7-4x6.5-14.5 cm, triplinerved; petiole rather slender, 8-9 cm long. Inflorescence lax and rather few-flowered, minutely tomentose, branchlets few, slender. Flowers densely pilose, pale yellow; pedicel upto 5 mm long; perianth 3+3, thickish, ovate, acutish, 2-4 mm long; stamens 3+3+3, 2-2.5 mm long, anther oblong, 4-locular, introrse, whorl 3rd latrorse, filament pilose, glands adnate to the basal part of the filament or slightly higher up; staminode 3, 1 mm long, pilose, head narrowly sagittate; ovary ellipsoid, as long as style, stigma minute, peltate. Fruit ellipsoid (Fig. 5A).

Phenology: Flowering : September to November; Fruiting : December to February.

Occurrence, distribution and uses: Sporadically found in evergreen forests in the hill districts of Assam and Arunachal Pradesh between the altitudes 450-1130 m.

Stem-bark, possessing an odour and taste similar to that of cinnamon spice, is used as a kind of cinnamon and sold in the local markets.

Salient foliar epidermal and venation characters: Epidermal cells pentagonal to polygonal with moderately sinuous walls; stomata/mm^2 586 and stomatal index 17.85; average frequency of areole/mm^2 22, absolute areoles number/mm^2 68.7, veinlet entering absent.

Figs. 5A-D. Comparative herbarium specimens of the variants of *C. sulphuratum* : A. Variant I, B. Variant II, C. Variant III and D. Variant IV, Scale = 15 cm

Variant II (RRLJ 1809)

A medium to large-sized evergreen tree similar to that of Variant I, in respect of morphological and odoriferous characters of stem bark and phenology. However, the aromatic leaves possess odour similar to that of "Java Citronella-Lemon grass oils" (Fig. 5B).

Occurrence, distribution and uses: Sporadically found in evergreen forests in North-Cacher Hills district of Assam between the altitudes 650-980 m.

Stem-bark, possessing an odour and taste similar to that of cinnamon spice, is used as a kind of cinnamon and sold in the local markets.

Salient foliar epidermal and venation characters: Epidermal cells pentagonal to

polygonal with moderately sinuous walls; stomata/mm^2 448 and stomatal index 14.20; average frequency of areole/mm^2 19.4, absolute areoles number/mm^2 57.3, veinlet entering absent.

Variant III (RRLJ 1885):

A moderate to large-sized, evergreen tree similar to that of the Variant I, in respect of its morphological characters except comparatively larger leaf size (2-5.4x5.5-16 cm) and longer panicle (upto 15 cm long). The odoriferous characters of leaves and stem-bark including its phenology are also similar with the Variant I (Fig. 5C).

Occurrence, distribution and uses : Sporadically found in evergreen forests in Karbi-anglong district of Assam between the altitude 210-450 m.

Stem-bark, possessing an odour and taste similar to that of cinnamon spice, is used as a kind of cinnamon and sold in the local markets.

Salient foliar epidermal and venation characters: Epidermal cells pentagonal to polygonal with moderately sinuous walls; stomata/mm^2 774 and stomatal index 20.13; average frequency of areole/mm^2 34.53, absolute areoles number/mm^2 117.2.

Variant IV (RRLJ 1886):

A moderate to large-sized evergreen tree similar to that of the Variant III, in respect of its morphological characters including phenology, occurrence and distribution. However, the aromatic leaves and stem-bark possess odour similar to that of "methyl cinnamate type-sweet basil" (Fig. 5D). Stem-bark is used as a kind of cinnamon spice and sold in the local markets.

Salient foliar epidermal and venation characters: Epidermal cells pentagonal to polygonal with moderately sinuous walls; stomata/mm^2 589 and stomatal index 16.19; average frequency of areole/mm^2 35.2, absolute areoles number/mm^2 123.6.

Cinnamomum verum J. S. Presl., Priroz. Rostlin. 2 : 36. t. 7. 1825; Wscobecny Rostlin. 2: 1301. 1846; Kostermans, Biblogr. Laura. 360. 1964 & in Reinwardtia 7: 141. 1965. *C. zeylanicum* Blume, Bijdr. 568. 1826; Wight, Ic. t. 123. 1839.

Variant I (RRLJ 1620):

A moderate-sized, evergreen tree,25-35 ft. high. Bark smooth, brown, with a strong spicy smell and pleasant, pungent, sweet and warm taste, upto 12 mm thick. Leaves alternate, sub-opposite or opposite on the same twig, stiffly coriaceous, aromatic, smell like "clove oil", glabrous, shining above, dark green, pale beneath, ovate to ovate-elliptic, sometimes narrowly ovate-elliptic at flowering shoots, apex broadly acute to acute, base almost rounded or decurrently obtuse, 3-7.5x6.5-16 cm, triplinerved, rarely 5-nerved; petiole rather stout, slightly concave above,1-1.4 cm long; panicle terminal to sub-terminal or axillary, exceeding the leaves or slightly shorter than, upto 22 cm long, pale yellowish-green, silky tomentose, glabrate with age. Flowers 10-12 mm long, pale yellowish-green, silky tomentose; pedicel 6-7 mm; inner perianth lobes 3.5x1.5 mm, silky tomentose on both surfaces; stamens 3+3+3, pale yellow, villous to tomentose, whorl I and II 2 mm long, whorl 3rd 2.5 mm long; anther oblong- lanceolate, 4-locular, introrse but extrose in whorl 3rd, glands of whorl 3rd attached 1/3 of the base of the filament; staminode 3, 1.5 mm long, hastate, pale yellow, tomentose; pistil 3 mm long, stigma peltate, style as long as the ovary, ovary elliptic-ovate, puberolous, pale green. Fruit elliptic to narrowly obovoid-elliptic, upto 12 mm long, 9 mm across, pericarp thickness 0.8-1 mm, cotyledon thickness 3.5 mm, pedicel with truncate perianth length 1.3 cm.

Phenology: Flowering : February to April; Fruiting : May to August.

Occurrence, distribution and uses: Found only in cultivated stand in the homestead gardens of some people in the region.

Stem-bark, possessing a sweet, pungent and warm taste, is used in the region for flavouring various local dishes.

Salient foliar epidermal and venation characters: Epidermal cells pentagonal to polygonal with highly sinuous walls; stomata/mm^2 725 and stomatal index 23.16; average frequency of areole/mm^2 6.13.

Variant II (RRLJ 1622)

Habit and bark characters similar to that of Variant I. Leaves alternate, sub-opposite or opposite on the same twig, coriaceous, aromatic, smell like Variant I, glabrous, shining above, dark green, pale beneath, elliptic to oblong-lanceolate or rarely narrowly elliptic-lanceolate, sometimes narrowly ovate-lanceolate at flowering shoots, apex acute to bluntly acute, base mostly acute, sometimes obtuse to decurrently obtuse, 2.5-6x5-16 cm, triplinerved, rarely 5-nerved; petiole stout, slightly concave above, 1-1.8 cm long. Panicle terminal to sub-terminal or axillary, exceeding the leaves or slightly shorter than, upto 18 cm long with upto 7 cm long 2° peduncle, pale yellowish-green, silky tomentose, glabrate with age. Flowers 7-8 mm long, pale yellowish-green, silky tomentose; pedicel 3-5 mm long; perianth 3+3, oblong-lanceolate, acutish or obtuse, subequal, outer lobes 2.5x1.5 mm, inner lobes 2x1.5 mm, silky tomentose on both surfaces; stamens 3+3+3, pale yellow, tomentose, whorl I and II 1.5-2 mm long, whorl 3rd 2 mm long; anther oblong-lanceolate, 4-locular,introrse but in whorl 3rd extrorse, glands of whorl 3rd attached 1/3 of the base the filament; staminode 3, 1 mm long, hastate, pale yellow, tomentose; pistil 2.5 mm long, stigma peltate, style and ovary equal in length, ovary elliptic-ovate, puberolous, pale green. Fruit oblong-ovoid, upto 13 mm long, 7 mm across, pericarp thickness 0.5 mm, cotyledon thickness 3 mm, pedicel with truncate perianth length 1 cm .

Phenology: Same as of Variant I.

Occurrence, distribution and uses: Same as of Variant I.

Salient foliar epidermal and venation characters: Epidermal cells pentagonal to polygonal with highly sinuous walls; stomata/mm^2 629 and stomatal index 20.26; average frequency of areole/mm^2 11.47.

Note: The Variant I and Variant II have been named as Cultivar – JORLAB CV 1 and JORLAB CV 2, respectively (Nath *et al.*, 1997).

Variant III (RRLJ 1606)

A moderate-sized, evergreen tree, 20-25 ft. high. Bark aromatic, smooth, 3-5 mm thick. Leaves alternate, opposite to subopposite on the same twig, aromatic, coriaceous, glabrous, shining and dark green above, pale below, elliptic to oblong-lanceolate, apex acute to mostly shortly acuminate, acumen upto 1.5 cm long, base acute to rarely decurrently obtuse, 2.5-5.5x6.5-14 cm, triplinerved, rarely 5-nerved; petiole stout, slightly concave above, 0.5-1.3 cm long. Panicle sub-terminal to axillary, reduced, few-flowered, minutely puberulous, glabrate with age, shorter than leaves or rarely slightly exceeding them, 2-8 cm(but the panicle bearing leaves are upto 12 cm long), less stout, pale yellowish-green, 2° peduncle 0.5-1 cm long, decurrently opposite, bears 2-3 flowers, 3° peduncle absent. Flowers 4-5 mm long; pedicel 1-1.5 mm long. Perianth 3+3, elliptic-lanceolate to narrowly obovate-lanceolate, subequal, 2x1 mm, silky pubescent on both surfaces; stamens 3+3+3, filament villous; anther 4-locular, pale brownish-white, pollen dehiscence occur by splitting the valves, introrse while extrorse in whorl 3rd, whorl I and II 1.5 mm long, whorl 3rd 1.5-1.8 mm long with brownish glands attached 1/3 of the base of the filament; staminodes 3, 1 mm long, head broadly hastate with decurrently acute apex, tomentose; pistil 2 mm long, pale brownish-white, silky puberolous, ovary elliptic-oblong, 1 mm long, style slender, stigma capitate. Fruit setting is very poor .

Phenology: Flowering : February to April; Fruiting : May to July.

Occurrence, distribution and uses: Rarely found in evergreen forests in Brahmaputra valley

of Assam. It is also found to be cultivated by some people of Jorhat district of Assam.

Stem-bark, possessing a taste and odour similar to some extent of 'cinnamon spice', is used as a kind of cinnamon spice. The stem bark paste applied against scabies.

Salient foliar epidermal and venation characters: Epidermal cells pentagonal and polygonal with highly (broadly) sinuous walls; stomata/mm^2 558 and stomatal index 35.41; average frequency of areole/mm^2 8.87.

Note: Morphological as well as foliar epidermal and venation, and essential oil characters, however, indicate the taxon a separate identity from *C. verum*. Hence, this variant has been named as *C. assamicum* S.C. Nath & A. Baruah (Baruah and Nath, 2001a).

DISCUSSION AND CONCLUSION

The results indicate that 14 taxa of *Cinnamomum* are known in the region as cinnamon spice, of which botanical identities of 13 taxa representing 7 species namely *C. assamicum*, *C. bejolghota, C. cassia, C. iners, C. pauciflorum, C. sulphuratum* and *C. verum* have been ascertained.

The identity of *C. bejolghota* Variant II (RRLJ 1603), morphological as well as foliar epidermal and venation characters of which are found to be unlike to that of the rest two variants of the species, is yet to be confirmed. The degree of differences as indicated by this particular taxon from the rest two variants of *C. bejolghota* are found to be indicative of species category, not being recorded and described so far from India (Hooker, 1885; Kanjilal *et. al.* 1940; Kostermans, 1983; Manilal & Shylaja, 1986). Thus, the taxon could be contemplated as a new species from the flora of North-East India (Fig. 1). The finding, thus, accordingly indicates the necessity of nomenclatural correction of the taxon at CAL, with the help of which the accession RRLJ 1603 was identified as *C. bejolghota* (letter by T. Bhattacharyya dated 10.07. 1995 of CAL). Necessary process is on to establish the taxon (RRLJ 1603) as new species other than *C. bejolghota*.

Likewise, the Variant I of *C. bejolghota* represents the typical characters of the species. However, *C. bejolghota* Variant III, due to its comparatively different shape and size of leaves and floral morphology, especially the size of the individual floral parts, could easily be separated from the Variant I. The differences between the two taxa with regards to the above characters are further supported by their differences in distributional patterns of the papillae in their leaves, and venation characters like size and number of areole, nature of veinlet entering and vein thickness. The differences as observed between the two taxa are found to be indicative of varietal status. Hence, the Variant III has been named as *C. bejolghota* (Buch.-Ham.) Sweet var. *jarainum* A. Baruah & S.C. Nath (Baruah & Nath, 2001b).

Likewise, while consulting the herbarium specimens preserved at BSI (ASSAM) three accessions of *Cinnamomum* (Mizoram, Lushai Hills 21.02.1952, L. K. Deka, collection Nos. 39636 to 39638), identical to the accession RRLJ 1606, and named as *C. verum* came across. Thus, the accession RRLJ 1606 was although identical as *C. verum*, but its morphological, foliar epidermal and venation characters are found to be significantly different from the rest of *C. verum* variants, indicating the accession (RRLJ 1606) a

separate taxon of *Cinnamomum* at species category other than *C. verum*. However, no such specimens that matched with the accession RRLJ 1606 were found available at CAL and K (letter of communication dated 30.09.1994 by Dr.V.J. Nair, former Liaison officer of India to K). The taxon has, therefore, been described as a new species and named as- *C. assamicum* S.C.Nath & A. Baruah. (Baruah & Nath, 2001a). The separate identity of this taxon other than *C. verum* has also been evidenced by its different chemical characters (Baruah & Nath, 2001a) from that of the typical *C. verum* (Nath *et. al.*, 1997).

As regards the *C. verum* Variant I and Variant II growing in North-East India, the present finding indicates them as two phenotypic forms. However, there is a positive correlation between the differences of their morphological and yield attributing characters (Nath *et al.*, 1997). Thus, the naming of the variants as reported previously (Nath *et al.*, 1997) as cultivers, viz. Variant I as JOR LAB CV1 and Variant II as JOR LAB CV2 could be contemplated as justified.

On the basis of leaf size and panicle length, the four variants of *C. sulphuratum* gathered in this investigation could be classified into two groups of equal status. Variant I together with the Variant II in one group, while the Variant III together with the Variant IV in the other group. The group constituted with the Variant I and Variant II represents the leaf comparatively smaller in size and panicle always longer than leaves. The differences between the two groups have further been supported by the differences of their foliar epidermal characters like presence or absence of hairs and size of epidermal cells, and venation characters like presence or absence of veinlet entering and size of areoles. The groupings of *C. sulphuratum* are on the basis of characters indicative of varietal status. Thus, each group could be proposed as distinct variety of the species. However, as regards individual identity of the variants belonging to each group , these could be differentiated from each other only by their few quantitative foliar epidermal and venation characters like number of stomata/mm^2, stomatal index and absolute areoles number, indicating the variants below varietal status as evidenced by their individual chemical characters (Baruah, 2000; Baruah & Nath, 2003). Hence, the variants could be contemplated as chemotypes of the respective varieties (Figs. 5A, B, C and D).

Furthermore, as regards the variants of *C. cassia,* no such significant differences, except the odoriferous nature of the leaves and stem-bark, have been found. The smell of leaves and stem-bark of the Variant I is similar to that of the typical cinnamon spice, while it is unlike in the Variant II as evidenced by their chemical constituents (Baruah, 2000). Hence, the variants could be referred as chemotypes of the species (Figs. 2A and B).

Authenticity of folklore uses of the bark of *C. verum* Variant I, *C. verum* Variant II, *C. sulphuratum* Variant I, *C. sulphuratum* Variant II, *C. sulphuratum* Variant III, *C. cassia* Variant I and *C. pauciflorum* have been evidenced by the occurrence of cinnamaldehyde as major component in their chemical compositions (Baruah, 2000). However, as regards the stem-bark of the taxa like *C. bejolghota*

Variant I, *C. bejolghota* Variant II, *C. bejolghota* Variant III (named as *C. bejolghota* (Buch.-Ham.) Sweet var. *jarainum* A. Baruah & S.C. Nath (Baruah & Nath, 2001b), *C. verum* Variant III (named as *C. assamicum* S.C. Nath & A. Baruah (Baruah & Nath, 2001a), *C. sulphuratum* Variant IV, *C. cassia* Variant II and *C. iners*, the major components examined in their chemical compositions are α-terpineol (Baruah, 2000; Baruah *et al.*, 1997), α-terpineol (Baruah, 2000), linalool (Baruah, 2000), benzyl benzoate (Nath *et al.*, 1995), methyl cinnamate (Baruah, 2000), linalool (Baruah, 2000), and 1,8-cineole (Baruah, 2000) respectively, indicating the plant parts as flavouring agents (Atal & Kapur, 1982), although not characteristics of the cinnamon spices of commerce.

The present findings thus brought into the light four new sources of cinnamon spice having cinnamldehyde as major component in the oils, viz. *C. pauciflorum*, *C. sulphuratum* Variant I, *C. sulphuratum* Variant II and *C. sulphuratum* Variant III, besides the existing ones (Sennanayaka & Wijesekera, 1983; Rethinum & Edison, 1991).

Key to the species

1a Leaves thickly coriaceous:

2a Small to moderate sized tree; fruit ellipsoid:

3a Epidermal cells are moderately sinuous on lower surface of leaf:

4a Leaves aromatic, broadly obovate-elliptic to oblong-elliptic or oblong-lanceolate or rarely broadly elliptic-lanceolate; fruit ellipsoid to oblong or subglobose:

5a Perianth ovate-elliptic-lanceolate; stamens silky pubescent to villous; staminode with broadly sagitate head, villous; ovary globose, silky puberulous:

6a Papillae present in abaxial surface of leaf, hairs absent; number of stomata/mm^2 and stomatal index 33 ± 2 and 1.18 ± 0.05, respectively:

7a Leaves larger in size (5-12 x 15-30 cm); petiole rounded or slightly flattened above, 3 mm in diameter, upto 1.7 cm long; papillae frequently distributed; areoles are comparatively larger in size and less in number, vein endings are either dichotomously forked or simple, veinlet entering and termination number more... ..... *C. bejolghota* Variant I

7b Leaves smaller in size (1.7-5.5x7-19 cm); petiole concave above, 1 mm in diameter, upto 1.2 cm long; each abaxial epidermal cell modified into a single papillae; areoles are comparatively smaller in size and more in number, vein endings are simple, veinlet entering and termination number less ..... *C. bejolghota* Variant III (named as *C. bejolghota* (Buch.-Ham.) Sweet var. *jarainum* A. Baruah & S.C. Nath (Baruah & Nath, 2001b).

5b Perianth oblong-elliptic-lanceolate; stamens silky, minutely puberulous; staminode with narrowly hastate acutish head, silky puberulous; ovary ellipsoid, silky pubescent.

6b Sparsely distributed microscopic, simple, unicellular and filiform hairs present in abaxial surface of leaf, papillae absent; number of stomata/mm^2 and stomatal index 644 and19.00, respectively ..... *C. bejolghota* Variant II (proposed as new species)

4b Leaves faint aromatic, oblong to narrowly elliptic-oblong; fruit oblong..... *C. iners*

3b Epidermal cells are highly sinuous on both surfaces of leaf:

8a Panicle lax; staminode hastate with decurrently acute apex; epidermal cells are comparatively smaller in size; stomatal index ranging from 20.21-23.16:

9a Leaves stiffly coriaceous, ovate to ovate-elliptic, rarely narrowly ovate-elliptic; petiole 1-1.4 cm long; flowers comparatively larger; fruits elliptic to narrowly obovoid-elliptic, pericarp and cotyledon thickness 0.8-1 mm and 3.5 mm, respectively; number of stomata/mm^2 725; areoles are comparatively larger in size and their average number/mm^2 6.13..... *C. verum* Variant I (named as **JOR LAB CV1 :** (Nath *et al.*, 1997)

9b Leaves coriaceous, elliptic to oblong-lanceolate or rarely narrowly ovate-lanceolate; petiole 1-1.8 cm long; flowers comparatively smaller; fruits oblong-ovoid, pericarp and cotyledon thickness 0.5 mm and 3 mm, respectively; number of stomata/mm^2 629; areoles are comparatively smaller in size and their average number/mm^2 11.47..... *C. verum* Variant II (named as **JOR LAB CV2** (Nath *et. al.*, 1997)

8b Panicle reduced; staminode broadly hastate with decurrently acute apex; epidermal cells are comparatively larger in size; stomatal index 35.41..... *C. verum* Variant III (named as *C. assamicum* S.C. Nath & A. Baruah. (Baruah & Nath, 2001a)

2b Bushy handsome shrub to small tree; fruit globose; bark and leaves with a strong smell of "cinnamon"; leaves ovate-elliptic-lanceolate to oblong-lanceolate; panicles few-flowered; lower epidermal cells slightly sinuous, number of stomata/mm^2 and stomatal index 802 and 24.00, respectively; veinlet entering absent ..... *C. pauciflorum*

1b Leaves thinly coriaceous:

10a Leaves elliptic-oblong to oblong-lanceolate, apex acute to acuminate, base decurrently acute; ovary globose; upper epidermal cells highly sinuous; areoles tetragonal to polygonal:

11a Leaves and stem bark smelling of "cinnamon" spice; average frequency of areole/mm^2 24.33; upper epidermal cells are smaller in size and more in number..... *C. cassia* Variant I

11b Leaves and stem bark smelling unlike to "cinnamon" spice; average frequency of areole/mm^2 14.30; upper epidermal cells are larger in size and less in number..... *C. cassia* Variant II

10b Leaves ovate-elliptic to elliptic-lanceolate or elliptic, apex shortly acuminate to rarely acute, base acute to cuneately acute; ovary ellipsoid; epidermal cells moderately sinuous; areoles trigonal to polygonal:

12a Panicles comparatively shorter (5-9 cm) and leaves comparativly smaller in size (1.7-4x6.5-14.5), glabrous; epidermal cells are comparatively larger in size, number of epidermal cell/mm^2 in upper and lower surface ranging from 1926-2138 and 2696-2707, respectively; veinlet entering absent, areoles are comparatively larger in size, average frequency of areole/mm^2 ranging from 19.40-20.67:

13a Leaves and stem-bark smelling of "linalool type-sweet basil" and "cinnamon" spice, respectively; absolute areoles number 68.7. ..... *C. sulphuratum* Variant I

13b Leaves and stem-bark smelling of "Java citronella-Lemon grass" oils and "cinnamon" spice, respectively; absolute areoles number 57.3. ..... *C. sulphuratum* Variant II

12b Panicles comparatively longer (upto 15 cm) and leaves comparatively larger in size (2-5.4x5.5-18 cm) with sparsely distributed, simple, unicellular and filiform hairs on lower surface; epidermal cells are comparatively smaller in size, number of epidermal cells/mm^2 in upper and lower surface ranging from 2286-3071, respectively; veinlet entering present, areoles are comparatively smaller in size, average frequency of areole/mm^2 ranging from 34.53-35.20.

14a Leaves and stem bark smelling of "cinnamon" spice; number of stomata/mm^2 and stomatal index 774 and 20.13, respectively; absolute areoles number 117.2. ..... *C. sulphuratum* Variant III

4b Leaves and stem bark smelling of "methyl cinnamate type-sweet basil"; number of stomata/mm^2 and stomatal index 589 and 16.19, respectively; absolute areoles number 123.6... ..... *C. sulphuratum* Variant IV

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