

Ranjith Senaratne
Ranjith Pathirana *Editors*

Cinnamon

Botany, Agronomy, Chemistry and
Industrial Applications

 Springer

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The editors dedicate this book to the people of Ceylon (Sri Lanka) who introduced cinnamon to the world, dedicated their lives to cinnamon and made it their livelihood; to those who were forced to harvest and process cinnamon under Sinhalese kings' royal prerogative, first for the kingdom and then to supply the foreign invaders; and to those who managed and sustained the industry despite change in priorities of the foreign powers and amidst untold obstacles and formidable challenges since independence in 1948 to date.



Peeling cinnamon in Ceylon circa 1672 from Atlas of Mutual Heritage; A collection of images related to Dutch East India Company

Preface

From time immemorial, cinnamon has been valued not only as a spice and an incense but also as an antiseptic. The history of cinnamon dates back to about 2800 B.C. and it is even mentioned in the Bible. Ancient Egyptians used cinnamon in mummification because of its antibacterial properties and fragrance, and the Romans used it in perfumes and fragrances and to flavor wines. Around the fourteenth century, Europeans started using cinnamon to improve the keeping quality of meat. It was the quest for spices that led European nations to explore the world in the fifteenth century.

The island nation of Sri Lanka had been a hub and a prominent cradle of spice trade in the ancient world, in which true cinnamon (*Cinnamomum zeylanicum* Blume) occupied an exalted position. It was the key spice that attracted Europeans to Sri Lanka (then Ceylon). The Portuguese, who conquered Sri Lanka in the early sixteenth century, wrested the cinnamon trade from the Arabs who had kept it as a jealously guarded secret for many centuries. Following the Portuguese takeover of the cinnamon trade, growing demand for cinnamon throughout the world created a lucrative market; this led the Dutch into battle with the Portuguese and gain control of the cinnamon industry and Sri Lanka in the mid-seventeenth century. In 1953, in his treatise titled “Ceylon under the British Occupation,” Dr. Colvin R de Silva, a former minister and a legal colossus in Sri Lanka, recorded “If the vagaries of wind and wave brought the Portuguese to Ceylon, the lure of cinnamon kept them in the Island,” and according to Fr. Philippus Baldaeus (1732), a Dutch minister, cinnamon was the “Helen or Bride” for whom the Dutch and Portuguese contended for many years. Such was the esteem in which cinnamon was held by Europeans.

C. zeylanicum, belonging to the Family Lauraceae, is indigenous to Sri Lanka and contributes around 90% of the global trade of true cinnamon. It is a unique and versatile plant that has oil in its leaves, bark, and roots, the chemical composition of which is completely different. Both bark and leaves contain essential oils, with cinnamaldehyde being predominant in the bark and eugenol in leaves; root-bark oil contains camphor. These substances have a wide range of industrial applications. Cinnamaldehyde is a proven natural bactericide widely used in the food and beverage industry, being particularly effective against *Salmonella* spp. and *Escherichia*

coli. Given its organoleptic, medicinal, germicidal, and carminative properties, cinnamon has found applications in a wide range of industries, not only in food and beverage, but also liqueur, perfumery, nutraceutical, cosmeceutical and oral care, and traditional medicine.

Cinnamon, which has a highly fragrant aroma and a subtle, delicate, pungent, and sweet taste, contains insignificant traces of coumarin – a hepatotoxic hazardous substance. On the other hand, cassia – a cheap and inferior substitute for cinnamon – has a bitter, coarse, and strong flavor and contains appreciable quantities of coumarin, that is, 5–7 g kg⁻¹ of bark and ~ 8% in oil. Yet no distinction has hitherto been made between cinnamon and cassia in global trade, and cinnamon is often adulterated with cheap cassia and sold under the label of cinnamon. In some countries like the USA, cassia is sold as cinnamon. Given the proven health implications of cassia, it is inconceivable why the European Union, North America, and other OECD countries, which have laid down stringent regulations and fastidious requirements to ensure food safety, have not enacted legislation to separate labeling of cassia from true cinnamon.

Today, markets are becoming increasingly globalized, sophisticated, and dynamic and consumers are increasingly health conscious. Therefore, there is growing demand for healthy natural foods and beverages, additives and flavors, pharmaceuticals, nutraceuticals, cosmeceuticals, and perfumes in the global market which has fueled the growth of the green economy. In view of this change in consumer behavior, preferences, and food habits, there has been a steady increase in the demand for cinnamon by the consumer as well as by a multitude of industries enumerated above. This has resulted in a surge of publications on various aspect of this agro-industrial crop ranging from ethnobotany, genetics, and agronomy to processing, value creation, and new product development.

To date, there has not been a comprehensive treatise covering the latest advances in research related to true cinnamon. This book, with chapters written by experts in diverse fields including ethnobotany, ecology, genetics, biotechnology, chemistry, pharmacology, agronomy, and value creation, has distilled and condensed current knowledge into a single source and contributes to the advancement and dissemination of knowledge and technology.

Inclusion of seminal work done and published recently related to molecular characterization, genetic barcoding, and chemical profiling of the germplasm of cinnamon and its pharmacological, nutraceutical, and cosmeceutical efficacy and industrial applications constitutes a salient feature of the book. Moreover, it has made a clear distinction between true cinnamon (Ceylon cinnamon) and cassia cinnamon (Chinese and Indonesian cassia) based on their biochemical profiles, highlighting the presence of a high content of coumarin, which is carcinogenic and hepatotoxic, in cassia. At present, both cinnamon and cassia are sold as cinnamon in the global market, and consumers are not aware of the health hazards associated with regular consumption of cassia. This book will create much needed global awareness about this issue, paving the way for formulating necessary food regulations and legislation in the interests of consumers.

Contributors to the book constitute internationally renowned senior scientists and academics with hands-on experience as well as movers and shakers in the cinnamon industry, thereby striking a right balance between theory and practice. Therefore, this will be a valuable source book for students, teachers, scientists, planners, policy makers, practicing agriculturists, and industrialists, and a prized acquisition to any library in higher education institutions, R & D institutions, and public and private sector institutions in agriculture and allied fields.

It is our fervent hope that this book will stimulate strategic research on cinnamon, unleashing and harnessing the potential of this wonder plant for the benefits of mankind while providing necessary knowledge and technology for the benefit of consumers and other stakeholders in the cinnamon industry.

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Acknowledgements

Cinnamomum zeylanicum Blume (true or Ceylon cinnamon) is indigenous to Sri Lanka and has a wide range of food and industrial applications. It has potential to be a multi-billion dollar industry, but operates far below its potential. Therefore, the Ministry of Primary Industries (MoPI) in Sri Lanka, the predecessor of the current Ministry of Plantation Industries and Export Agriculture, provided a special grant to carry out results-oriented, high-impact research with an aim to expand the cinnamon industry in Sri Lanka during 2017–2019. The project constructed a platform enabling senior scientists and technologists in academia, R&D institutions, and industry to work together to achieve the above objective. The project was administered by the Technology Division of the National Science Foundation (NSF), Sri Lanka.

The desire to produce a book on Ceylon cinnamon has been oscillating in us for quite some time, largely due to the lack of a comprehensive treatise on true cinnamon that covers the latest findings on ethnobotanical, biological, and agronomic aspects as well as its food, industrial, and medicinal applications. The project, funded by MoPI, gave a powerful stimulus that made us move forward with this idea. Findings emanating from research funded by the project constitute a sizable proportion of the book chapters. Therefore, we wish to record our sincere appreciation to Mr. Daya Gamage, former Minister of Primary Industries, for his initiative in allocating substantial funds for strategic research on cinnamon; chairman, director general, and staff of the Division of Technology of NSF during the said period; and members of the project steering committee and the project coordinator for the efficient administration, monitoring, and coordination of the project, which contributed in no small measure to the production of the book.

Contributions to this book have been made by renowned scientists and technical experts with considerable knowledge and experience in various aspects of cinnamon ranging from history, botany, and genetics to agronomy, medicinal properties, processing, and marketing. We wish to express our profound gratitude to them for their valuable contributions amidst busy schedules and heavy preoccupation.

The editors offer their heartfelt thanks to Dr. S. Sivasegaram, retired professor of mechanical engineering, University of Peradeniya, Sri Lanka; Prof. David Cooper,

retired professor of philosophy, University of Durham, UK; and Drs. Andrew Granger, Vincent Bus, Michael Lay-Yee, Cath Kingston, Bruce Smallfield, and Ed Morgan and editorial staff at the New Zealand Institute for Plant and Food Research Limited for their valuable comments and for kindly editing some chapters of the book despite their heavy professional commitments. The editors wish to record their sincere gratitude to Springer for the meticulous care with which the book has been produced.

Last but not least, the editors wish to thank their spouses, Tamara and Sriya, and families for their understanding, support, love, and care during the period of editing the book.

Ranjith Senaratne and Ranjith Pathirana, May 11, 2020

Contents

1	An Introduction to Sri Lanka and Its Cinnamon Industry	1
	Ranjith Pathirana and Ranjith Senaratne	
2	Historical, Ethno-Botanical and Social Aspects of Cinnamon Cultivation in Sri Lanka.	39
	Nirmal R. Dewasiri, Lodewijk J. Wagenaar, and Jayadeva Uyangoda	
3	Ceylon Cinnamon Production and Markets.	63
	Achini M. De Silva and Mohamed Esham	
4	Botany of Endemic <i>Cinnamomum</i> Species of Sri Lanka.	85
	Pushpa Damayanthi Abeyasinghe, Pradeepa C. G. Bandaranayake, and Ranjith Pathirana	
5	Genetics and Molecular Characterization of Genus <i>Cinnamomum</i>.	119
	Pradeepa C. G. Bandaranayake and D. K. N. G. Pushpakumara	
6	Germplasm Resources, Breeding Technologies and the Release of Cinnamon Cultivars ‘Sri Wijaya’ and ‘Sri Gemunu’ in Sri Lanka.	147
	Sheron N. Weerasuriya and Ranjith Pathirana	
7	Ecology, Agronomy and Management of Cinnamon (<i>Cinnamomum zeylanicum</i> Blume)	171
	D. N. Samaraweera, Sheron N. Weerasuriya, A. S. Karunaratne, S. Subasinghe, and Ranjith Senaratne	
8	Pests and Diseases of Cinnamon (<i>Cinnamomum zeylanicum</i> Blume)	201
	G. G. Jayasinghe, R. H. S. Rajapakse, K. L. Wasantha Kumara, D. Ratnasekera, and N. K. B. Adikaram	
9	Cinnamon Process Technology	233
	K. D. N. Weerasinghe and N. P. G. Pushpitha	

10	Chemistry and Bioactive Compounds of <i>Cinnamomum zeylanicum</i> Blume	251
	P. A. Paranagama, K. R. Dayananda, and Jinasena W. Hewage	
11	Tapping into the Potential of Cinnamon as a Therapeutic Agent in Neurological Disorders and Metabolic Syndrome	273
	Hanouf Ismail, Nalaka Wijekoon, Lakmal Gonawala, Stephanie Perera, Shamali Wasala, Yoonus Imran, Liraj Kodithuwakku, Nuwani Kodithuwakku, and Ranil De Silva	
12	Pharmacological Properties of Ceylon Cinnamon	307
	G. A. S. Premakumara and W. P. K. M. Abeysekera	
13	Industrial Applications of Ceylon Cinnamon (<i>Cinnamomum zeylanicum</i> Blume) as Nutraceuticals and Cosmeceuticals	327
	Tuley De Silva	
14	Public-Private Partnership in Growth and Development of Cinnamon Industry in Sri Lanka	349
	Kumudini Gunasekare, Sarada de Silva, and Ravindu Runage	
15	Value Creation and Food Products of Cinnamon	363
	Renda K. C. Jeewanthi, Achini M. De Silva, and Tharaka Weddagala	
16	Cinnamon Value Chain Dynamics and Enhancement	377
	Achini M. De Silva and Mohamed Esham	
17	Planning and Strategic Policy Interventions for Building a Globally Competitive Cinnamon Industry in Sri Lanka	407
	Buddhi Marambe, Jeevika Weerahewa, and A. P. P. Disna	
	Index	435

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About the Editors



Ranjith Senaratne, PhD professor and chair, Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Sri Lanka, has over 40 years of experience in higher education, including teaching, research, and administration and community development. He has held several senior administrative positions with distinction for a period of over 20 years, including the posts of dean, Faculty of Agriculture, and vice chancellor, University of Ruhuna, chairman of the Ocean University, and the vice chair of University Grants Commission of Sri Lanka. Currently he is Chairman of the National Science Foundation in Sri Lanka.

Prof. Senaratne is a visionary leader and an institution builder; moreover, in recognition of his outstanding contribution in education, science, community development, and international cooperation, the University of Durham, UK, conferred an honorary doctorate (*honoris causa*) on him in 2007. He has been the recipient of several internationally competitive and prestigious research grants and has held a number of coveted fellowships. He has over 100 research communications and papers to his credit and has written and edited around 10 books related to agriculture, higher education, science and technology, and national development.



Ranjith Pathirana, PhD began his career as a research officer in the Department of Agriculture, Sri Lanka, where he initiated the National Coordinated Oilseeds Programme. He was coordinator of the program before joining the University of Ruhuna, Sri Lanka, where he was the chair and professor of agricultural biology. There he initiated plant biotechnology programs and was the founding editor-in-chief of *Tropical Agricultural Research and Extension*, a peer-reviewed international journal. Dr. Pathirana has served as a FAO/IAEA expert in several developing countries and also served as a FAO/IAEA resource person for developing and implementing plant mutation breeding programs and conducting training courses.

In 2002, he joined the New Zealand Institute for Plant and Food Research Limited, where he initiated germplasm preservation research. Dr. Pathirana pioneered cryopreservation and cryotherapy of horticultural species in New Zealand and established the cryo-genebank in Palmerston North where he was the curator for 5 years and the principal investigator of several government-funded projects. He is a consultant to Acadia University, Nova Scotia, Canada, and the Kentville Research and Development Centre of Agriculture and Agri-Food, Canada, in cryopreservation and cryotherapy, as well as a reviewer of the Biological Sciences section of the Czech Academy of Sciences. His principal interests are in applying *in vitro* cell and plant biotechnologies for crop improvement, conservation, and elucidating biochemical pathways, particularly in plant stress response.

Chapter 1

An Introduction to Sri Lanka and Its Cinnamon Industry



Ranjith Pathirana and Ranjith Senaratne

1.1 Introduction

The cinnamon of commerce comes from the genus *Cinnamomum* Schaeffer belonging to the family Lauraceae, a large family of mostly evergreen woody trees or shrubs (except for the herbaceous hemiparasite *Cassytha*) consisting of about 53 genera and 2500–3000 species distributed throughout tropical and subtropical latitudes (Chanderbali et al. 2001; Kostermans 1957; Rohwer 1993). *Cinnamomum zeylanicum* Blume (syn. *Cinnamomum verum* Berchthold & Presl), the true or Ceylon cinnamon, and seven other species are endemic to Sri Lanka. Sri Lanka had different names in ancient times such as Lanka (in the Ramayana; seventh to fourth centuries BCE), Lankadeepa or Lakdiva (in Buddhist writings; fifth century BCE), Tambapanni (named by the first Sinhalese King of Sri Lanka, Vijaya; fifth century BCE), Taprobane (the name used by Megasthenes, the Greek ambassador to the court of the Mauryan King, Chandragupta, and Eratosthenes, one of the first Greek geographers; second century AD), Serendib (most of the Arab travellers and writers used this name; Taprobane, Sigaldip and Saheelan were also used by early Arab writers), Zeylan or Seylan (first European travellers used this name, derived from the Arab word Saheelan) and Ceylon—the name used by the colonizing British and the official name from that time until 1972 when it was changed to the present name. Sri Lanka was the major supplier of true cinnamon to the world for over seven centuries and continues to dominate the market with a 90% share. Originally harvested from the rainforests of the south-western region of Sri Lanka where

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C. zeylanicum originated, it was domesticated during the Dutch rule of the coastal areas of the country in the seventeenth century. By 2018, the area under cinnamon in Sri Lanka was up to 33,000 ha producing 24,000 MT (FAOSTAT 2018). Although low-quality cassia (mainly the product from *Cinnamomum cassia*, syn. *Cinnamomum aromaticum*, grown in China and Vietnam, and *Cinnamomum burmannii* grown in Indonesia) exports have increased much faster and exceed true cinnamon exports in quantity, Sri Lanka still ranks first in value of exports, with a US\$259 million turnover in 2018. Over 90% of this is exported in the form of quills without value addition. This introductory chapter outlines the ecological and edaphic conditions of the cinnamon-growing area in Sri Lanka, a brief history of Sri Lankan cinnamon production and trade and a vision for the future.

1.2 Origin and a Brief Biogeography of the Rainforest Region of Sri Lanka, Home to Eight Endemic *Cinnamomum* Species

1.2.1 Origin and Geography of Sri Lanka

The island of Sri Lanka has a total area of 65,610 km² and is located southeast of the southernmost tip of peninsular India, between 50°53' and 9°51' North and 79°43' and 81°53' East. North to south the island is c. 435 km at its greatest length, and c. 240 km at its greatest width, east to west. Eighty per cent of the land mass consists of coastal plains and hills to an elevation of 900 m, and the remainder is a south-central mountainous region reaching 2527 m at Pidurutalagala. The physiography of the island consists of three penepains: the lowest at 75 m above sea level (average 30 m), the second at 125–750 m (average 500 m) and the third at 750–2500 m (mostly 1500–1800 m) above sea level (Fig. 1.1; Ashton and Gunatilleke 1987; Cooray 1984; Erdelen 1988; Werner and Balasubramaniam 1992).

Sri Lanka was part of the ancient supercontinent of Pangea during the Mesozoic Era (c. 250 million years ago [mya]) when it was geologically connected to Madagascar, Africa, southern India and Antarctica (Dissanayake and Chandrajith 1999). During the second segment of the Mesozoic Era, the Jurassic period (c. 150 mya), it rifted from Africa of the Gondwana megacontinent as the Antarctica-India-Seychelles-Madagascar plate (Briggs 2000; Raven and Axelrod 1974). Thereafter, India-Madagascar separated from Antarctica c. 130 mya, India-Seychelles from Madagascar c. 84–96 mya and India from Seychelles c. 65 mya (Briggs 2000; Gunatilleke et al. 2017; Raven and Axelrod 1974). Post-Jurassic tectonic events shaped the geology of the mountains of Sri Lanka. The island consists mainly of Palaeozoic granitic rocks of the Deccan Plate of Gondwanan origin, uplifted in the post-Miocene period (Cooray 1967). Nevertheless, Gunatilleke et al. (2017) argue that there is no evidence for a mountain bridge between India and Sri Lanka since the Miocene, and possibly since the Jurassic period. Similarly, there is no reason to

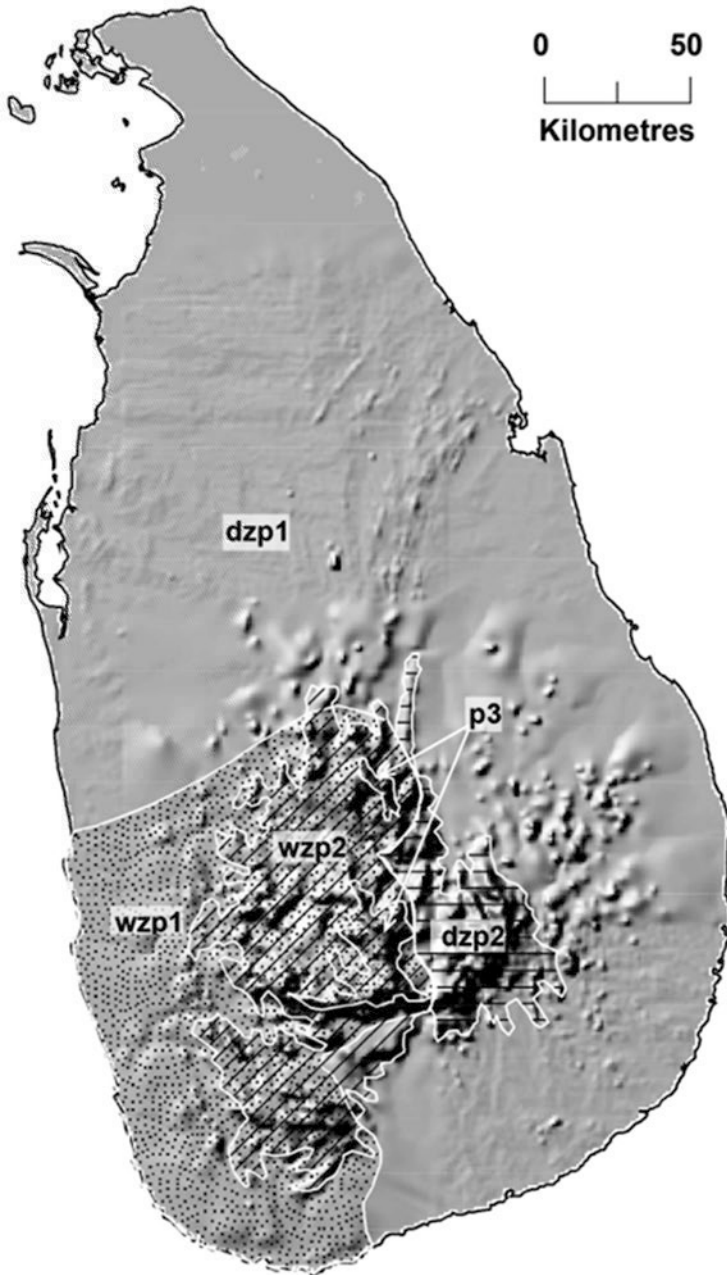


Fig. 1.1 The three penepains of Sri Lanka and the main climatic zones: dzp1, dry zone penepain 1; dzp2, dry zone penepain 2; wzp1, wet zone penepain 1; wzp2, wet zone penepain 2; p3, penepain 3. (Adapted from Biswas and Pawar (2006))

believe that there has been a direct mountain bridge between the newly uplifted Hindu Kush and Himalaya in the past either (Gunatilleke et al. 2017). Based on geological, mineralogical and isotopic data, Dissanayake and Chandrajith (1999) suggest that Sri Lanka is more closely associated with the south-eastern parts of Madagascar than with the Archean granulites of southern and eastern parts of India as has long been postulated. It is part of the same belt connecting to the Lützow-Holm Bay area in Antarctica (Dissanayake and Chandrajith 1999).

1.2.2 Biogeography of the Rainforest Region

South Asia to which Sri Lanka belongs lies on the Indian plate that has traversed from warm temperate through dry, then seasonally wet and equatorial tropical climates (Dittus 2017; Gunatilleke et al. 2017). Fossil pollen and wood reveal a southern retreat of the rich forest tree flora, which is now confined to a tiny, 10,000 km² area in southwest Sri Lanka (Gunatilleke et al. 2017), including seven wild *Cinnamomum* spp. In the lower parts of the south and south-western ‘wet zone’, the natural vegetation comprises evergreen rainforest while in the western slopes of the highlands, between 600 and 900 m, the lowland rainforest gradually changes into the lower montane rainforest (Gunatilleke and Gunatilleke 1991; Werner and Balasubramaniam 1992).

The lower montane rainforests are similar to lowland rainforests in terms of floristics and structure, and these rainforest floras must have survived the partly drier conditions of the Pleistocene (Werner and Balasubramaniam 1992). The 1500 m elevation forms the lower limit of a frequent and dense cloud cover, thus marking a sharp boundary between the lower and upper montane rainforests. Temperature in the montane forest region ranges between 15 and 25 °C (Ranawana 2014; Weerawardhena and Russell 2012; Wickramasinghe et al. 2008).

The mountain ranges in the upper part of the montane rainforest resemble an anchor set from west to east with a slight curve to the south. Peak Wilderness Sanctuary forms the western part and Haputale ranges in the east. The highest peaks (1800–2100 m) are in the centre, with another mountain chain that runs northwest (Fig. 1.1). Further to the north of this massif is the relatively isolated Knuckles range formed in a northwest to southeast direction, exactly perpendicular to the two principal wind currents (southwest and northeast monsoons) that bring a substantial proportion of the rainfall to the island. Being perpendicular to the wind currents, it also acts as a climatic barrier, influencing climatic conditions on its two sides. Thus, the highland and western parts of the Knuckles range are extremely wet throughout the year, with an annual rainfall of about 5000 mm, whereas the lower eastern slopes are drier with less than 2500 mm annual rainfall (DMSL 2019).

Unlike in many montane forests, those in Sri Lanka lack conifers and Fagaceae, which form a major component of the diversity in montane forests elsewhere in Southeast Asia (Manos and Stanford 2001). In the upper montane rainforests of Sri Lanka, their ecological role has been taken over by other families, with Lauraceae,

Myrtaceae, Clusiaceae and Symplocaceae having an exceptionally high frequency (Erdelen 1988; Werner and Balasubramaniam 1992). This composition obviously has developed from the lowland flora during the gradual uplift of the mountains during the Tertiary period. The lower montane and lowland rainforests are a mixed dipterocarp type (Ashton et al. 2001; Ashton and Gunatilleke 1987; Gunatilleke and Ashton 1987).

Perhumid southwest Sri Lanka has an extraordinary degree of endemism and species richness. For example, in Sinharaja Forest Reserve, a UNESCO Heritage site, 60% of tree species are endemic and many are rare. This refuge is the last extensive patch of tropical rainforest in Sri Lanka, covering an area of 8864 ha with a range in altitude from 300 to 1700 m. It is home to at least 139 endemic plant species (UNESCO 2020), including several endemic *Cinnamomum* species (details in Chap. 4 in this book). The cinnamon species endemic to Sri Lanka are dispersed in all parts of the country except the vast dry zone peneplain 1 shown in Fig. 1.1. However, some species are limited to just one zone (details in Chap. 4 of this book).

1.3 Cinnamon Trade in Ancient Ceylon (Sri Lanka): A Historical Sketch

1.3.1 Pre-colonial Period

According to many authors, cinnamon has been a prized commodity since the time of early civilizations of the Middle East. Cinnamon was used in ancient Egypt for mummification and as a medicine. It was an expensive commodity in ancient times and was available only to monarchs and the elite. Cinnamon is also mentioned in the Bible, and in ancient Greek and Latin texts (Abdel-Maksouda and El-Amin 2011; Braun 2006; David 1992). Using gas chromatography–mass spectrometry, Namdar et al. (2013) provide archaeological evidence for storage of cinnamon oil in small Phoenician flasks discovered in the store rooms of temples and treasuries of the southern Levant, dating back to the eleventh and late tenth centuries BCE. The organic residue in these clay flasks retained cinnamaldehyde, the major component of the oil of some of the *Cinnamomum* spp., including bark oil of *C. zeylanicum* from Sri Lanka (Ariyaratne et al. 2018; Senanayake and Wijesekara 2004; Sritharan 1984). Cinnamaldehyde is a terpenoid apparently exclusive to *Cinnamomum* spp. (Joshi et al. 2009; Simic et al. 2004; Senanayake and Wijesekara 2004; Shylaja et al. 2004). Furthermore, the sixth-century merchant and traveller, Cosmas Indicopleustes, the first westerner to visit the Island, mentioned in his book, titled *Topographia Christiana*, the importance of the spice trade in Ceylon (Ginigaddara 2018). There is evidence that between A.D. 1273 and A.D. 1284, the Sinhalese kings endeavoured to enter into a trade agreement with the Sultan of Egypt, to supply him with cinnamon, precious stones and elephants. The Sinhalese emissaries travelled by sea up the Persian Gulf and thence by land to Cairo, passing through Baghdad and the

desert of Syria. Foreign trade had really become a matter of considerable importance during this period to the Sinhalese kingdom (Jayasuriya 1949). Although evidence indicates that trade in this region with Asia, including cinnamon, took place much earlier than hitherto suspected (Gilboa and Namdar 2016), specific mention of cinnamon of Sri Lankan origin is unavailable in literature until about the tenth century. However, Haw (2017) argues that the reference to cinnamon in the Mediaeval period is related to some other taxa from the African continent. For more details on trade between south Asia and the Mediterranean in the Iron and Bronze Ages, the reader is referred to Gilboa and Namdar (2016) and Jayasuriya (1949).

Cinnamon was one of the important types of merchandise travelling via Indian Ocean trade routes since the tenth century (Gunaratna 2002; Paranavitana 1960; Biedermann and Strathern 2017). The Sri Lankan origin of quality cinnamon was a well-kept secret among the Muslim merchants who made fortunes by shipping the product to the Red Sea and then transferring it to the Mediterranean region. International trade was welcomed by Sinhalese kings as an important factor in economic prosperity. Arab traders established themselves in small communities along the Sri Lankan west coast near many ports with the king's patronage, operating as autonomous clusters and paying port dues (Paranavitana 1960; Somaratne 1975). Some historians argue that the royal centre Kotte was located close to Colombo to take advantage of the developing cinnamon trade (Somaratne 1975; Strathern 2004; de Silva 2000; Halikowski Smith 2001).

1.3.2 Colonial Period

1.3.2.1 The Portuguese Period

In the pre-colonial period, cinnamon peelers worked for the king in return for the crown land they cultivated (land tenure) under a system called *Rajakariya*. This system was later to be used by the colonial powers to exploit labour for harvesting and peeling cinnamon. The arrival of Lourenço de Almeida, the son of the first Portuguese Viceroy of India, in Colombo in 1505 or 1506 led to the establishment of Portuguese diplomatic ties with the Kingdom of Kotte ruled by King Parakramabahu VI, with the Portuguese eventually taking control of the cinnamon trade from the Arab merchants. King Vijayabahu of Kotte in 1518 allowed the construction of a fort in Colombo to protect the Portuguese trading interests. The king even allowed the Portuguese to establish a cinnamon processing factory (Gunaratna 2002) and the whole island was brought into suzerainty and required to pay an annual tribute payment of a certain quantity of cinnamon under the watchful eye of the Portuguese governor (Halikowski Smith 2001; de Silva 1989). This alliance continued until 1540, but due to emerging conflicts the Kotte Kingdom was abandoned by 1597 (Gunaratna 2002; Strathern 2004; de Silva 2000; Halikowski Smith 2001). In the period between the 1590s and the 1640s, the Portuguese came

close to controlling the production and world trade of cinnamon, but this was challenged by cinnamon from other Asian countries (Halikowski Smith 2001).

During the Portuguese period, harvesting of cinnamon was mainly concentrated in the forests of the lower slopes of western and south-western parts of Sri Lanka (coastal plains of wet zone peneplain 1—Fig. 1.1), where the Kotte Kingdom operated. However, vast swathes of the rainforest under the Kandyan and Sitawaka Kingdoms did not have agreements with the Portuguese: these Kingdoms were in constant rivalry with the Kotte Kingdom and the Portuguese were not welcome. Within their jurisdiction, the Portuguese ruthlessly exploited cinnamon forests by changing the services (*Rajakariya*) due from peelers. This was earlier based on extent and quality of land held by the local population. The Portuguese later associated it with the person rather than the land and by the mid-seventeenth century it became the standard for every person of *Salagama* caste over 12 years to supply a fixed quantity of cinnamon to the ‘state’, thus establishing a system of slavery (de Silva 1981; Ginigaddara 2018; Halikowski Smith 2001; Somaratne 1975). The peeling and the preparation of cinnamon for the market was a skilled profession and had become the caste occupation of an important segment of the population, the *Salagama* or the *Chalea* caste. The *Salagamas* were immigrants from South India (Biedermann and Strathern 2017; de Silva 1993). The Portuguese, and thereafter the Dutch, managed to take advantage of the system established by Sinhalese Kings, keeping the *Rajakariya* (free labour for the king) intact. For further details of the Portuguese period and cinnamon trade, see Chap. 2 of this book and de Silva (1993).

1.3.2.2 The Dutch Period

Access to cinnamon was the reason for the Dutch arrival in Sri Lanka in the fifteenth century (de Silva 1981, 1993; Devasiri 2008). Early in the seventeenth century, several competing Dutch trading companies had merged into a new commercial enterprise: the Dutch East India Company (Dutch: *Vereenigde Oostindische Compagnie*—VOC), whose primary goal was to gain a trade monopoly of East Asian spices. In order to protect trade, the VOC was given a mandate by the government of the Netherlands to conquer land, build forts and maintain an army (Jayasena 2013).

By the time the Dutch arrived in Sri Lanka in the 1630s, the Kingdom of Kandy, which was an accessory kingdom of the Kingdom of Kotte, had established itself as the sole independent polity on the island. King Rajasinghe II of Kandy signed a treaty in 1638 (Hanguranketha Treaty, also called Batticaloa treaty) with the VOC that secured the terms under which the two parties would cooperate in defending the Kingdom of Kandy from the Portuguese; the Dutch were appointed as the sole protector of the country. In exchange, the VOC secured the lucrative cinnamon trade. It took another two decades for the Dutch to drive the last Portuguese forces out of Sri Lanka. The VOC controlled the territories of southern and western Sri Lanka and continued to use forced labour for harvesting and peeling of cinnamon (Biedermann and Strathern 2017; van Meersbergen 2017).

Within the 5-year period from 1665 to 1670, the area occupied by the Dutch increased twofold and more people of other castes were thrust into cinnamon peeling (de Silva 1981), the most arduous task in the industry. Slaves of Indian origin were also imported. In the period around 1660, over 10,000 Indian slaves were transported by the VOC (Schrikker and Ekama. 2017). The price of cinnamon in European markets doubled in the mid-seventeenth century, at which time relocation of villages from cinnamon lands to marginal areas and further pressure on the cinnamon lands and on peelers resulted in discontent among the population. Cinnamon prices remained steady until the end of Dutch rule in Sri Lanka near the end of the eighteenth century. The Dutch managed to meet this demand and export sufficient quantities of cinnamon by improving relations with the Kandyan Kingdom where more cinnamon was available for harvest. At the same time, the peelers were unable to escape to Kandyan Kingdom.

To meet the export demand and compensate for the loss of cinnamon trees due to population growth in the coastal areas of the southwest, the Dutch started establishing cinnamon plantations during 1767–1770 (Weiss 2002). A report on cinnamon plantations in 1786 and a series of maps from 1794 provide a vivid picture of the expansion of cinnamon plantations along the western coastal line. By the late eighteenth century, cinnamon plantations occupied a large proportion of land from Kalutara, in the south of Colombo, to Negombo, in the north (Dewasiri 2007). In the years to come, this decision to grow cinnamon helped to contain further erosion of genetic resources in the rainforest (Pathirana 2000; Wijesinghe and Pathirana 2000), albeit for a short period until the British transformed the landscape into coffee and then to tea and rubber plantations. The cinnamon industry and its rise during the Dutch period are discussed in more detail in Chap. 2 of this book and in de Silva (1993) and Dewasiri (2007).

1.3.2.3 The British Period

With the surrender of the Dutch forces to the British military on 17th February 1796 and the capture of the last King of Kandy, Sri Wickrama Rajasinghe, in January 1816, the whole island came under British rule. The British succeeded to a very rich legacy in cinnamon and were determined to preserve it. The British East India Company enjoyed a monopoly of export of cinnamon from 1802 until it was abolished and taken over by the Crown in 1821 (Mendis 1952). The period of British rule had a more significant impact on the rainforest region (where high endemism, including that of cinnamon exists) of Sri Lanka than the Portuguese or the Dutch. In parallel with cinnamon production and exports, they increased land under coffee and rubber, resulting in deforestation of large swathes of rainforest.

A regulation instituted in the very early days of British rule prohibiting Europeans from acquiring land in the island was repealed, and Europeans were given grants of land free of tax. Local civil servants were also encouraged to take to planting, and very soon tens of thousands of hectares were brought under coffee cultivation. Nevertheless, the annual revenue of Ceylon in and round 1830 did not exceed

£333,000, of which nearly half was derived from the cinnamon and salt monopolies. The coffee peak was reached in 1845 by which time most of the hill country forests of the island colony had been converted to plantations. European settlers were attracted in increasing numbers, and followed by cheap labour obtained in the form of workers from South India who were settled in plantation areas (Jayasuriya 1949). By 1936, Indian Tamils numbered over 1.1 million, more than 15% of the total population of the country, the majority of whom did not have citizenship of either country until in the post-Independence Indo-Ceylon pact of 30th October 1964 (MEA 1964). The area under coffee plantations doubled between 1845 and 1847 to 50,071 acres (20,263 ha; de Silva 1981). Cultivation of coffee had to be abandoned gradually in the 1870s after the incursion of coffee rust (*Hemileia vastatrix*) in 1869 and the decline of the crop as a result (Waller 1982). Planters then took to the cultivation of tea, mainly in the second and third peneplains, and rubber in the first peneplain of the wet zone (Fig. 1.1).

The British continued to derive considerable profit from the sale of cinnamon until 1835, but from that year its price began to fall owing to the competition from cassia. The Dutch, who had been deprived of the high-quality cinnamon from Ceylon by the British, carried away 3000 cinnamon plants and seeds as well as a number of cinnamon peelers from Ceylon in 1825 in one of their ships. Before long the Dutch were selling quality cinnamon from Java at a lower price than British product from Ceylon and the Dutch began to re-capture the market (Mendis 1952). The higher price of true cinnamon from Ceylon was because of a high export duty that remained in place until 1853. By then it was too late for the British to recover trade and capture the market, resulting in conversion of large tracts of cinnamon plantations to rubber and coconut, and some at higher elevations to tea (de Silva 1981; Peiris 1981).

Peiris (1981) considered the period between 1830 and 1930 as the beginning and the end of major landmarks of Sri Lanka's political and economic history and suggests that it be treated as a distinct phase. The Portuguese and the Dutch who ruled the maritime provinces of Sri Lanka in the two centuries that preceded the British regime did not attempt to initiate basic structural changes in the traditional system of land tenure. Their overall impact on the economy was slight and, by and large, they remained content with extracting services, revenue and products for trade through the media of existing tenure relationships. In most parts of their operations, the existing service obligations of the land holders were retained with only minor modification (de Silva 1981; Peiris 1981).

In terms of economic development, the period of British rule was characterized by the increasing importance of systematic and large-scale expansion of plantation crops for export. Plantation agriculture, which was confined to a few hundred acres of coffee at the commencement of the period, soon became the dominant sector of the colony's economy. By the end of this period, plantation crops covered over two million acres (ca. 405,000 ha; Peiris 1981). Within a period of less than half a century, most of the forests in the hill country were cleared for plantation crops. For example, 2796 ha of ecologically fragile Knuckles alpine forest with unique biodiversity (Werner 1995) was deforested to plant tea within 2 years (1874–1875)

for the establishment of the Kallebokka estate (Forrest 1967). Between 1830 and 1930, nearly one million ha of land was sold, most of which was in hill country forests. In 1875, a total of 191,351 ha had been bought by plantation owners in the hill country. However, only 52%, or 99,079 ha, of the land bought was under coffee cultivation; most of these lands were later planted with tea. An overwhelming proportion of the land that was under forest cover at the turn of the nineteenth century was covered with plantation crops by the end of this period.

Development of the plantation industry in Sri Lanka by the colonial administration became possible because of the appropriation and sale of land to which no proof of ownership could be presented by the local population. Most of the land in the two upper penepains fell into this category and the ruling British elite as well as new European arrivals in the island were the main buyers of land. Under the Sinhalese kings, land was given for services provided, and most of the land used by the villagers did not have titles. The Crown Lands Encroachment Ordinance no. 12 of 1840 opened the way for the acquisition and sale of the King's forests, unoccupied lands, waste lands and the seasonally cultivated lands including communal forests. Introduction of land sales by the colonial government enabled the Europeans and locals loyal to the administration to start coffee plantations in the island (Bandarage 2019; Mendis 1952; Meyer 2008; Peiris 1981). At the time of Independence in 1948, 90% of Sri Lanka's foreign exchange earnings were from tea, rubber and coconut—all these crops occupying the former rainforest regions of western and south-western wetlands and the central hills; and a country that had been self-sufficient in its main staple rice at the beginning of the colonial era, was spending 25% of its foreign exchange to import rice.

1.4 Agro-Ecology of Cultivated Cinnamon in Sri Lanka

1.4.1 *Impact of Deforestation to Establish Plantation Agriculture*

Unlike in many other European colonies, the primary agricultural strategy adopted by the British in Sri Lanka was not peasant or small-holder cultivation, but large-scale plantation agriculture. The effects of expansion of the plantation industry on the wet zone forest areas and the resulting population increase had long-term consequences on the ecology of the central hills and the southwest montane and rainforest regions of Sri Lanka. It even had effects on the drier areas because of silting of river beds resulting in frequent flooding (Bandarage 2019; Peiris 1981) as most of the dry zone rivers, including the country's largest and longest, Mahaweli River, have their headwaters in the wet montane area. Unlike in many Asian countries, 'population explosion' in Sri Lanka is not a twentieth-century phenomenon. It started in the mid-nineteenth century. Within a 70-year period, it rose from 1.72 to reach 4.50 million by 1921. The population density was highest in

the strip extending about 12 km into the interior, that covered the coastline from Negombo to Dondra Head—the area that was used by the Dutch to plant cinnamon in the west and southwest. This trend of population growth continued into the post-Independence period and most of the districts where cinnamon is grown now have a population density of over 600 persons per square kilometre compared with the national average of 310 persons (BM 2015; DCS 2006b; de Silva 1981). Overall, Sri Lanka, the 25th largest island in the world, now has the 5th largest island population density after Java, Honshu, Luzon and Mindanao (BM 2015).

Although the present level of forest cover in Sri Lanka as a whole is around 20%, only Matale and Nuwara Eliya among the plantation districts have a forest cover at or above this national average. This is due to the banning of the sale of land above 1524 m (5000 ft) and the declaration of two areas, Horton Plains-Peak Wilderness region and Hakgala, as nature reserves in the later phase of the colonial government (Wickramagamage 1998) and declaration of more forest reserves under protection post-Independence. The change from forest cover to over 2,000,000 acres (ca. 810,000 ha) of plantations has had its effects on the climates of the cinnamon-growing regions, with lower and more erratic rainfall. The stability of the ecosystem and soil has suffered irreparable damage as immediate changes occurred in the pattern of soil formation (Wickramagamage 1998). As Peiris (1981) recorded, the edaphic effects of the plantation practices that were adopted in Sri Lanka during the colonial period can be summarized as follows:

- Direct loss of soil through removal by erosion.
- Formation of a hard-baked upper soil surface lacking in adequate moisture.
- Lowering of the potential nitrogen and organic matter content of the soil.
- Widening of the soil temperature range resulting in the enhancement of soil activity.
- Enhanced siltation of river beds due to forest clearing resulting in increased frequency and intensity of flooding and silting of irrigation tanks, destroying irrigation systems for paddy and other crops.
- In extreme cases, excessive siltation resulting in the conversion of paddy lands into uncultivable wasteland.

1.4.2 Socio-economic Structure

It was in the ‘cinnamon belt’ (from Negombo to Dondra Head) that most of the churches were built and missionary schools started during the colonial period, resulting in a population of educated youth who were not too inclined to work in agriculture, particularly in the arduous and monotonous task of cinnamon peeling. Moreover, as discussed before, there was social stratification in different occupations during the times of kings, described as the caste system. Thus, cinnamon peeling was the ‘duty’ of the *Salagama* caste. People of this caste are descendants of workers from South India, brought into Sri Lanka before the arrival of the Portuguese

(Biedermann and Strathern 2017; de Silva 1993; Dewasiri 2007). Thus, even today there is reluctance from people of other castes to participate in cinnamon peeling as rural populations hold on to cultural traditions more strongly than city populations. Hence, even to this date the labour shortage in the cinnamon industry, particularly of peelers, is felt despite the high population density in the areas of cinnamon cultivation. Attempts to mechanize the peeling process are underway and highlighted in Chap. 9 of this book. Breeding programmes should go hand in hand with this, to select genotypes more amenable for mechanization of peeling and processing. Another aspect highlighted later in this book (Chaps. 15 and 16) is the value addition before export, so that the technique of peeling does not have to be ‘perfect’ to fit the stringent requirements of quality of the bales as demonstrated in https://www.srilankanspices.com/sl_spices_cinnamon.html (CCE 2020).

1.5 Progress and Challenges of the Sri Lankan Cinnamon Industry

1.5.1 Trends in Cinnamon Production in Post-Independence Sri Lanka

Since Independence in 1948, the cinnamon industry was neglected as preference was given to three major plantation crops, tea, rubber and coconut, that were earning enough to support the import of rice and other food, production of which was neglected during the colonial period. In 1972, the Government of Sri Lanka created a separate department (Department of Minor Export Crops) targeting spices and other neglected crops with potential. In the 1960s, annual cinnamon production averaged 6275 MT from about 13,200 ha (Table 1.1; range from 5500 to 8250 MT). There was an expansion in cinnamon lands in the 1970s but thereafter the area of cinnamon cultivation remained static until 1992. The production increased to a modest ~10,000 MT in the 1970s, and stagnated at that level until 1992.

Table 1.1 Trends in cinnamon production in Sri Lanka in the last five decades

Period	Area, ha	Yield, kg/ha	Production, MT
1961	11,000	4727	5200
1961–70	13,177	4760	6275
1971–80	21,628	4773	10,324
1981–90	21,088	4752	10,016
1991–00	23,558	4967	11,695
2001–10	26,157	5155	13,492
2011–18	30,353	6513	19,797
2018	33,094	7258	24,020

Note: Values calculated from FAOSTAT (2018); the values are averages for the period indicated