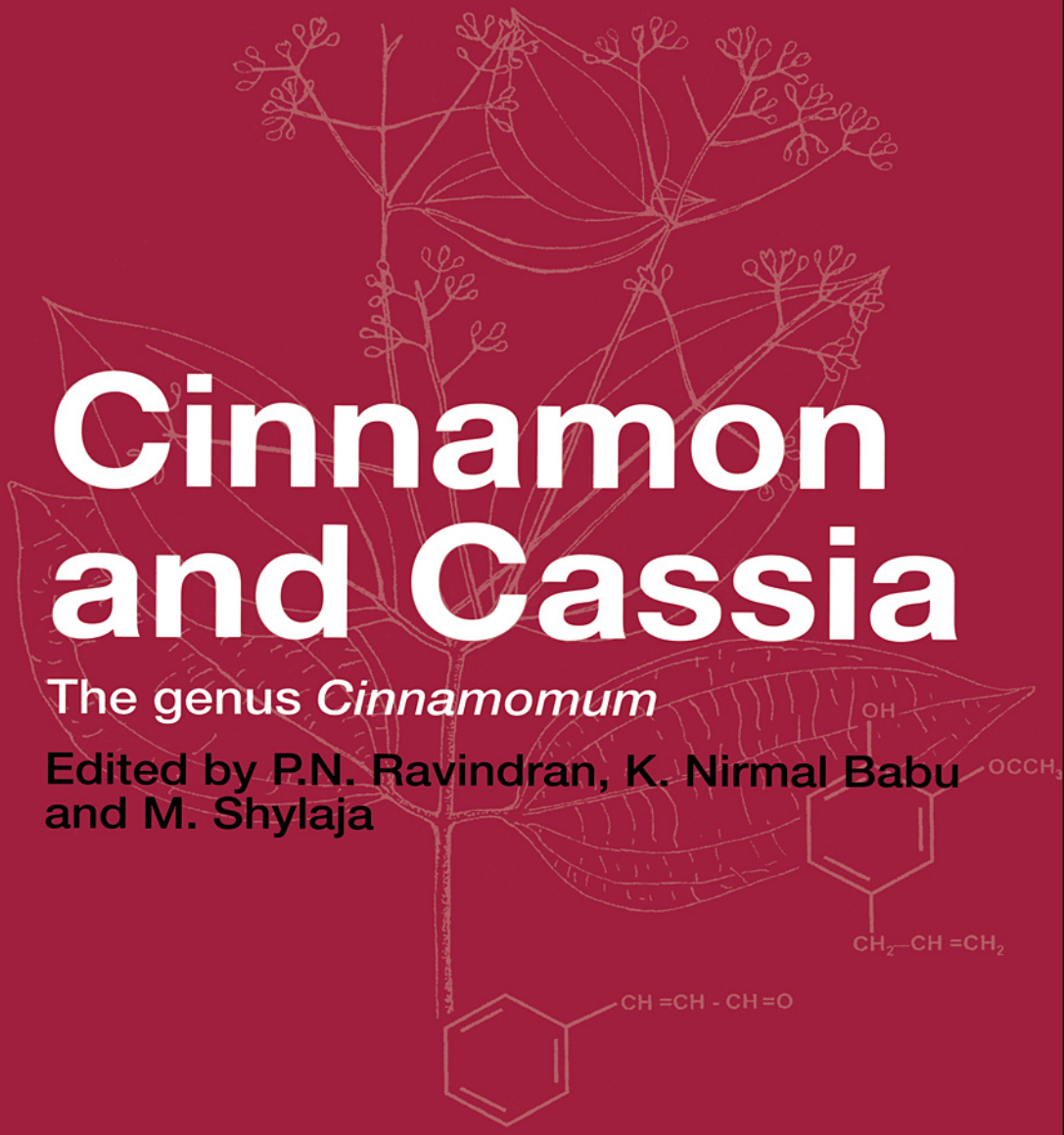

Cinnamon and Cassia

The genus *Cinnamomum*

Edited by P.N. Ravindran, K. Nirmal Babu and M. Shylaja

Medicinal and Aromatic Plants — Industrial Profiles

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Cinnamon and Cassia

The genus *Cinnamomum*

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Cinnamon and Cassia

The genus *Cinnamomum*

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Preface to the series

There is increasing interest in industry, academia and the health sciences in medicinal and aromatic plants. In passing from plant production to the eventual product used by the public, many sciences are involved. This series brings together information which is currently scattered through an ever increasing number of journals. Each volume gives an in-depth look at one plant genus, about which an area specialist has assembled information ranging from the production of the plant to market trends and quality control.

Many industries are involved, such as forestry, agriculture, chemical, food, flavour, beverage, pharmaceutical, cosmetic and fragrance. The plant raw materials are roots, rhizomes, bulbs, leaves, stems, barks, wood, flowers, fruits and seeds. These yield gums, resins, essential (volatile) oils, fixed oils, waxes, juices, extracts and spices for medicinal and aromatic purposes. All these commodities are traded worldwide. A dealer's market report for an item may say "Drought in the country of origin has forced up prices".

Natural products do not mean safe products and account of this has to be taken by the above industries, which are subject to regulation. For example, a number of plants which are approved for use in medicine must not be used in cosmetic products.

The assessment of safe to use starts with the harvested plant material, which has to comply with an official monograph. This may require absence of, or prescribed limits of, radioactive material, heavy metals, aflatoxin, pesticide residue, as well as the required level of active principle. This analytical control is costly and tends to exclude small batches of plant material. Large scale contracted mechanised cultivation with designated seed or plantlets is now preferable.

Today, plant selection is not only for the yield of active principle, but for the plant's ability to overcome disease, climatic stress and the hazards caused by mankind. Such methods as *in vitro* fertilization, meristem cultures and somatic embryogenesis are used. The transfer of sections of DNA is giving rise to controversy in the case of some end-uses of the plant material.

Some suppliers of plant raw material are now able to certify that they are supplying organically farmed medicinal plants, herbs and spices. The Economic Union directive (CVO/EU No. 2092/91) details the specifications for the *obligatory* quality controls to be carried out at all stages of production and processing of organic products.

Fascinating plant folklore and ethnopharmacology leads to medicinal potential. Examples are the muscle relaxants based on the arrow poison, curare, from species of *Chondrodendron*, and the anti-malerials derived from species of *Cinchona* and *Artemisia*. The methods of detection of pharmacological activity have become increasingly reliable and specific, frequently involving enzymes in bioassays and avoiding the use of laboratory animals. By using bioassay linked fractionation of crude plant juices or extracts,

compounds can be specifically targeted which, for example, inhibit blood platelet aggregation, or have anti-tumour, or anti-viral, or any other required activity. With the assistance of robotic devices, all the members of a genus may be readily screened. However, the plant material must be *fully* authenticated by a specialist.

The medicinal traditions of ancient civilisations such as those of China and India have a large armamentarium of plants in their pharmacopoeias which are used throughout South-East Asia. A similar situation exists in Africa and South America. Thus, a very high percentage of the World's population relies on medicinal and aromatic plants for their medicine. Western medicine is also responding. Already in Germany all medical practitioners have to pass an examination in phytotherapy before being allowed to practise. It is noticeable that throughout Europe and the USA, medical, pharmacy and health related schools are increasingly offering training in phytotherapy.

Multinational pharmaceutical companies have become less enamoured of the single compound magic bullet cure. The high costs of such ventures and the endless competition from "me too" compounds from rival companies often discourage the attempt. Independent phytomedicine companies have been very strong in Germany. However, by the end of 1995, eleven (almost all) had been acquired by the multinational pharmaceutical firms, acknowledging the lay public's growing demand for phytomedicines in the Western world.

The business of dietary supplements in the Western World has expanded from the health store to the pharmacy. Alternative medicine includes plant-based products. Appropriate measures to ensure the quality, safety and efficacy of these either already exist or are being answered by greater legislative control by such bodies as the Food and Drug Administration of the USA and the recently created European Agency for the Evaluation of Medicinal Products, based in London.

In the USA, the Dietary Supplement and Health Education Act of 1994 recognised the class of phytotherapeutic agents derived from medicinal and aromatic plants. Furthermore, under public pressure, the US Congress set up an Office of Alternative Medicine and this office in 1994 assisted the filing of several Investigational New Drug (IND) applications, required for clinical trials of some Chinese herbal preparations. The significance of these applications was that each Chinese preparation involved several plants and yet was handled as a *single* IND. A demonstration of the contribution to efficacy, of *each* ingredient of *each* plant, was not required. This was a major step forward towards more sensible regulations in regard to phytomedicines.

My thanks are due to the staff of Taylor & Francis who have made this series possible and especially to the volume editors and their chapter contributors for the authoritative information.

Roland Hardman, 1997

Preface

Cinnamon is one of the most popular spices used by humankind, as a glance through any cookbook will indicate. From breakfast rolls to spiced cookies, pudding and pies to quickbreads and chutneys, cinnamon finds its way into recipes for standard family fare as well as special treats. Cinnamon is the second most important spice (next to black pepper) sold in U.S. and European markets.

Cinnamon occupied a pre-eminent position in the ancient world and was much sought after. In the middle ages, the lure of spices tempted the Western powers to explore the unknown seas in search of the famed spice lands of the east. These explorations eventually led to the discovery of America and the sea route to India by Portuguese explorers. With those discoveries human history witnessed the transition from the medieval to the modern era. Imperialism and colonialism reigned the world scene in the next few centuries. It was the period when the world powers fought bitter wars for naval supremacy and for monopoly in the spice trade. In this struggle, cinnamon was the Holy Grail for foreign invaders, over which many a costly war was fought by Portugal, Holland, France and Britain.

Cinnamon and its close relative cassia are among the most popular spices. Cinnamon is often qualified as 'sensational cinnamon' and 'spice of life' because of the emotional attachment of Sri Lankan people with cinnamon; settlements, housing colonies and residential areas are often named after cinnamon.

The genus *Cinnamomum* has a centre of diversity in Western Ghats and the adjoining regions of south India. Two of the editors of this volume, P.N. Ravindran and M. Shylaja, carried out a detailed botanical study of the *Cinnamomum* species occurring in south India during the early 1980s. Subsequently, similar studies were also taken up by Baruah and his colleagues on the species occurring in north-east India, and Kostermans published a paper on the species occurring in south India. The third editor of this volume, K. Nirmal Babu, is involved in the collection, *in vitro* germplasm conservation, micropropagation and molecular characterisation of Cinnamon, Cassia and Camphor.

We took interest in this genus because of the fascinating history behind this spice and because no information was available on the species occurring in the region. Apart from our own work, we also had the occasion to be close to the research work being carried out at the Indian Institute of Spices Research, Calicut, where a good germplasm collection of cinnamon exists and that work is going on in the areas of crop management and improvement. The Senior editor also had the occasion to monitor and supervise the research work on cinnamon being carried out in various centres under the All India Coordinated Research Project on Spices. The research workers in all these centres have whole-heartedly collaborated with us during the production of this volume.

When we approached the Ceylon Institute of Scientific and Industrial Research (Currently the Industrial Technology Institute (ITI)) its Director General Dr. WOB Wijesekera readily agreed to author the various chapters on Sri Lankan Cinnamon. We record here our deep appreciation to ITI and all the Scientists who wrote the chapters included in this volume on Ceylon cinnamon. We also received the collaboration of the Research Institute for Spices and Medicinal Plants of Indonesia and of the IEBR, Vietnam, in writing chapters on Indonesian and Chinese cassia respectively.

This volume contains fifteen chapters covering all aspects of cinnamon, camphor and on various cassia types and a chapter on other useful species on which information is available. Chapters on botany and crop improvement, economics and marketing, pharmacology and toxicology and end uses are common for both cinnamon and cassia. We have made sincere efforts to collect and collate as much information as we possibly could. This is the first monograph on cinnamon and cassia and we hope that this will remain as the main reference work on these sensational spices for many years to come. We hope that this volume will be useful to students and research workers in the areas of botany, economic botany, ethnobotany, horticulture, agriculture and allied fields, as well as to exporters, processors, planters and to all those who are interested in this spice of life.

Editors

Acknowledgements

The editors express their deep gratitude to all the contributors of this monograph who found time to collaborate in its production. We are especially thankful to Dr. WOB Wijesekera, former Director General, and to Dr. U.M. Senanayake, former Principal Scientist, Ceylon Institute of Scientific and Industrial Research (currently Industrial Technology Institute) for the interest they have taken in the preparation of the chapters on Ceylon cinnamon.

The editors are grateful to Dr. Roland Hardman, General Editor of the series on Medicinal and Aromatic Plants: Industrial profiles, for his constant encouragement and timely help during the production of this volume. I am thankful to him for accepting my proposal of editing this important monograph. He helped us by providing updated literature searches and photographs on cinnamon processing. His help and guidance were immensely helpful to the senior editor during the production of the earlier volumes in the series viz. Black pepper and Cardamom. Spices workers all over the world accepted these volumes as the most authentic and comprehensive publications on these crops.

We are extremely grateful to Professor K.V. Peter, former Director of Indian Institute of Spices Research and the present Vice Chancellor, Kerala Agricultural University, Kerala, India, for providing the necessary permission and facilities for the preparation of this volume and for allowing us to dedicate this volume to him. We are thankful to many of our friends and colleagues who helped us in the preparation of this volume. Our special thanks go to Mr. A. Sudhakaran for various drawings, Mr. K. Jayarajan and Mr. K.V. Tushar for computer work, Ms. P.V. Sali, Ms. Lovely and Ms. Nisha for typing work and Mr. P.A. Sheriff for library assistance. Our colleagues Ms. Geetha S. Pillai and Ms. Minoo Divakaran, provided us with invaluable support during various stages in the preparation of this volume. We are deeply grateful to them.

In the preparation of this volume, especially the chapter on Botany and Crop Improvement, we have made use of published information from many sources and by many authors. We acknowledge with gratitude all these authors, many are not with us now, but their contributions will continue to survive through this volume in the years to come. We salute all of them with reverence and gratitude.

We have sincere appreciation to Taylor & Francis Publishers for giving us the opportunity to edit this first monograph on Cinnamon and Cassia. We thank all our well-wishers and all those who helped us in the preparation of this volume.

P.N. Ravindran
K. Nirmal Babu
M. Shylaja

1 Introduction

P.N. Ravindran and K. Nirmal Babu

Cinnamon and cassia are among the earliest known spices used by humankind. Frequent references to these spices are available in both pre-biblical and post-biblical writings. The cinnamon of commerce is the dried inner bark of the tree *Cinnamomum verum* (= syn. *C. zeylanicum*), belonging to the family Lauraceae. It is native to Sri Lanka where it is grown on a large scale, and exported (known in trade as Ceylon cinnamon or Sri Lankan cinnamon). Cassia or cassia cinnamon comes from different sources, the important ones being the Chinese cassia (*C. cassia*, syn. *C. aromaticum*), and Indonesian cassia (*C. burmannii*). Chinese cassia is indigenous to the China–Vietnam region and is an important spice traded in the international market. Indonesian cassia is a native of the Sumatera–Java region of Indonesia and is exported on a large scale to the USA. The Indian cassia comes from *C. tamala* and a few other related species (*C. impressinervium*, *C. bejolghota*), which are indigenous to the north-eastern region of India.

The term *Cinnamomum* is derived from the Greek root *kinnamon* or *kinnamomon*, meaning sweet wood. This term possibly had a Semetic origin from the Hebrew *quinamom*. The Malayan and Indonesian name *kayu manis* also means sweet wood, and an ancient version of this term possibly might have contributed to Hebrew and Greek terminology. The Dutch (*kaneel*), French (*cannelle*), Italian (*cannella*) and Spanish (*canela*) names are derived from the Latin *canella* (meaning small tube or pipe, referring to the form of cinnamon quills). The Hindi name *dalchini*, meaning Chinese wood, refers originally to the Chinese cinnamon, which was popular in northern India before the Ceylon cinnamon became known. The name cassia seems to have derived from the Greek *kasia*, which probably has its roots in Hebrew *qeshiiah*. The name for cinnamon in different languages is given in Table 1.1.

There exists some confusion regarding the use of the terms cinnamon and cassia. In continental Europe and the UK, cinnamon applies only to *C. verum* (Ceylon cinnamon) while cassia to *C. cassia*. But in the USA cinnamon applies to the bark from both sources and also from *C. burmannii*. The US Food, Drug and Cosmetic Act officially permits the term cinnamon to be used for Ceylon cinnamon, Chinese cassia and Indonesian cassia. The delicately flavoured Ceylon cinnamon is rarely used now in the USA and cassia cinnamon has conquered the market almost wholly (Rosengarten, 1969).

Early History

The early history of cinnamon and cassia is fascinating. They are among the earliest spices used. They formed the ingredients of the embalming mixture in ancient Egypt, and were among the most expensive materials in ancient Greece and Rome; only royalty could afford

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Table 1.1 Cinnamon – terminology in different languages

Amharic	*K'erefa*
Arabic	*Qurfa*, *Darasini*, *Kerfa*
Assamese	*Dalchini*
Bengali	*Dalchini*, *Daruchini*
Burmese	*Thit-ja-bo-gank*, *Hminthin*, *Timboti kyobri*
Chinese	*Jou kuei*, *Yuk gwai*
Czech	*Skorice*
Danish	*Kanel*
Dutch	*Kaneel*
English	*Ceylon cinnamon*; *Sri Lanka cinnamon*
Estonian	*Tseiloni kaneelipuu*
Fante	*Anoater dua*
Farsi	*Dar chini*
Finnish	*Kaneli*, *Ceyloninkaneli*
French	*Canelle type ceylan*, *Cannelle*
German	*Zimt*, *Echter Zimt*, *Ceylon-Zimt*, *Zimtblute* (buds)
Greek	*Kanela*, *Kinnamon*
Gujarati	*Tuj*
Hebrew	*Kinamon*, *Quinamom*
Hindi	*Darchini/Dalchini*
Hungarian	*Fahej*, *Ceyloni fahej*
Icelandic	*Kanell*
Indonesian	*Kayu manis*
Italian	*Cannella*
Japanese	*Seiron nikkei*, *Nikkei*
Kannada	*Lavangapatta*
Malay	*Kayu manis*, *Kulit manis*
Malayalam	*Patta*, *Karuapatta*, *Ilavangam*
Mandarin	*You kwei*
Marathi	*Dalchini*
Nepalese	*Newari dalchini*
Norwegian	*Kanel*
Oriya	*Dalochini*
Pashto	*Dolchini*
Persian	*Darchini*
Portuguese	*Canela*
Romanian	*Scortisoara*
Russian	*Koritsa*
Sanskrit	*Tvak*, *Tvaka*, *Twak*, *Darusita*
Singhalese	*Kurundu*
Spanish	*Canela*
Swahili	*Madalasini*
Swedish	*Kanel*
Tamil	*Illavangam*
Telugu	*Lavangamu*, *Dalchini chekka*
Thai	*Op cheuy*
Turkish	*Tarchin*
Twi	*Anoatre dua*
Cassia (*C. cassia*)	
Arabic	*Darseen*, *Kerfee*, *Salikha*
Chinese	*Kuei*, *Rou gui pi*
Duch	*Kassie*, *Bastaard kaneel*, *Valse kaneel*
English	*Chinese cassia*, *Bastard cinnamon*, *Chinese cinnamon*
Estonian	*Hiina kaneelipuu*
Finnish	*Talouskaneli*, *Kassia*

French	*Casse*, *Canefice*, *Canelle de Chine*
German	*Chinesisches Zimt*, *Kassie*
Hungarian	*Kasszia*, *Fahejkasszia*, *Kinai fahej*
Icelandic	*Kassia*
Italian	*Cassia*, *Cannella della Cina*
Japanese	*Kashia keihi*, *Bokei*
Laotian	*Sa chouang*
Norwegian	*Kassia*
Russian	*Korichnoje derevo*
Spanish	*Casia*, *Canela de la China*
Swedish	*Kassia*
Thai	*Ob choey*
Urdu	*Taj*
Tejpat (*C. tamala*)	
Arabic	*Sazaj hindi*
Bengali	*Tejpat*
Burmese	*Thitchubo*
English	*Indian cassia*, *cassia lignea*
French	*Cannelle*
German	*Zimtbaum*
Hindi	*Tejpat*, *Tajpat*, *Taj-kalam*
Japanese	*Tamara Nikkei*
Nepalese	*Tejpat*
Persian	*Sazaj hind*
Sanskrit	*Tejapatra*, *Tamalapatra*, *Patra*, *Tamalaka*
Singhalese	*Tejpatra*
Tamil	*Perialavangapallai*, *Perialavangapattai*, *Talishappattiri*
Telugu	*Talispatri*
Urdu	*Tezpat*

Source: Compiled from various sources.

Notes
Cinnamon is used as an adjective in naming some plants. Such plants have no relationship with cinnamon or the genus *Cinnamomum*, e.g.:
Cinnamon fern: *Osmunda cinnamomea* L. (Osmundaceae).
Cinnamon rose: *Rosa majalis* Herrm. (Rosaceae).
Cinnamon vine: *Dioscoria batatas* Decne. (Dioscoriaceae).
Cinnamon wattle: *Acacia leprosa* Sieber ex DC (Mimosaceae).
Cinnamodendron Endl. Agenus in Canellaceae.
C. corticosum Miers (wl)-bark of this tree is used as a spice and a tonic.
Cinnamosma Baillon (Canellaceae). Indigenous to Madagascar. *C. fragrans* Baillon has highly scented wood, produces scented fumes on burning. Used in religious ceremonies.

them. History tells us that the Egyptian Queen Hatshepsut (around 1500 BC), sent out an expedition of five ships to bring spices and aromatics from the land of "Punt" (which was believed to have been the land on either side of the lower Red Sea and Gulf of Eden). These ships returned loaded with "fragrant woods of god's land, heaps of myrrh-resin of fresh myrrh trees, cinnamon wood, with incense, eye-cosmetic" (Parry, 1969). Rosengarten (1969) writes that the origin of cinnamon which Hatshepsut collected is uncertain as cinnamon trees are not indigenous to the land of "Punt". According to the historian Miller (1969), there are indications that as early as the second millennium BC, cassia and cinnamon from China and South-East Asia might have been brought from Indonesia to Madagascar in primitive canoes, along a "cinnamon route" which might have

existed at that time. These aromatic barks were then transported northward along the East African coast to the Nile Valley and from there to the land of "Punt".

References to cinnamon and cassia exist in the Old Testament of the Bible. In Exodus, the Lord spoke to Moses on the top of Mount Sinai and gave instructions that the children of Israel should build a tabernacle, so that he might dwell among them; and further instructed for the preparation of an anointing oil for the tabernacle containing cinnamon and cassia with other things:

> The Lord spake unto Moses. Take thou also unto thee principal spices, of pure myrrah five hundred shekels, and of sweet cinnamon half so much . . . and of cassia five hundred shekels . . . . . And thou shalt make of it an oil of holy anointment. And thou shalt anoint the tabernacle of the congregation therewith and the ark of testimony
>
> (Exodus 30:23–26).

This is the first biblical reference to cinnamon and cassia (Parry, 1969). The building of the tabernacle is believed to have taken place around 1490 BC, and the biblical reference indicates that these spices were well known and held in very high esteem at that time. Again later in Psalm 45 (Verse 8) cassia is mentioned as perfume: "All thy garments smell of myrrh, and aloes and cassia, out of the ivory palaces, whereby thy hand made thee glad". Cinnamon is mentioned in the beautiful passages of the Song of Solomon, where there are many references about spices:

> . . . . thy plants are an orchard of pomegranates, with pleasant fruits, camphire, with spikenard and saffron, calamus and cinnamon, with all trees of frankincense, myrrh and aloes, with all the chief spices
>
> (Chapter 4:13:14).

We also find in the Revelations that St. John the Divine foretells the fall of the great city of Babylon and the distress that ensues:

> . . . . . and the merchants of the earth shall weep and mourn over her, ... and cinnamon, and odours, and odours and ointments . . . . thou shalt find them no more at all . . . . .
>
> (Revelation 18:13).

It is thus amply clear that cinnamon and cassia were held in high esteem in those ancient days. At one time it was more valuable than gold (Farrell, 1985). They were among the most valuable medicinal plants for ancient Greeks and Romans. Dioscorides records:

> Cinnamon provoked urine, it cleared the eyes and made the breath sweet. An extract of cinnamon would bring down the menses and would counteract the stings and bites of venomous beasts, reduce the inflammation of the intestines and kidneys, comfort the stomach, break wind, would aid in digestion and when mixed with honey would remove spots from the face that was anointed there with
>
> (Farrell, 1985).

Parry (1969) was of opinion that the founders of the spice trade between India and the rest of the world were either the Phoenicians or the Arabs. The Phoenicians

were accomplished sailors, and they might have been responsible for transporting cinnamon from the east to the west. They were expert traders of all commodities, including spices. There are references of cassia and cinnamon in Ezekiel (Chapter 27), where there are high praises about the richness of Tyre, the capital of Phoenicians under the emperor Hiram, and also references about Arabian merchants carrying spices. The Phoenicians were probably the first to carry cinnamon and cassia to Greece, and along with the spice, its name "cinnamon" also passed on to the Greeks.

It is not always possible to correctly identify the plants mentioned in ancient writings. The reference about the aromatic wood collected by Hatsheput's expedition casts a shadow of doubt as to its identity. Most probably it was not the present cinnamon at all. The wood of cinnamon has not much fragrance, and on burning cinnamon wood does not give fragrant smoke, only its bark has the spicy taste and smell. Again there were references about Nero burning cinnamon in the funeral pyre of his wife, why? Was it not for the fragrance it was giving out? Then can it be some other wood, having fragrance that produces fragrant smoke on burning? If so, a possible case is the small tree species, *Cinnamosma fragrans* (Canellaceae) occurring in the eastern coastal African forests as well as in Madagascar. The wood of this tree is fragrant and produces fragrant smoke on burning. It was easier for the Egyptians or to the enterprising people of "Punt" to travel along the coast line of Africa to the eastern coastal forests and collect the fragrant wood of C*innamosma* rather than travelling to Ceylon or the Far East. The name probably came to be applied to cinnamon at a later time.

In ancient times, the south Arabian region was occupied by a nomadic race, the Sabians, whose vocation was sailing and sea trading. Their main merchandise was spices. It was possibly from these people the ancient Egyptians collected their requirement of spices. Probably it was the same people who carried spices from Gilead to Egypt, and it was possibly from Arabia that the Egyptian Queen Hatshepsut collected cinnamon and cassia over 3500 years ago (the land of "Punt"). The south Arabians held a virtual monopoly on the spice trade for a very long time. Historical evidence is quite insufficient to come to a conclusion on the relative roles played by the Arabians and Phoenicians in the ancient spice trade.

The central position occupied by Arabia also gave way to the belief that cassia and cinnamon were produced in that country. Herodotus and Theophrastus recorded the magical stories perpetuated by the Arabians about the source of cinnamon and cassia. Theophrastus describes south-west Arabia as the land of myrrh, frankincense and cinnamon. The aromatics are in such abundance there, says Strabo, that the people use cinnamon and cassia instead of sticks as firewood (Parry, 1969). The Sabean traders fabricated all sorts of stories about cinnamon and cassia, and they were successful for a long time in shrouding the source of cinnamon in mystery. One such story goes like this:

> Far away, in a distant land, said Arab traders to spice buyers from Europe, there is a great lake. It is surrounded by deep and fragrant woods and high cliffs. On those cliffs nests a great dragon-like bird with a scimitar-sharp beak and talons like Saladin's sword. The nest of this bird is made of only one material; the bark of a rare tree. And when it has made its nest, it does not lay eggs in it. Oh no. It does not need to. It flaps its wings so fast that the bark catches fire and then

> the bird sits in the middle of its blazing pyre. And then, lo and behold, it emerges from the flames refreshed, renewed, rejuvenated. The name of the bird is Phoenix. And the name of the bark? Ah! It is cinnamon. And that is why, that is exactly why, cinnamon is so expensive.

Thus, the astute Arabs, not only enhanced the value of cinnamon but they also concealed its origin for many centuries. This is perhaps one of the best kept trade secrets of all time. It was only when the Europeans started sailing around the world, in search of pepper, that they discovered cinnamon and its cousin cassia and that they grew fairly easily in South, South-East and East Asia (Gantzer and Gantzer, 1995).

The Arab domination of the spice trade was broken by the rise of the Roman empire. Around AD 40, Mariner Hippalus discovered the trade wind systems in the Indian Ocean, hitherto known only to the Arabs. It is believed that he had travelled to India and back around AD 40, thereby opening up the direct trade route between Rome and the West Coast of India. As a result, by the end of the first century AD, the use of spices in Rome had grown miraculously. Cinnamon, cassia and cardamom occupied the pride of place among the spices. The extravagance is clear from references to the huge supplies of the aromatic spices that were strewn along the path behind the funeral urn bearing the ashes of Commander Germanicus. Emperor Nero is said to have burned a year's supply of Rome's cinnamon at his wife's funeral pyre (AD 66). It was also customary for men to be heavily perfumed and even "the legionaries reeked of the fragrances of the east" (Rosengarten, 1969). Even lamp oil was mixed with aromatics to keep harmful vapours away.

By the end of the third century AD, the Arabians had established trade relationships with China, mainly for trading in cassia. This aided them to trade not only in cassia, but also in spices that came from the far eastern countries (East Indies). In AD 330, the Roman emperor Constantine founded the city of Constantinople on the site of the ancient Byzantium, which became the capital of the Byzantine Empire. During this period cassia from China, nutmeg and cloves from Moluccas, cinnamon from Ceylon, pepper and cardamom from the Malabar coast of India reached the new city in large quantities. Ceylon and the Malabar Coast were the transshipment spots in this spice trade.

The course of history never runs smoothly for long. Alaric the Gothic invaded and captured Rome in AD 410. The hegemony and splendour of Rome and her supremacy over trade all came to an abrupt end. Once again the Arabs came in and soon became the masters of the spice trade. This supremacy continued till the fifteenth century, when the sea route to India was discovered and Vasco-da-Gama landed in the West Coast of India on 20 May 1498.

During the middle ages (between the fifth and fifteenth centuries) spices started reaching Western Europe and were among the choicest gifts to royalty and the privileged, especially to the monasteries and ecclesiastical establishments (Parry, 1969). The travelogues of Marco Polo, the most renowned traveller of the middle ages, give the most authentic information on the spice trade in the middle ages. He writes about the cassia cultivation in China, cloves of Nicobar, pepper, ginger, cardamom and cinnamon of the Malabar Coast and many seed spices, such as sesame.

The earliest recorded reference to cinnamon bark as a product of Ceylon dates back to the thirteenth century (Redgrove, 1933). Redgrove writes:

> It seems quite probable that the Chinese, who traded with Ceylon were concerned in the discovery of the valuable qualities of the bark of Sinhalese tree, similar but superior, to the cassia of their own country . . . . . At any rate when the Sinhalese product was imported into Europe, its superior character was soon recognised and the product fetched very high prices (1933).

By the thirteenth century, the East Indies became a busy trading centre in spices. Java was the main centre for trading in nutmeg, mace and cloves that came from the Moluccas Islands. From Java the Arabian ships carried these spices to the west. In fact, "the East Indies gradually eclipsed the Malabar Coast of India as the most important source of costly spices, and both places attracted the princes and merchants of Western Europe to bring in the fifteenth and sixteenth centuries, the greatest and brightest age of discovery the world has ever seen" (Parry, 1969).

China emerged as a major trader of spices during this period, trading in cassia and ginger and procuring large quantities of pepper and other spices from the Malabar Coast and the East Indies. At this time cassia and cassia buds became popular spices in Europe and England. Of course, spices were beyond the reach of common folk, as they were so costly, mainly because no direct trade links existed between Europe and the eastern spice-producing countries. The Arabs monopolised the trade in the east, and Venice controlled the trade in the Mediterranean.

Spices like pepper, cardamon, cinnamon and cassia contributed greatly to European cooking. Parry (1969) writes:

> The coming of the highly aromatic and pungent spices of the orient was the greatest boon to the European food and cooking of all times. New methods of preserving food quickly came into existence; dishes took on a fullness of flavour previously unknown; beverages glowed with a redolent tang, and life experienced a new sense of warmth and satisfaction.

Spices were also used as medicines by the people of ancient and middle ages. Warren R Dawson made a collection of medical recipes of the fifteenth century, wherein some 26 spices were indicated for various ailments. Cinnamon and cassia were components of medicines recommended for coughs, chest pain, headache, digestion and gas problems. In Chinese traditional medicine, cassia bark (cortex cinnamomi – *Rou gui*) and dried twig (ramulus cinnamomi – *Guo shi*) are two separate drugs used differently.

Modern History

The modern chapter in the saga of spices begins with the discovery of the sea route to India and the landing of Vasco-da-Gama on the Malabar coast (near the present day Calicut in Kerala state) of India on 20 May 1498. This indeed was the beginning of the history of modern India too. The West European countries were compelled to establish a sea route to the eastern spice lands following the conquest of the Roman Empire and the closure of Constantinople for trade by the Ottoman Turks in 1453. The quest for spices opened up the era of great expeditions; Columbus discovered America and Vasco-da-Gama sailed eastwards round the Cape of Good Hope and arrived in India. In the decades that followed the Portuguese gradually established their hold on spice trading.

By the beginning of the sixteenth century, the Portuguese started direct trading in spices with the Malabar Coast, and with this the Arab supremacy over the spice trade came to an end. The Portuguese soon established a monopoly in the spice trade, not only with India but also with Ceylon and later with the spice islands of the Far East. It was during the time of Portuguese domination that the cinnamon trade began to attain considerable stature. In 1506, the Portuguese forced the Sinhala kings to undertake the supply of about 11,000 kg of cinnamon bark annually. In the process of fulfilling this undertaking the cinnamon forests came to be ruthlessly exploited. By the end of the century the Portuguese had secured for themselves a monopoly on the world's cinnamon trade (Wigesekera *et al*., 1975). This Portuguese monopoly led to a growing price rise of pepper and cinnamon, causing a wave of resentment in Western Europe. Soon the other West European countries wanted to break this monopoly and many expeditions were sent out to establish a route to the Malabar Coast and the spice islands of the East Indies. Cinnamon was the Holy Grail of foreign invaders to the island of Ceylon.

Soon the Dutch navigator Cornelius Van Hortman reached the East Indies (1596) and established trade relations with some of the islands in spite of the stiff resistance from the Portuguese. Many more expeditions followed and the Dutch gradually established their supremacy in the East Indies, virtually expelling the Portuguese from the scene. The Dutch gradually conquered all important spice-producing islands, and they became the masters of the spice trade. The Dutch captured the Portuguese establishments in Ceylon in 1658, and secured control of the island and its rich cinnamon trade. In 1663 the Dutch also conquered Cochin and Cannanore of the Malabar Coast. They commenced large scale monopolistic cultivation of cinnamon in Ceylon, until which their cinnamon had been growing in patches of forests in the south-western coast of the island. The bark was obtained by the government in the form of tributes. In 1767 the Dutch Governor Falk introduced a planned system of cinnamon cultivation by allocation and distribution of land and by the enactment of legislation to ensure cultivation. The entire stock produced and purchased by them was not, however, exported. Only a sufficient quality to meet the demand was permitted to be exported. Large quantities of cinnamon were frequently destroyed, the idea being to limit exports in order to maintain high prices (Wijesekera *et al*., 1975).

The seventeenth century saw the rise of British naval supremacy. Yet another chapter in the saga of cinnamon starts with the British occupation of Ceylon in 1796, and the monopoly of cinnamon trade changed hands once more. The prohibitive export duty, which had been prevailing was reduced and finally in 1843 it was abolished. This resulted in large shipments of cinnamon being moved out of the island to serve the European markets. The mean annual exports rose from 200,000 kg to 375,000 kg within the next few years (Wijesekera *et al*., 1975). Large scale plantations of cinnamon were established in Ceylon, and by 1850 about 40,000 acres of cinnamon were under cultivation (Rosengarten, 1969). Cinnamon was introduced into many islands in the tropics by British and Dutch colonists. Cinnamon from Ceylon was introduced into India in 1798 by Mr. Murdock Brown, who was then Superintendent of the East India Company in Anjarakandy (in the present Kannur District of Kerala). He established a cinnamon plantation in the Anjarakandy Estate, which still exists. The cultivation of cinnamon spread to other regions, especially in the islands of Seychelles, Madagascar and the West Indies, but Ceylon continued to be the major producer. In 1867 quills and chips were introduced as export products, and as a result the export from Ceylon

rose to 450,000 kg. Soon afterward the cheaper substitute, cassia cinnamon, was introduced into the European markets (Wijesekara *et al*., 1975).

The traditionally known cinnamon was the peeled cinnamon bark that was rolled into the form of 'quills' in order to facilitate storage and transportation. Cinnamon oil was not a commodity of commerce in those days, although oil distillation was known and cinnamon oil was used in cosmetics and pharmaceutical preparations. The first references to cinnamon oil are seen in the price ordinance in Berlin in 1574 and in Frankfurt in 1582 (Wijesekera *et al*., 1975). It is believed, however, that the cinnamon oil distillation in Sri Lanka would have probably commenced during the Dutch regime.

The global production and trade in spices were affected drastically by the world wars. The Japanese occupation of the Dutch East Indies led to the devastation and decline of the spice production of the region and in the war-torn western countries imports declined sharply. The end of the Second World War witnessed the decline of colonialism and the spread of independence in the colonial countries. The old scenario changed rapidly. The spice producing eastern countries gained independence and spices became one of their major export earnings.

Cinnamon is associated with the lives of people of Sri Lanka, emotionally, socially and economically. For them it is the spice of life (Ratwatte, 1991). Sri Lanka's cinnamon groves are located in the western and south-western regions of the island. The tropical sunshine and abundant rain in these areas provide the ideal habitat for the growth of cinnamon. The sweetest, most prized variety grows in the 'Silver Sand' coastal belt of the Colombo District, just north of Colombo (Ratwatte, 1991).

Research and Development Efforts in Cinnamon and Cassia

Though cinnamon and cassia have played important roles in human cuisine from ancient times, efforts on research and development of these tree spices have not received the required attention. Some R&D efforts on cinnamon were initiated in Sri Lanka during the post-independence period by the Ceylon Institute of Scientific and Industrial Research and by the Department of Export Agriculture. These R&D efforts were mainly concentrated on chemistry, quality assessment, on developing agro-technology for cultivation and post-harvest processing. Certain elite lines (varieties) have been identified through selection. Refinement of the conventional practices were attempted and a package of practices has been brought out (Anon., 2000; Wijeskera *et al*., 1975).

The only other country that has carried out some R&D efforts is India, where research on tree spices was initiated a couple of decades ago with the establishment of a Research Station at Calicut (Kozhikode) under the Central Plantation Crops Research Institute (Kasaragod, Kerala). This Research Station, established in 1975 (presently the Indian Institute of Spices Research-IISR), has initiated the collection and evaluation of germplasm. Cinnamon germplasm, both indigenous and introduced, were screened for quality and evaluated in the field. Subsequently two elite lines (*Navasree* and *Nithyasree*) were released (Krishnamoorthy *et al*., 1996). Similar clonal selections were also carried out by Konkan Krishi Vidyapeeth in Dapoli (Maharashtra), Tamil Nadu Agricultural University (Horticultural Station, Yercaud), and at the Regional Research Laboratory, Bhubaneswar. So far five elite lines have been developed. The IISR has also established a germplasm collection of Chinese cassia and from this a few high quality lines have been identified. Little crop improvement work has gone into the Chinese and Indonesian cassias.

The Present Scenario

Cinnamon is grown mainly in Sri Lanka, whilst minor producing countries include Seychelles, Madagascar and India. It occurs naturally in Sri Lanka and southern India, and also in the Tenasserim Hills of Myanmar (De Guzman and Siemonsma, 1999). Sri Lanka produces the largest and the best quality of cinnamon bark, mainly as quills. The area under cultivation is estimated to be around 24,000 ha in Sri Lanka and 3400 ha in the Seychelles producing respectively around 12,000 and 600 t (Coppen, 1995). 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.

As already mentioned cassia or cassia cinnamon is derived from different sources, such as:

Chinese cassia – *Cinnamomum cassia*
Indonesian cassia – *C. burmannii*
Indian cassia – *C. tamala*
Vietnam cassia – *C. cassia*/*C. loureirii*

In addition to cinnamon and cassia the genus also contains the camphor tree (*C. camphora*) which yields camphor and camphor oil. *C. cassia* or Chinese cassia occurs mainly in south China, Vietnam and also in Laos and Myanmar (Burma), and is grown commercially in China and Vietnam. In China the main production areas are in the Kwangsi and Kwangtung provinces in south China, the area being around 35,000 ha with a production of around 28,000 t of cassia bark annually. The UAE is the major buyer of cassia bark and cassia leaf oil. Cinnamaldehyde is the major component of bark and leaf oil. *C. burmannii* is the Indonesian cassia, sometimes called Padang cassia (Padang in west Sumatera) or Korintgi cassia (produced in the Kortingi mountain area of Indonesia). This is harvested from an area of about 60,000 ha, and the production is around 40,000 t. This is an important export product from Indonesia, mainly to the USA. The main component of the oil of bark and leaf is cinnamaldehyde.

Vietnam cassia or the Saigon cassia is also *C. cassia* and is cultivated in an area around 6,100 ha and the production is around 3,400 t which is exported mainly to the USA. The essential oil consists mainly of cinnamaldehyde. However, some doubts still exist regarding the correct botanical identity of Vietnam cassia. All the earlier literature identified Vietnam cassia with *C. loureirii* Nees. But this was reported to be a very rare species, and hence cannot be the source of Vietnam cassia. Recent reports (Dao, this volume) show that Vietnam cassia is nothing but *C. cassia*. The differences in the commercial samples of Vietnam and Chinese cassia are mainly due to the difference in harvesting and post-harvest treatment of the bark.

C. tamala, the Indian cassia, is distributed in the forests of north-eastern India and Myanmar (Burma). In the north-eastern region of India this is grown for the leaves that are extensively used in flavouring various dishes. The leaves are collected from forest grown trees as well as from cultivated ones. *C. tamala* is inferior to other cassias because of the lower oil content in the bark and leaves. The major component of oil is cinnamadehyde (in bark) and eugenol (in leaf). In addition there are other species of *Cinnamomum* in South and South-East Asian countries that are used as substitutes for cinnamon and cassia.

Sri Lanka has been the traditional producer and exporter of cinnamon and its value added products such as bark oil and leaf oil. Cinnamon bark oil is a very high value oil and Sri Lanka is the only supplier of this commodity with an annual production of only around 2.8 to 3 t. Western Europe is the major importer (especially France), followed by the USA in recent times.

The world demand for cinnamon leaf oil is around 150 t per annum, a demand met mainly by Sri Lanka. The USA and western Europe are the largest consumers of leaf oil. The eugenol-rich cheaper clove leaf oil poses severe competition for cinnamon leaf oil. The oil is useful for eventual conversion to iso-eugenol, another valuable flavouring agent.

Sri Lanka holds a virtual monopoly over the production of cinnamon bark and leaf oil. Small quantities are distilled in Madagascar, Seychelles and India to meet internal demands. Though a very costly oil, there is no international standard for cinnamon bark oil; the higher the cinnamaldehyde content, the higher the price. In USA the Essential Oil Association (EOA) standard specifies an aldehyde content of 55–78% (EOA, 1975). But in the case of leaf oil, international standards exist. In this case a phenol content of 75–85% has been specified for oil of Sri Lankan origin (ISO, 1977). In fact leaf oil from Seychelles has a higher eugenol content (about 90%). Cinnamaldehyde is another constituent of leaf essential oil contributing to the total flavour and the specification limits its content to 5%. In the USA the FMA (Fragrance Materials Association) specifies the eugenol content in cinnamon leaf oil in terms of its solubility in KOH (80–88%) (FMA, 1992).

Cassia oil is distilled from a mixture of leaves, twigs and fragments of bark and there is only one type of cassia oil, as mentioned earlier. Cassia oil is used mainly for flavouring soft drinks, confectionary and liquors and its use in perfumery is limited because of its skin sensitising properties (Coppen, 1995). The world trade in cassia oil is controlled by export from China and information on production is scarce. Imports into the USA are rising mainly due to the boom in the soft drinks industry. Cassia oil has specific ISO standards (ISO, 1974). The cassia oil imported into Japan is also re-exported to the USA. The total annual production of cassia oil is estimated to be more than 500 t (Coppen, 1995). The oils distilled in Indonesia (from *C. burmannii*) and Vietnam (*C. cassia*) are also being marketed as cassia oil, but they are less valued and are much less widely traded. Indonesian cassia has a good market in the USA.

Apart from cinnamon and cassia, there are other *Cinnamomum* species that could be exploited commercially. The potential of such species requires study because it is known that some species produce oil of differing compositions due to the existence of different chemotypes (Coppen, 1995). Such variations are well known in the case of camphor tree, where trees yielding camphor, linalool, safrole or cineole as the major constituent are available (Wang-Yang *et al*., 1989). The genus holds a lot of promise in the future search for aroma chemicals. *C. tamala* leaf, for example, is widely used all over north India for flavouring a variety of vegetable, meat and fish preparations. There are populations of *C. tamala* producing predominantly cinnamaldehyde or eugenol. Recently two other species (*C. pauciflorum* and *C. impressinervium*) have been reported to possess high oil content and quality (Nath and Baruah, 1994; Nath *et al*., 1996). From Malaysia, *C. molissimum* has been reported to contain safrole and benzyl benzoate as major constituents (Jantan and Goh, 1990). *C. rigidissimum* and *C. petrophyllum* are the other species having high safrole (Lu *et al*., 1986). *C. petrophyllum* (syn. *C. pauciflorum*), growing in China in the Sichuan province, is now being commercially exploited for safrole production.

Until recently, attention has not been given to quality improvement through breeding, although some elite lines have been identified in Sri Lanka and India, and some varieties have been evolved. In addition to screening for quality, crossing involving distinct populations and interspecific hybridization involving *C. verum* and *C. cassia* have been contemplated by IISR, Calicut, India.

Conclusion

Spices like pepper and cinnamon tempted explorers such as Vasco-da-Gama to sail round the storm tossed Cape of Good Hope in search of a new spice route to the spice lands of the east when the Ottoman Turks closed Constantinople to trade in 1453. It was indeed the same quest that made Columbus sail westwards to the unknown seas, when he discovered America. Cinnamon was the "rich bride Helen" for whom the Netherlands and Portuguese had for so many years contended (Ratwatte, 1991). It was precious enough to these colonial powers to wage bitter and frequent wars and to sacrifice many human lives.

Cinnamon/cassia continue to enchant us thorough its varied uses in a variety of food; it is the classic flavour for apple pie, Madeira cake, doughnuts, and for a host of cookies and pastries. It is the mainstay of sweet pudding spice and cinnamon cakes, which are essential items in Christmas celebrations. Cinnamon is a savoury spice too, and in Sri Lanka it is always added to vegetables, fish and meat curries, fancy rice dishes and sweet meats. In Mexico, cinnamon tea is a popular beverage. Cinnamon leaf and bark oils are essential ingredients in a variety of soft drinks. The tallow from cinnamon fruits makes the sweet scented candles used in Greek Orthodox churches.

In the Vietnamese language of flowers, cinnamon is translated as meaning "my fortune is yours". In Austria, lovers would exchange a posy containing cinnamon as a symbol of affection and love (Morris and Mackley, 1999).

Spices like cinnamon, cassia and pepper have influenced the course of human history. Parry (1969) writes:

> It is difficult for us who buy our supplies of pepper, cassia, cinnamon, cloves, ginger, mace and nutmeg, so casually and so cheaply, to believe that there was ever a time when these spices were so eagerly sought after and represented so much wealth and power that destiny itself was indivisible from them.

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2 Botany and Crop Improvement of Cinnamon and Cassia

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Genus *Cinnamomum*

The genus *Cinnamomum* Schaeffer, comprises evergreen trees and shrubs, found from the Asiatic mainland to Formosa, the Pacific Islands, Australia and in tropical America. The American species have only recently been recognised (formerly they were included mostly in *Phoebe*, an entirely Asiatic genus). There are 341 reported binomials in the genus, which according to Kostermans (1957) could be reduced considerably in a revision. According to Willis (1973) the genus comprises of 250 species. In a later publication Kostermans (1964) lists 452 binomials including synonyms under the genus.

Cinnamomum was earlier thought to be a purely Asiatic genus occurring only in the eastern hemisphere, specifically in the Asia-Pacific region. Later taxonomists, especially Kostermans (1957, 1961), transferred species from neotropical genera such as *Phoebe* to *Cinnamomum*. Flowers of *Phoebe* do not show any differential characters and are very similar to those of *Cinnamomum*. In fact even the earlier taxonomists (Nees, *Syst. Laur*. 1836) recognised the closeness between new world *Phoebe* and Asiatic *Cinnamomum*. Meissner (in DC Prodr. 15(1) 1864) went a step further and coined the subgenus *Persoideae* for the Asiatic and subgenus *Cinnamoideae* for the American species of *Phoebe*. Kostermans (1961) felt that the closely knit genera of Lauraceae could only be separated on minor characters, which can result in good natural groups. He was of the opinion that the nature of the perianth tube as found in the fruit represented a very natural and useful character for classification. A swollen, shallow fruit cup combined with a swollen pedicel with remnants of tepals (partly or entire) is a common feature in Asiatic *Cinnamomum*. Thus from a purely Asiatic genus (as thought earlier), *Cinnamomum* now occupies a pantropical status, occurring in both hemispheres, consisting of both Asiatic and new world species.

In *Cinnamomum*, the basal part of the tepals with the tube persists under the fruit. Here the abscission line goes half way through the tepals and results in a cup crowned with six truncate lobes. In a later publication Kostermans (1980) has given the main identifying characters of *Cinnamomum* species as: (i) the length of the two basal or subbasal ascendant veins; (ii) the indumentum (covering of hairs); and (iii) the thalamus cup under the fruit. The number of anther cells of the third whorl of stamens was also considered to be a useful character.

The true cinnamon or Sri Lankan cinnamon (C. verum *Berchthold & Presl.*)

Berchthold & Presl., Priroz. Rostlin 2:36 at 37–44, t. 7, 1825; Sweet, Hort. Britt. 344, 1827; Loujon, Hort. Britt. 160, 1830; Arbor. & Fructic. Britt. 3: 1305, 1838;

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Heynold, Nom. Bot. Hort. 197, 1840; Steudel, Nom., ed. 2, 1:366, 1840; Buchanin, Trans. Hort. Soc. Ser. 2.2: 168, 1842; Baillon, Hist. Pl. 2:462, 1872; Hager's Handb. Pharm. Praxix 1: 1019, 1849; Eichler, Blutendiagar. 2: 131, 1854; Kostermans, Bibl. Lau. 360, 1964.

Syn: *C. zeylanicum*, Breyne; Nat. Curdec. 1, ann. 4: 139, 1666: *C. zeylanicum* (Garc.) Bl. Blume, Bijdrm F1. Ned. Ind., 568, 1826; Th. Nees, Pl.of.t.128, 1828; Wallich, Cat. No.2573, 1830; Th. Nees & Ebermayer, Med. Pharm. Bot. 2:420 et 427, 1831 (*zeylonicum*); C.G. Nees in Wallich, Pl. As. rar. 2: 74, 1831; 3:32, 1832; in Flora 15(2): 580, 1831; Progr. Grat. Laur. Expos. 9, 1833; Syst. Laur 45, 95, 664, 1836; in Linnaea 21: 487, 1848 (*Ceylanicum*); Miquel, Leerb. Artsenijgew. 228–230, 1839; Fl. Ind. bat. 1(1):898, 900, 1858; Graham, Cat. Pl. Bombay, 173, 1839; Wight, Icon 1: t. 123, 129, 134, text No.VII (*ceylanicum*) 1839; Presl., Wseobecny Rostalinopsis z: 1301, 1846; Bentham in Hooker, Niger F1. 498, 1849; Thwaites, Enum. Pl. Zeyl.252, 1861; Meissner, in DC., Prodr. 15(1): 13, 20, 31, 1864; Birdwood, Cat. Veg. Prod. Bombay, ed. 2: 72, 1865; Balfour, Timber trees of India and S.E. Asia, ed. 3:75, 1870; Beddome, F1. Sylv. Ind. T. 262, 1872; Stewart and Brandis, For. F1. N.W. India, 375, 1874; Kurz, For. Fl. Br Burma, 2:287, 1877; Hooker, F1. Br. India, 5:131, 1886; Talbot, Cat. Trees & Shrubs, Bombary, 167, 1894; Dalgado, F1. Goa, 161, 1898; Gamble, Man. Indian timb. 305, 1881; F1. Madras Pr. 1224, 1925; Ridley, Flora Malay. Pen 3: 97, 1924; Rao, Flow. Pl. Travancore, 341, 1914; Fischer in Rec. bot. Sur.Ind. 9: 153, 1921; 12(2): 128, 1938; Kostermans in Meded. Bot. Mus. Uterecht. 25:50, 59, 1936; in Notul. Syst. 8:120, 1939; in Humbert, F1. Mad. Fam. 81:86, 1950; Commun. For. Res. Inst., Bogor, 57:8, 21, 24, 41, 58, 1957; in Reinwardtia 4:200, 213, 216, 233, 250, 1957; Bib. Lau., 364, 1964.

Nomenclatural notes

In 1825 Berchthold & Presl (*Priroz. Rostlin* 2:36–44, 1825) coined the binomial *C. verum*. Blume, almost immediately after this, described the same plant using the binomial *C. zeylanicum* (Blume, in *Rumphia* 1:1826). *C. zeylanicum* Blume was accepted by many later workers (Wallich, Cat.No.2573, 1830; Nees and Ebermeyer, *Med. pharm. Bot*. 2: 1831; Nees, *Systema Laurinarum*, 1836 etc.). Linnaeus (Sp.pl.I, 369, 1753) earlier described the material as *Laurus cinnamomum*, which according to Kostermans (1980) might have derived from *Laurus malabatrum*, given for 'Katou karua' of Rheede (Burman, *Thesaurus Zeylanicus*, 64, 1739). Kostermans was also of the opinion that what Burman described under *C. perpetuoflorens* was nothing but *C. verum*, and the one described by Nees von Esenbeck (*Syst. Laurinarum*, 1836) as *L. malabatrum* was also *C. verum*.

Even earlier to this, Breyne (*Nat. Curdee*. 1, 1666) described the plant and *C. zeylanicum*. Breyne was accepted by many earlier workers (Miquel, Fl. Ind.Bat.1(1): 898, 900, 1858; Meissner, in DC. Prodr. 15(1): 13, 20, 31, 1864; Hooker, 1885; Bourdillon, 1908; Rao, 1914 etc.). But Breyne's name was not valid as it was prior to the publication of *Genera Plantarum*. The first author to use the binomial *C. zeylanicum* after 1753 was Blume. But Berchthold & Presl's publication of the binomial *C. verum* precedes and hence the valid name for ceylon cinnamon or true cinnamon is *Cinnamomum verum* Bercht. & Presl. *C. cassia, C. camphora* and *C. malabatrum* are the three other species which Berchthold & Presl. described in their publication (1825).

Taxonomical description

C. verum is a native of Sri Lanka and south India. It is a moderately sized, bushy, evergreen tree. The dried inner bark of semi-hardwood shoot is the true cinnamon of commerce. Under cultivation, the shoots are coppiced regularly almost at ground level, which results in the formation of dense bushes. The following taxonomical description is adapted from Kostermans (1983, 1995):

> Moderately sized tree, up to 16 m tall, up to 60 cm diameter at breast height. Buttresses up to 60 cm high, out 70 cm, thin. Bark smooth, light pinkish brown, thin; live bark brown, up to 10 mm thick with a strong pleasant cinnamon smell and a spicy, burning taste. Branchlets slender, often compressed, glabrous; end bud partly finely silky; flush almost glabrous, bright or light red. Leaves opposite or sub opposite, glabrous, thinly to stiffly coriaceous, oval or elliptic to lanceolate-oval or narrowly elliptic, $3 \times 7-8 \times 25$ cm (1.5×5 cm in the inflorescence), shortly or broadly acuminate, base acutish or cuneate, triplinerved (or with very slender, additional basal nerves: 5-nerved); upper surface dark green, shining, smooth; lower surface paler, dull, the 3 main nerves prominant on both surfaces; the basal or sub-basal ones running out near the base of the acumen; secondary nerves faint, bent in the middle, more or less parallel. Petiole rather stout, 10–20 mm, slightly concave above. Inflorescence is paniculate cymose, the initial branching of the inflorescence paniculate, with alternate or opposite branches, while the flowers are arranged in cymes (Type two of Van der Werff and Richter 1996). Panicles axillary, up to 20 cm long (or longer or shorter), consisting of a long main peduncle and a few, stiff short branches. Flowers pale yellowish green; perianth ca. 8 mm, silky; tube short, campanulate, tepals oblong-lanceolate, acutish or obtuse, up to 3 mm long, persistent. Fruit ellipsoid to oblong-ovoid, dark purple, up to 12.5 mm long; cup hemispheric, ribbed, topped by the indurate, enlarged tepals (Fig. 2.1 and Fig. 2.2).

The flowering time varies from October to February, and the fruit ripens in May to June. Trees start putting forth flushes in the monsoon period, around July to September. They look very attractive during the flushing period, dressed in purple flushes. In a population, the flush colour varies from green to deep purple. The flowers when open have a pleasant smell, and are visited by a number of insects, especially bees. Flowers exhibit protogynous dichogamy, the male and female phases are separated by almost a day.

The Chinese cassia (*C. cassia *(L.) Berchthold & Presl.)

Berchthold & Presl., Priroz. Rostlin 2: 36 et 44–45, 5, 6, 1825; Blume, Bijdr. Fl. Ned. Ind., 11 stuk 570, 1826; Sweet, Hort. Brit. 344, 1827; Th. Nees, Pl. Off. 1: 5. 129, 1829; London, Hort. Brit. 160, 1830; Nees & Ebermayer, Handb. Med. pharm. Bot. 2:424, 427, 1831; CG Nees in Wallich, P1. As. Rar. 2: 73 et 74, 1831; Syst. Laur. 42 et 52, 1836; Lindley, F1. Med. 330, 1838; Miquel, F1. Ind. Bat. 1(1): 896, 1858: Meissner, in Dc., Prodr. 15(1): 12, 18, 466, 1864; Balfour, Timb. Trees & For. India & SE Asia ed. 3. 74, 1870; Kurx. For Fl. Brit. Burma 2: 288, 1877; Gamble, Man. Ind. Timb. 306, 1881 ed 2.560, 1902; Hooker, Fl. Brit. India 5: 130, 1886; Staub, Ge Schichte Genus *Cinnamomum* 11, 19, 27, 31, 32, 39, 40, 1905; Dunn & Tutcher, in Kew Bull., Add. Ser. 10:223, 1912; Kostermans, in J. Sci. Res. Indon, I: 84, 85, 1952;

Figure 2.1 (a) A cinnamon tree – about five years old with fruits and flowers. (b) A close view of a flowering branch. (c) A twig with inflorescence.

Commun. For. Res. Inst. Bogor, 57: 24, 1957; in Reinwardtia r: 216, 1956; Chopra *et al*., Gloss. Ind. Med. Pl. 65, 1956; Wood, in J. Arnold Arb. 39: 335, 1958; Kostermans, Bib. Lau., 276, 1964.

Syn. *C. aromaticum* Nees. Nees, in Wallich, Pl. As. Rar. 2: 74, 1831; in Flora 15 (2): 585, 1831; Syst. Laur, 52, 1836; Nees & Ebermayer, Handb. Med. Pharm. Bot., 526, 1832; Lindley, F1. Med. 330, 1838; Wight, Icon. 136, 1839. *Laurus cassia* Wight in Madras J.Lit. & Sci. 9: 130–135, 1839. Presl., Wseobecny, Rostalinopsis, 2:1302, 1846; Miquel, F1. Ind. Bat. 1(1): 896, 1858; Meissner, in Dc: Prodr. 15(1): 12, 1864; Balfour, timber Trees & For. India & E Asia, ed. 3: 74, 1870; Lukmanoff, Nomencl. Icon. Canell. Comphr. 11, 1889, Kostermans, Bib. Lau, 253, 1964.

C. cassia is a native of China and Vietnam, being cultivated in those regions as well as in the Malayan Archipelago and the north-eastern Himalayan region. It is a small tree, the bark of which forms the cassia bark or Chinese cassia or Chinese cinnamon. Leaves are opposite, glabrous above, minutely hairy below, hairs microscopic, oblong-lanceolate, three-ribbed from about 5 mm above the base, side veins ascending to the apex, exstipulate. The length/breadth value is 4.26. Inflorescence is axillary panicle (panicled cyme), exceeding the leaves, many flowered, peduncle long, flowers with long pedicel and minutely hairy. Floral characteristics are similar to those of *C. verum*. Fruit is an ovoid one-seeded berry, seated in an enlarged perianth cup with truncate perianth lobes. Flowering from October to December (see also Chapter 6).

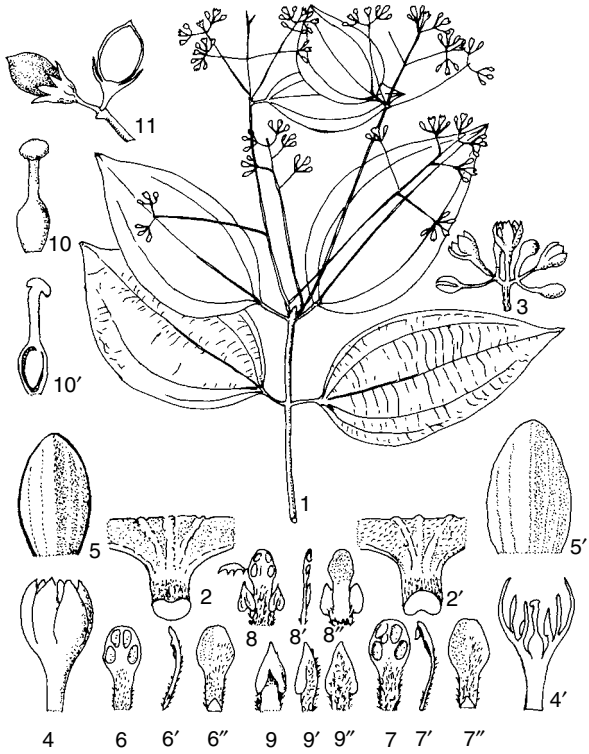

Figure 2.2 General characteristics of *C. verum*. 1 – Flowering branch (right hand leaf lower surface, left hand one upper surface). 2 – Base of the upper leaf surface, upper side of the petiole glabrous, grooved; 2′ – Base of lower leaf surface. 3 – Flowers in cymes. 4 – Flower and 4′ – flower in sectional view. 4″ – outside pilosity of flower. 5 – Interior tepal, inside hairy and punctulate; 5′ – outer tepal. 6, 6′, 6″ – Stamens of whorl 1. 7, 7′, 7″ – Stamens of whorl 2. 8, 8′, 8″ – Stamens of whorl 3. 9, 9′, 9″ – Staminodes of whorl 4. 10 – Pistel; 10′ – Pistel in L.S. 11 – Fruit (Adapted from Kostermans, 1983).

Nomenclatural notes

Berchthold & Presl were the first to describe *C. cassia* (*Priroz. Rostlin* 2:36 ct 44–45, 1825) followed by Blume (*Pl. Ned. Ind.*, 11, 570, 1826). Nees described the same species under *C. aromaticum* Nees, (in Wallich, *Pl. As. rar.* 2: 74, 1831., in Flora 15(2): 585, 1831) and this name became popular with the publication of *Systema Lauracearum* in 1836. But *C. cassia* precedes *C. aromaticum*. Hence the correct name for Chinese cassia should be *C. cassia* (Linn.) Bercht. & Presl. The original description by Linneaus was under *Laurus cassia* L. (Sp.pl.528). Later it was included under *Cinnamomum*, retaining the species epithet that Linneaus used. For a complete listing of nomenclature and synonyms see Kostermans (1964).

This is known as *Kwei* or *Kui* in China and as *cassia lignea* on the European market. All of the plant parts are aromatic, though only its leaves and bark are exploited commercially. The essential constituent of bark and leaf oil is cinnamaldehyde. Under

cultivation, trees are coppiced periodically keeping the height to 3–4 m. Uncut trees of 15–20 years have a central bole of 15–20 m. Because of the acute angle at which the branches are produced, the tree generally has a conical shape.

The bark is widely used as spice and is an important Chinese medicine. For medicinal use bark from mature trees grown in the wild is preferred. For spice the inner bark from young shoots as well as bark from older trees are used, which is peeled or scraped and dried. The inner bark contains 1.5–4% essential oil, having up to 98% cinnamaldehyde. The bark produced from higher altitudes (*Kwangsi* bark) is of better quality, having higher oil content than that produced from plants grown in lower elevations (*Kwantung* bark). The immature fruits are often dried and sold in market as cassia buds (see Chapter 6 for details).

Saigon cassia or Vietnam cassia – C. cassia *or* C. loureirii – *A case of mistaken identity*

This is a much-disputed species. Allen (1939) has commented on this species as follows:

> 'The material, which seems to answer the description given by Loureiro, comes from near the type locality in Indochina. It has a sweet sandalwood odour. Loureiro mentions the fact that it is fairly rare, which is certainly true, if one can judge from the scarcity of herbarium specimens. The *C. loureirii* from Japan cited by Nees, bears no resemblance to the Indochinese specimens that conform to Loureiro's original description. The Japanese specimens have a sweet spicy odour ... At this point it seems pertinent to discuss the so-called Saigon cinnamon used commercially.... As Merrill (1920) commented in his discussion on the subject, the commercial cinnamon must necessarily be a widespread species, that it cannot have escaped the notice of collectors and taxonomists for all these years. Chevalier (Allen, 1939) believes that it is either purchased from Chinese or Annamese merchants and thus brought into the port of Saigon, or else it is furnished by *C. loureirii*. This latter belief would indicate that *C. loureirii* is a widespread species, a fact belied by the scarcity of herbarium specimens...'

Dao (this volume, Chapter 6), who spent more than twenty years studying the *Cinnamomum* species of Vietnam, came to the conclusion that the Vietnam cassia is nothing but *C. cassia. C. loureirii* was previously wrongly identified as Vietnam cassia (see in this volume Chapter 6 on Chinese and Vietnam cassia).

*Indonesian (Java) cassia (*C. burmannii *C.G. Th. Nees)*

C. burmannii (C.G. Th. Nees) Bl. Blume, Bijdr. Fl. Ned. Ind., II st UK: 569, 1826; Nees & Ebermayer, Handb. Med. Pharm. Bot. 31; 525, 1832; Nees, in Wallich, Pl. As. Rar. 2:75, 1831; in Flora 15(2): 587 et 600, 1831; Syst. Laur. 67, 1836; Lindley, Fl. Med. 330, 1838; Presl, Wseobecny, Rostalinopsis, 2:1303, 1846; Miquel, Fl. Ind. Bat. 1(1):910, 1858; Ann. Mus. Bot. Lugd. Bat. 1:266 et 270, 1864; Meissner, in DC. Prodr. 15(1):16, 1864; Hance, Suppl. Fl. Hongkong, 31, 1872; in J. Linn. Soc. 13: 119, 1872; Franchet & Savatier, Enum. Pl.Japan. 1:410, 1875; Bokorny, in Flora N.R.40: 359, 1882; Hooker f., Fl. Brit. India 5: 136, 1886; Pax in Engler & Pr., Nat. Pfl. Fam. 3(2): 114, 1889; Hemsley, in J. Linn. Soc. 26: 371, 1891; Holmes, Catal. Hanbury, Herb. 99, 1892; Cat. Med. Pl. 129, 1896; Pharmac. J. 12 May 1894; Exkurs, Fl. Java,

21: 263, 1912; Allas Baumarten, Java 2: 266, 1914; Deane, in Pro. Linn. Soc. N.S. Wales, 25: 6. 37 (1), 1901; Merrill, Review spec. Blanco 73, 1905; Enum. Phillip. Flow. Pl. 2:187, 1923; in Lingnan Sci. J. 5:79, 1927; Staub, Gesch. Gen. Cinnamomum 20, 29, 31, 39, 40,. T. 1,2, 1905; Matsumura, Index Pl. Java, 2(2): 135, 1912; Chevalier, in Sudania 2:47 et 53, 1914; Expl. Bot. Afr. Occ. Fr. 1:543, 1920; Chung, in Mem. Sci. Soc. China 1(1): 58, 1924; Heyne, Nutt. Pl. Ned. Ind. ed. 2, 1: 649, 1927; ed. 3, 1: 649, 1950; Santos, in Phillip. J.Sci. 43(2):348–53, t. 11, 18, 19, 1930; Gimlette & Burkill, in Garden's Bull. S.S. 6: 340 et 446, 1930; D. Bois, Pl. aliment. 3662, 1934; Burkill, Dict. Econ. Prod. Malay Pen. 1:546, 1935; Kostermans, in Natul. Syst. Paris 8:120, 1939; Comm. For. Res.Inst., Bogor, 57, 11:21, 1957; in Reinwardtia 4, 203, 213, 1957; Backer, Fl. Java, Fam. 27: 8, 1941; Chow & Wang, Cat. Pl. Kwangsi 22, 1955; Kostermans, Bib. Lau., 256, 1964. (See Kostermans 1964 for full nomenclature citation).

Indonesian cassia is commonly imported to the USA and the bark has high oil content. All plant parts are aromatic, but only the bark is commercially exploited. This plant (known as *kaju manis* in Indonesia) is grown on a large scale in certain areas and based on quality. Two types have been recognised: one is known as Korintji cassia and the other Padang (or Batavia) cassia. The former is grown in higher altitudes and is much superior in quality having a higher oil content (about 4% in the bark), the main constituent of which is cinnamaldehyde. The leaf on steam distillation yields about 0.5% oil, the main constituent of which is also cinnamaldehyde (50–65%) (see Chapter 8 for details). The species epithet is spelled differently as *burmanni*, *burmannii* and *burmanii*. Here the spelling given by Kostermans (1964) is adopted.

Indian cassia* (C. tamala *(Ham.) Th Nees & Eberm.)

Th. Nees & Ebermayer, Hanb. Med. Pharm. Bot. 2: 426 et 428, 1831; CG Nees, in Wallich, Pl. As. Rar. 2: 75, 1831; in Flora 15(2): 591 et 596, 1831; Syst. Laur. 56 et 666, 1836; Th. Nees, Pl. Office, Suppl. 4:22, 1833; Hayne, Getreue Darstell. Arzneigew, 12:t. 26, 1856, Blume, Rumphia 1(3):t.14, 1833 et 1836; Miquel, Leerb. Artsenijew., 360, 1838; Fl. Ind. Bat.1(1): 892, 1858; Ann. Mus. Bot. Lugd. Bat. 1: 268, 1864; Stendel, Nom. ed. 2, 1: 366, 1840 et 2: 15 et 17, 1841: Meissner, in DC. Prodr.15 (1): 17, 1864; Bentham, fl. Austral. 5: 303. 1870; in Bailey, Queensland. Fl. 4:1309, 1901; Udoy Chand Dutt, Materia Med. Hindus, 224, 1872; rev.ed. 224,320, 1900; Steward and Brandis, For. Fl. N.W. India, 374, 1874; Gamble, List Trees & Shrubs Darjeeling Dist. 63, 1878; ed. 2:64, 1896; Man. Ind. Timb., 306, 1881; ed. 2, 560, 1902; Hooker f., Fl. Brit. India, 5: 128, 1886; Watt, Dict. Econ. Prod. India 2, 319–323; 1889; Pax, in Engl & Pr. Nat. P.fl. fam; 3(2): 114, 1889; Gage, in Rec. bot. Surv. India 1: 355, 1893; 3(1): 98, 1904; Pharmc. J. 12 May 1894, 941; Kanjilal, For. Fl. School circle, N.W. Pror. 275, 1901; For. Fl. Sivalik 326, 1911; Prain, Bengal Pl. 2:899, 1903; in Rec. bot. Survey India 3(2): 270, 1905; Staub, Geschichte gen. Cinnam. 21, 39, 42, t. 17, 1905; Brandis, Ind. Trees, 533, 1906; Lace, List of Trees, shrubs Burma 109, 1912, ed. 2:137, 1922; Duthie, Fl. Upper Gangetic plain 3(1): 57, 1915; Haines, Bot. Bihar & Orissa 797, 1924; Burkill, in Rec. bot, Sur. Ind. 10(2): 351, 1925; Dic. Eco. Prod. Malay Penin, 1: 543 et 556, 1935; Osmanton, For. Fl. Kumaon, 443, 1927; Fischer in Rec. Bot. Sur. India 12(2); 128, 1938; Kanjilal *et al*.; Fl. Assam, 4: 56, 1940; Kostermans, Bib. Lau, 354, 1964. (For full nomenclature citation see Kostermans, 1964).

Indian cassia leaves (known as '*Tejpat*' in India) have been used as a spice in the whole of north India from ancient times. It is an evergreen tree, found mainly in the tropical and subtropical Himalayas up to an altitude of 2400 m. *Tejpat* occurs naturally in the Khasi and Jaintia Hills, but is also grown in the homesteads. The main trading centre for *tejpat* leaves is Shillong in Meghalaya. Baruah *et al*. (2000) found that several species (in addition to *C. tamala*) are traded as *tejpat*, and are used by consumers. The other species used as '*tejpat*' (Indian cassia) are *C. impressinervium* Meissn.; *C. bejolghota* (Buch. Ham.) Sweet and *C. sulphuratum* Nees (see Chapters 8 and 15 for more details).

Baruah *et al*. (2000) identified four morphotypes, two of which are more popularly used. Leaves are alternate, sub-opposite or opposite on the same twig, coriaceous, aromatic, glabrous; pink when young. Leaves are ovate to ovate-lanceolate in morphotype I; elliptic-lanceolate in morphotype II; broadly elliptic-lanceolate in morphotype III; small and elliptic to oblong-lanceolate in morphotype IV; apex acute to acuminate, base acute to obtusely acute, triplinerved, lateral veins not reaching the tip; panicle subterminal to auxillary, equal to the leaves or slightly exceeding them. Floral morphology is similar to other species. In all morphotypes leaves are hypostomatic, stomata sunken, epidermal cells highly sinuous on both surfaces, glabrous except in one morphotype; venation acrodromous, areoles tetragonal to polygonal, variable in size.

Camphor* (C. camphora *(L.) Bercht. & Presl.)

Berchthold & Presl., Priroz. Rostlin 2: 36 at 47–56, t. 8, 1825; Th. Nees, P1. Off. t. 127, 1825; Sweet, Hort. Brit. 344, 1827; London, Hort. Brit. 160, 1830; Wallich, Catal. No. 6347, 1830; Nees & Ebermayer, Handb. Med. Pharm. Bot. 2, 430–434, 1831; CG Nees in Wallich, P1. As. Rar. 2, 72, 1831; Heynold, Nom. Bot. Hort. 197, 1840; Steudel, Nom. Ed. 21: 271 et 366, 1840; Miquel, F1. Ind, Bat. 1(1), 905, 1858;Meissner in DC. Prodr. 15(1), 24 et 504, 1864; Stewart and Brandis, For. F1. N.W. India, 376, 1874; Gamble, Man. Ind. Timb. 305, 1881; Hooker f., F1. British India, 5: 134, 1885; Engler, Syllabus 127, 1903; Kutze, in Engl. Bot. Jahrb, 33: 421, 1903; Prain, Bengal P1. 2. 899, 1903; Brandis, Ind. Trees 534, 1906; Duthie, F1. Upper Gangetic Plain 3(1): 57, 1915; Sawyar & Dan Nyun, Classif. List. Pl. Burma, 32, 1917; Troup, Silvicult. Ind. Trees, 3: 790–795, 1921; Exot. For Trees Brit. Emp. 70, 1932; Howard in Indian Forest Rec. 9(7): 1–34, 1923; Parker, For. F1. Punjab ed. 2: 429, 1924; Haines, Bot. Bihar & Orissa, 797, 1924; Fujita, Y, in Trans. Nat. Hist. Soc. Formosa, 21: 254–258, 1931; 22: 43–45, 1932; 25: 429–432, 1935; in bot. Mag. Tokyo, 65, 245–250, 1952; Kostermans, Natual. Syst. Paris, 8: 120, 1939; in Humbert, F1. Madag. Fam.81: 86, 1950; in J. Sci. Res. Indon. 1: 84, 85, 1952; Commu. For. Res. Inst. Bogor 57: 6, 10, 21, 24, 1957; in Reinwardtia, 4: 198, 202, 213, 216. 1957; Kanjilal, F1. Assam, 4: 60, 1940.

C. camphoratum Bl. Blume, Bijdr, Fl, Ned. Ind. 11, 571, 1826;
C. camphoratum F. Villar, Villar in Blanco Fl. Filip. 1880;
C. camphoratum Merr. Merril, Enum, Philip. Fl. Pl. 1923;
C. camphoriferum St. Lag. St. Lager in Ann. Soc. Bot. Lyon., 7: 122, 1880;
C. camphoroides Hay. Hayata, Icon. Pl, Formos. 3, 158, 1913.