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Spice diversity and conservation of plants that yield major spices in India

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Summary

Spice diversity and conservation of plants that yield major spices in India

India is the land of spices. The spices from the Malabar coast of Kerala have long been used in western cuisine. Spices like black pepper have their origin in India, which is also a major production centre of many of the other spices such as cardamom, ginger, turmeric, nutmeg and clove. The Western Ghat forests and northeastern India are also well-known centres of biodiversity for some of the major spices. Species and varietal diversity are very important components of biodiversity, especially in black pepper, ginger, turmeric and cardamom. However, for tree spices such as nutmeg, clove and cinnamon, true varietal diversity has not yet been determined.

Keywords: biodiversity; centre of origin; India; spice-diversity

Résumé

Diversité chez les épices et conservation de plantes qui produisent les épices majeures en Inde

L'Inde est le pays des épices. Les épices de la côte du Malabar au Kérala sont utilisées depuis longtemps dans la cuisine occidentale. Des épices telles que le poivre noir sont originaires d'Inde, qui est également un centre majeur de production pour nombreuses des autres épices telles que la cardamome, le gingembre, le safran, la noix de muscade et le clou de girofle. Les forêts des Ghats occidentaux et l'Inde du nord-est sont aussi des centres bien connus de biodiversité pour certaines des épices majeures. Les espèces et la diversité variétale sont des composants très importants de la biodiversité, particulièrement chez le poivrier noir, le gingembre, le safranier et la cardamome. Cependant, pour des plantes arbustives telles que le muscadier, le giroflier et le cannelier, la véritable diversité variétale n'a pas encore été déterminée.

Resumen

Diversidad de especias y conservación de plantas productoras de las principales especias en la India

La India es el país de las especias. Las especias de la Costa de Malabar, Kerala, se han utilizado durante mucho tiempo en la cocina occidental. Especias como la pimienta negra tienen su origen en la India, que es también un importante centro de producción de muchas otras especias como cardamomo, jengibre, cúrcuma, nuez moscada y clavo de olor. Los bosques de Ghat occidental y del nordeste de la India son también centros renombrados de biodiversidad para algunas de las principales especias. Las especias y sus variedades son componentes muy importantes de la biodiversidad, en especial en la pimienta negra, jengibre, cúrcuma y cardamomo. No obstante, todavía no se ha determinado la verdadera diversidad de variedades de especias arbóreas como nuez moscada, clavo de olor y canela.

Introduction

Biodiversity refers to the multiplicity of life forms existing on the earth. In the last few years, there has been increasing international action regarding biodiversity, culminating in the 1992 Earth Summit, with the completion of Agenda 21 and an International Convention of Biological Diversity, signed by 165 nations including India. India is recognized as a country rich in all aspects of biodiversity: ecosystem, species and genetic diversities. The plant wealth of India is represented by about 45 000 species, which comprise 12% of the global wealth of plants. Nearly 33% of these are endemic, mainly located in 26 centres (Khoshoo 1995).

Biodiversity in spices

The tropical evergreen forests of the Western Ghats are home for at least two major spices – black pepper and cardamom. This region is also a secondary centre of origin of another spice, cinnamon. The depletion of forest area, rampant destruction of the forest trees and undergrowth, and changes in the agro-ecological conditions all have led to a sharp decline in the populations of wild pepper and cardamom and their related taxa. It is believed that cultivation of black pepper started about 6000 years ago. Today, about 100 black pepper cultivars are prevalent in India, apart from the wild relatives. While South Asia is believed to be the centre of origin of ginger, South East Asia is believed to be the centre of origin of turmeric. Both crops have been cultivated in Kerala since ancient times. In fact, Cochin ginger (=*Zingiber officinale*) and Alleppey turmeric (=*Curcuma longa*) are synonymous with the highest quality in these spices. About 50 cultivars each of ginger and turmeric are available in the country (Velayudhan *et al.* 1994). However, only three distinct cardamom varieties – 'Malabar', 'Mysore' and 'Vazhuka' – are cultivated in India (Madhusoodanan *et al.* 1994).

Tree spices [nutmeg (*Myristica fragrans*), clove (*Syzigium aromaticum*), cinnamon (*Cinnamomum verum*) and allspice (*Pimenta dioica*)] were introduced to India by the colonial rulers during the 18th century and subsequently became popular in certain pockets of southern India (Krishnamoorthy *et al.* 1995). The present-day nutmeg and clove populations have evolved from a few source trees introduced originally by the British rulers. Nutmeg and clove have now naturalized under southern Indian conditions. Elite trees are grown by the farmers in certain locations in the states of Kerala and Tamil Nadu.

Collecting and conservation of the biodiversity in spices have been one of the major mandates of the Indian Institute of Spices Research (IISR), Calicut. Consequently a sizeable amount of germplasm of these crops has been collected; they are maintained in *ex situ* and *in vitro* repositories at the IISR, Calicut.

Diversity in black pepper

Piper nigrum L. belongs to the genus *Piper*, family Piperaceae. It is a predominantly self-pollinated (geitinogamy) perennial vine propagated through cuttings (Sasikumar *et al.* 1992a). Rooted cuttings of the existing vines are the planting unit in black pepper, although seeds are fully viable and seedling populations are encountered in the plantations. Even though ecosystem diversity does not contribute much to biodiversity of black pepper, species diversity and varietal diversity are considerable (Hooker 1886; Gamble 1925; Rahiman 1981; Ibrahim *et al.* 1985).

The major centre of diversity of the genus *Piper* is central and northern South America where 60% of the species are concentrated. However, the humid tropical forest of the Western Ghats of India is the centre of origin of black pepper (Hooker 1886). More than 1000 species are included in the genus *Piper*, of which 110 are of Indian origin (Ravindran and Nirmal Babu 1994). The species and varietal diversity in *Piper* are given in Tables 1 and 2, respectively. Most of the vernacular names of black pepper varieties indicate a specific feature of the vine such as colour or appearance of the vine, leaf shape, spike features or the place from which the vine originated initially (the suffix 'kodi' after the name indicates a place, person or vine character).

The South Indian species are economically the most important, because they are closely related to the cultivated black pepper. Cytologically the predominant chromosome number reported is $2n$=52 (Ravindran and Nirmal Babu 1994). Ravindran and Nirmal Babu (1994) noted reasonable chemical affinities based on flavonoides between the following species, *P. galeatum* *P. trichostachyon* (87%), *P. attenuatum* – *P. argyrophyllum* (79%), *P. argyrophyllum* – *P. hymenophyllum* (78%) and *P. galeatum* – *P. sugandhi* (82%). However, chemical affinity between *P. longum*, *P. mullesua* and *P. silentvalleyensis* was low. But cluster analysis studies revealed that *P. mullesua* and *P. silentvalleyensis* are closely related while *P. longum* is distinct (Ravindran *et al.* 1992). Hooker (1886) included *P. mullesua* (syn. *P. brachystachyon*) under the section *Chavica* along with the species *P. longum*. Gamble (1925) also treated these species as closely related. *Piper mullesua* is the only South Indian species with a globose spike. *Piper silentvalleyensis* is a unique species with an erect, flexous, filiform spike and is the only wild bisexual species in South India. *Piper longum*, on the other hand, has a trailing habit and has cylindrical female spikes with laterally fused flowers.

Table 1. *Piper* species in South India (Western Ghats)

Species	Somatic chromosome number ($2n$)
P. argyrophyllum Miq.	36, 39, 52, 52
P. attenuatum Buch-Ham	36, 52, 26, 39, 52, 104, 52
† *P. barberi* Gamble	52
† *P. galeatum* (Miq) CDC	40, 52, 52
P. betle Linn.	32, 64,78, 42, 52, 58, 78, 105, 26
† *P. hymenophyllum* Miq.	104
† *P. hapnium* Ham.	–
† *P. hookeri* Miq.	60, 104
† *P. longum* Linn.	60, 24, 48, 96, 52, 52,52
P. mullesua Ham.	132
† *P. nigrum* Linn.	128, 48, 36, 60, 52, 52, 52, 65
† *P. pseudonigrum* Velayudhan	–
† *P. schmidtii* Hook. f.	96
† *P. silentvalleyensis* Ravindran and Asokan	–
† *P. sugandhi* Ravindran, Babu and Naik	52
P. trichostachyon CDC	52
† *P. wightii* Miq.	52

† Endemic species.

The species most closely resembling cultivated *P. nigrum* are *P. galeatum*, *P. sugandhi* and *P. wightii* (Nirmal Babu *et al.* 1993). Cultivated *P. nigrum* and some of the other South Indian species coexist in many localities in the Western Ghats. Isozyme studies suggest a moderate phylogenetic relationship among *P. nigrum*, *P. barberi* and *P. attenuatum* (Sasikumar *et al.* 1999). A common ancestry of South Indian *Piper* spp., including *P. nigrum* followed by introgression with different species giving rise to distinct species, is further suggested by hybridization studies (Sasikumar *et al.* 1999).

These cultivars, except the improved varieties, are evolved directly from the wild *P. nigruM*. Natural selection and conscious selection by humans for various traits have created diversity in cultivars. Most of these cultivars are popular in their respective area of cultivation.

Almost all these cultivars are intercrossable and a few hybrids have evolved by intercrossing of the popular black pepper cultivars such as 'Panniyur-1' and 'Panniyur-3'.

Besides *P. nigrum*, which is used as a spice, the other economically important Indian species are *P. longum*, *P. chaba*, *P. hapnium* and *P. betle*. The first three are used as long pepper and *P. betle* is used for masticatory use.

Conservation problems

Even though the early movement of settlers across the length and breadth of Kerala helped spread the landraces (cultivars) to new areas, the advent of improved-yield black pepper varieties (Table 2) is becoming a threat to many of the old cultivars. If not collected and conserved, these landraces may be lost forever. The species of *Piper* that are most affected by deforestation are *P. barberi*, *P. hapnium*, *P. silentvalleyensis*, *P. wightii* and *P. schmidtii*. Many of the taxa are now confined to only a few specific locations and may soon be extinct, if not collected and conserved.

Collecting, conservation, cataloguing and evaluation of genetic resources of black pepper are given high priority at

Table 2. Cultivar diversity in black pepper

Sl. no.	Cultivar/ variety	Remarks
1	Aimpiryan	High-yielding, performance excellent in higher elevations, good quality.
2	Arakkulammunda	Moderate and regular bearer, medium quality
3	Balankotta	Cultivar with large droopy leaves, moderate and irregular bearing, medium quality.
4	Bilimallegesara	Moderate yielder, grown in Karnataka state.
5	Chengannurkodi	Moderate yielder from South Kerala, medium quality.
6	Cheppakulamundi	Moderate yielder from Central Kerala, medium quality.
7	Cheryakaniakadan	Popular in North Kerala, moderate and early bearing variety.
8	Jeerakamundi	Cultivar with small leaves and short spikes, alternate bearing nature.
9	Kalluvally	A promising North Kerala cultivar, good yielder, medium quality with high dry recovery, drought tolerant.
10	Karimunda	Most popular cultivar suitable for most of the black pepper growing areas, high yielder and medium quality.
11	Kottan	A cultivar found in North Kerala, moderate in yield and medium quality.
12	Kottanadan	A high-yielding cultivar from South Kerala, medium quality, drought-tolerant type.
13	Kutching	A high-yielding Malaysian cultivar with medium quality.
14	Kurimalai	A cultivar from Karnataka, moderate yielder with medium quality.
15	Kuthiravally	A cultivar with long spikes, high yield and good quality.
16	Kuttianikodi	A moderate yielder from Central Kerala with relatively long spikes and good spiking intensity.
17	Malamundi	A moderate yielder, medium quality.
18	Malligesara	A common cultivar from Karnataka, relatively good yield.
19	Manjamundi	A moderate yielder from North Kerala, medium quality.
20	Narayakodi	Popular in South Kerala, moderate yielder with medium quality.
21	Neelamundi	A good yielder from central Kerala medium quality, tolerant to *Phytophthora* infection.
22	Nedumchola	A cultivar with small leaves and short spikes, moderate yielder.
23	Neyyattinkaramundi	A cultivar from Central Kerala, medium quality and yield.
24†	Panchami	An improved cultivar developed as a selection from 'Aimpiryan', high yielder.
25†	Panniyur-1	The first improved hybrid in black pepper. High-yielding, popular throughout the pepper-growing tracts, medium quality with bold berries.
26†	Panniyur-2	An improved cultivar, selection from open-pollinated progenies of 'Balankotta', high yielder with good quality.
27†	Panniyur-3	An improved hybrid with long spikes, high yield and medium quality.
28†	Panniyur-4	An improved cultivar developed as a selection from 'Kuthiravally'. Late maturing type, high in yield and medium quality.
29†	Panniyur-5	An open-pollinated progeny of 'Perumkodi'. A good yielder with medium quality.
30	Perambramunda	A cultivar from North Kerala, moderate yielder with medium quality.
31	Perumkodi	A cultivar from Central Kerala, moderate in yield and quality.
32	Poonjaranmunda	A cultivar originally from Central Kerala, sporadically found in gardens of North Kerala. Moderately good in yield and quality.
33†	Pournami	An improved cultivar tolerant to root knot nematode. Good yielder with high quality.
34†	Sreekara	An improved selection from 'Karimunda' high-yielding type with medium quality.
35†	Subhakara	An improved cultivar selected from 'Karimunda', high-yielding type with medium quality.
36	Thommankodi	A cultivar from central Kerala, moderately good in yield and quality.
37	Thulamundi	A Central Kerala cultivar, medium in yield and quality.
38	Uddagara	A popular cultivar of Karnataka, good yield and medium quality.
39	Vadakkan	A cultivar from North Kerala, medium quality and yield with relatively large berries.
40	Valliyakaniyakadan	A cultivar with larger leaves, medium yield and quality.
41	Vattamundi	A moderate yielder from Central Kerala.
42	Vellanamban	Relatively moderate yielder and medium quality characterized by the white colour of the young shoot-tip.

† Improved varieties.

the IISR, Calicut. Systematic surveys of all pepper-growing areas, the Western Ghat forests and part of the northeastern region of India are conducted to collect the existing variation of black pepper and *Piper* species and these accessions are being deposited at the National Repository of Black Pepper Germplasm at IISR, Calicut. At present, the IISR has the largest germplasm collection of black pepper in the world, consisting of nearly 2802 accessions. This includes a triploid cultivar ($2n$=78) and tetraploid line ($2n$=104), in addition to 213 accessions of cv. 'Karimunda' as well as 75 accessions of cv. 'Kottanadan', 430 accessions of wild relatives including about 100 accessions of wild *P. nigrum* and over 1000 F_1 and open-pollinated progenies.

Conservation of germplasm is done in four ways.

- In the nurseries, where each accession is trailed in bamboo splits in serial order and is under continuous multiplication.
- In the clonal repository, where 10 rooted cuttings of each accession are maintained.
- In the field genebank, where the accessions are planted for evaluation.
- In the *in vitro* genebank.

This multimethod conservation strategy is used because of the threat of diseases and pests (e.g. *Phytophthora* foot rot and nematodes). Characterization of the germplasm is done in a phased manner to evaluate the accessions for various qualitative and quantitative characters.

In addition to the germplasm collections at IISR, Calicut, some accessions of black pepper germplasm are also maintained under the All India Coordinated Research Project on Spices at the Pepper Research Station, Panniyur (KAU); Pepper Research Station, Sirsi; University of Agricultural Sciences, Dharwar; Regional Research Station, Chintapally, Andhra Pradesh Agricultural University and Horticultural Research Station, Yercaud, Tamil Nadu Agricultural University. The present status of black pepper germplasm holdings in these centres is given in Table 3.

Table 3. Black pepper germplasm under the All India Coordinated Research Project on Spices

Sl. no	Centre	Cultivated (including exotic)	Wild and related species	Total
1	Pepper Research Station, Panniyur, Kerala	75	120	195
2	Pepper Research Station, Sirsi, Karnataka	50	15	65
3	Regional Agricultural Research Station, Chintapally, Andhra Pradesh	27	19	46
4	Horticultural Research Station, Yercaud, Tamil Nadu	99	3	102

Biodiversity in cardamom

Cardamom (*Elettaria cardamomum* M.) belongs to the family Zingiberaceae. It is a tall herbaceous perennial with branching subterranean root stock. Cardamom is generally cross-pollinated and propagated through seedlings and suckers. However, selfing also takes place and this yields considerable variation in the progenies. Seedlings are raised from the fresh ripe capsules collected from the plantations, or from suckers taken from mother plants.

Ecosystem diversity and species diversity are very limited in cardamom. Most of the biodiversity in cardamom comes from varietal diversity (Madhusoodanan *et al.* 1994).

Table 4. Germplasm holdings of cardamom in India

Sl. no.	Conservatory	Germplasm holding		Total
		Cultivated	Wild and related taxa	
1	IISR Cardamom Research Station, Appangala, Karnataka	252	13	265
2	ICRI, Myladumpara, Idukki, Kerala	600	12	612
3	Cardamom Research Station, Pampadumpara, Idukki, Kerala	72	15	87
4	Regional Research Station, Mudigere, Karnataka	236	7	243
5	UPASI, Valparai, Tamil Nadu	45	–	45
6	Horticultural Research Station, Yercaud, Tamil Nadu	35	–	35

The generic name is probably derived from the ancient Tamil word 'elattari' meaning the seed of 'Elam'. Willis (1973) included seven species in this genus, distributed in the Indo Malayan-Indonesian region. However, only one species occurs in India, *E. cardamomum*, and this is the only species used as a spice. Two botanical varieties were recognized by earlier workers, namely var. *major* Thw. and var. *minor* Walt. or var. *cardamomum* M.). However, now var. *major* is treated as a separate species, *E. major* Thwaites (this is the native cardamom in Sri Lanka).

The origin of cardamom is not known. However, Holttum (1950) felt that *E. cardamom* and the Malaysian *Elettaria* represent parallel development from the genus *Alpinia*. Cardamom probably had an amphidiploid origin from wild species, and the two species considered to be the putative parents are the Sri Lankan cardamom *E. major* and the Malayasian species *E. longituba* (Ridl.) Holt.

Three types of varieties are distinguishable in cardamom based on the plant type:

1. Malabar: plants of medium size, panicle prostrate, capsule roundish to oblong.
2. Mysore: plants robust, panicles erect, capsules greenish and elongate.
3. Vazhuka: plants robust, panicles semi-erect, intermediate type between Malabar and Mysore.

Cardamom occurs in its native state only in the tropical evergreen forests of the Western Ghats. The wild

Table 5. Improved varieties of cardamom

Name	Type	Yield (kg/ha)		Capsule		Area of cultivation	Agency responsible and source of availability
		Rain-fed	Irrigated	Colour	Shape		
CCS-1	Malabar	408	–	Parrot green	Round	Karnataka	IISR, Appangala
ICRI-1	Malabar	325	656	Dark green	Round	Kerala	ICRI, Myladumpara
ICRI-2	Mysore	375	766	Parrot green	Long	Kerala and parts of Tamil Nadu	ICRI, Myladumpara
Mudigere-1	Malabar	300	–	Parrot green	Round	Karnataka	Regional Research Station (UAS), Mudigere
PV-1	Malabar	260	500	Green	Long	Kerala and Tamil Nadu	Cardamom Research Station (KAU) Pampadumpara
SKP-14	Malabar	439	599		Long bold	Karnataka	Indian Cardamom Research Institute, Regional Station, Sakleshpur

PRI 848
IISR Vijeta 500

population of cardamom started dwindling as a result of large-scale destruction of forest habitats. Conservation of cardamom genetic resources was initiated and they are now being conserved at the IISR (Cardamom Research Station, Appangala); Indian Cardamom Research Institute (ICRI), Myladumpara; Cardamom Research Station, Pampadumpara (Kerala Agricultural University) Regional Research Station, Mudigere; UPASI, Valpari and Horticultural Research Station, Yercaud (Table 4). Improved varieties of cardamom are listed in Table 5.

Biodiversity in ginger

Ginger (*Zingiber officinale* Rosc.) is a rhizomatous spice propagated exclusively through rhizomes. Even though ginger flowers profusely, seed set does not take place. Farmers preserve a portion of the rhizome from the previous harvest and use it as planting material in the next season. Seed rhizomes are maintained under sawdust/sand in storage pits. Species diversity and varietal diversity are the principal components of biodiversity in ginger (Mohanty and Sarma 1979; Ratnambal *et al.* 1985; Sasikumar *et al.* 1992b; Ravindran and Peter 1994; Ravindran *et al.* 1994).

The generic name *Zingiber* is derived from the Tamil word 'ingiver' meaning root of 'ingi' or ginger. Ginger is considered to have originated in South Asia, but its existence in the wild is yet to be established beyond doubt (Sasikumar *et al.* 1995). *Zingiber* is included in the tribe Hedycheae along with other genera such as *Curcuma*, *Hedychium* and *Kaempferia* (Holttum 1950) and in the series Zingiberae which contains only one genus, *Zingiber*. Baker (1894) divided the genus into four sections and *Z. officinale* is included in Section II, *Lampuzium*.

Table 6 Cultivar/varietal diversity in ginger

Sl. no.	Cultivar/variety	Sl. no.	Variety
1	Anamika	23	Rio-de-Janeiro†
2	Assam	24	Sargi guda
3	Arippa	25	Saw Thing laidum
4	Bajpal	26	Singhihara
5	Burdwan	27	Sierra - Leone†
6	China†	28	Suprabha‡
7	Ernad-chernad	29	Suruchi‡
8	Ernad Manjeri	30	Suravi‡
9	Edappalayam	31	Taiwan†
10	Himachal	32	Faffingiva
11	Jorhat	33	Thang-chang
12	Jugglgan	34	Thingpui
13	Jamaica†	35	Thing laidum
14	Karakkal	36	Thodupuzha
15	Kuruppampady	37	Tura
16	Kunduli Local	38	Uttarpradesh
17	Maran	39	Valluvanad
18	Mananthody	40	Varada‡
19	Nadia	41	Vengara
20	Narasapttam	42	Wynad Local
21	Poona	43	Wynad Kunnamangalam
22	Rajagarh Local	44	Zahirabad

† Exotic; ‡ Improved varieties (high yield).

Baker (1894) described a total of 24 species from the Indo-Malayan region. Gamble (1925) reported seven species from South India including *Z. officinale* Roscoe. However, none of these is related to cultivated ginger (*Z. officinale*) in quality and morphology though most species are cytologically $2n=22$. The seven species are: *Zingiber roseum* Roscoe ($2n=22$), *Z. nimmonii* Dalzeii, *Z. wightianum* Thwaites ($2n=22$), *Z. zerumbet* (Lin.) Smith ($2n=22$), *Z. neesanum* (Graham) Ramamoorthy (syn. *Z. macrostachyum* Dalzeii) $2n=22$, *Z. cernam* Dalzeii, and *Z. purpureum* Roscoe ($2n=22$) (syn. *Z. casumunar* Thwaites).

Ginger has been under cultivation since time immemorial. Good variation for yield and quality in cultivated ginger is encountered in North East India and Kerala. Geographical spread accompanied by genetic differentiation into locally adapted populations, caused by mutation, could be the main factor responsible for the diversity in this clonally propagated crop. The early movement of settlers across the length and breadth of Kerala and the story of shifting cultivation ('jhum') in northeastern India are well-documented sociological events (Ravindran *et al.* 1994). At present about 50 ginger cultivars, possessing various quality attributes and yield potential, are prevalent in India (Table 6), including a few of exotic origin. Most varieties are named after their place of origin/domestication.

Apart from ginger (*Z. officinale*), which is used as a spice and medicine, the other important economic species of the genus are *Z. zerumbet* and *Z. casumunnar* (used in medicine).

The National Conservatory of Ginger germplasm at IISR, Calicut has 530 accessions, including indigenous collections, exotic cultivars, improved lines, mutants, tetraploids and related species and taxa. These accessions are maintained in cement tubs in the field (*ex situ*) and in an *in vitro* genebank.

In addition to the IISR, Calicut collections, 147 accessions are maintained at the High Altitude Research Station, Pottangi (Orissa) and another 132 accessions are conserved at Dr Y.S. Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh.

Biodiversity in turmeric

Turmeric (*Curcuma longa* L., syn. *C. domestica* Val.) is a rhizomatous spice propagated mainly through rhizomes. However, viable seed set has been observed recently in this clonally propagated crop and open-pollinated progeny selection is an accepted breeding method for turmeric. Turmeric is adapted to cross-pollination (Nazeem and Rema Menon 1994).

Farmers generally use a portion of the rhizomes of the previous season as planting material in the next season. Seed rhizomes are preserved under sawdust/sand in storage pits.

The genus *Curcuma* is mainly Indo-Malayan in distribution and includes about 100 species. Species diversity, morphotype diversity and varietal diversity are characteristic of this genus (Philip and Nair

1986; Geetha and Prabhakaran 1987; Nirmal Babu *et al.* 1993; Velayudhan *et al.* 1994).

The genus *Curcuma* belongs to the family Zingiberaceae, which has a wide distribution and contains 49 genera and 1400 species. Valeton (1918) divided the genus into two subgenera, *Paracurcuma* and *Eucurcuma*. The two species coming under *Paracurcuma* are *C. aurantiaca* Van Zijip and *C. ecalcarata* Sivar & Indu. Under *Eucurcuma*, three main sections (*Tuberosa, Nontuberosa* and *Stolonifera*) are proposed.

Baker (1894) described 27 species of *Curcuma* in the Flora of British India. Seventeen species are reported from South India (Sabu 1991). Velayudhan *et al.* (1994) reported a total of 40 species as occurring in India (Table 7). Eight species – *C. coriaceae, C. ecalcarata, C. harita, C. kudagensis, C. montana, C. neilgherrenis, C. raktakanta* and *C. vamana* – are reported to be endemic to India (Velayudhan *et al.* 1994).

Among the related species *C. aromatica* is important in medicine and in the preparation of toiletry articles. *Curcuma amada* (mango ginger) is used as a vegetable, while *C. zedoaria*, the Indian arrowroot, is a major source of starch in many parts of India. *Curcuma angustifolia, C. caulina, C. montana, C. leucorrhiza, C. decipiens, C. raktakanta, C. pseudomontana, C. erubescens, C. xanthorrhiza, C. malabarica* and *C. harita* are also reported to be useful for arrowroot preparation (Velayudhan *et al.* 1994).

Even though no distinct taxonomical varieties are established in *C. longa*, the cultivated turmeric, there are about 60 agricultural varieties or cultivars (Table 8), which are named after the place of origin or cultivation. These cultivars are popular in their respective areas of cultivation. Agronomic and quantitative differences are noted in their performance (Velayudhan *et al.* 1994).

Collecting and conservation of genetic resources of *Curcuma* are pursued actively by IISR, Calicut and NBPGR Regional Station at Trichur, Kerala. The National Conservatory of Turmeric germplasm at IISR has currently 715 accessions of *Curcuma*, all maintained in large cement tubs in the field (*ex situ*) and also partly at the *in vitro* germplasm conservatory. Turmeric germplasm collections are also maintained at NBPGR, Regional Station, Trichur, Kerala (550 accessions), High Altitude Research Station, Pottangi, Orissa (157 accessions), Regional Agricultural Research Station, Jagtial, Andhra Pradesh (188 accessions) and Dr Y.S. Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh (164 accessions).

Table 7. List of *Curcuma* species occurring in India

Sl. no.	Species [Somatic chromosome number (2*n*)]
1	*Curcuma aeruginosa* Roxb
2	*C. albiflora* Thw.
3	*C. amada* Roxb. (42)
4	*C. amarissima* Rosc.
5	*C. angustifolia* Dalz & Cibs. (42, 64)
6	*C. aromatica* Salisb. (42)
7	*C. aurantiaca* Van.
8	*C. brog* Val.
9	*C. caesia* Roxb.
10	*C. cannanorensis* Ansari & Nair
11	*C. caulina* F.
12	*C. comosa* Roxb.
13	*C. coriaceae* Mangaly & Sabu
14	*C. decipiens* Dalz. (42)
15	*C. ecalcarata*, V.V.Sivarajan and Indu Balachandran
16	*C. erubescens* Roxb.
17	*C. ferrugenia* Roxb.
18	*C. harita* Mangaly and Sabu
19	*C. inodora* Blat.
20	*C. karnatakensis* Amalraj *et al.*
21	*C. kudagensis* K.C. Velayudhan *et al.*
22	*C. leucorrhiza* Roxb.
23	*C. longa* Linn. (32, 62, 63, 64)
24	*C. lutea* Ansari & Nair
25	*C. malabarica* K.C. Velayudhan *et al.*
26	*C. montana* Roxb.
27	*C. neilgherrensis* Wight.
28	*C. nilamburensis* Sp.nov. K.C. Velayudhan *et al.*
29	*C. oligantha* Trim.
30	*C. petiolata* Roxb. (64)
31	*C. pseudomontana* F.
32	*C. raktakanta* Mangaly and Sabu
33	*C. reclinata* Roxb.
34	*C. soloensis* Val.
35	*C. sulcata* Haines
36	*C. sylvatica* Val.
37	*C. thalakaveriensis* K.C. Velayudhan *et al.*
38	*C. vamana* Mangaly & Sabu
39	*C. xanthorrhiza* Roxb.
40	*C. zeodaria* Rosc. (63, 64)

Source: Velayudhan *et al.* 1994.

Table 8 Cultivar/varietal diversity in turmeric (*C. longa*)

Sl. No.	Cultivar/variety	Sl. No.	Cultivar/variety
1	Armur	32	Lokhande
2	Alleppey	33	Lekadong
3	Avanigadda	34	Mundage
4	Amruthapani	35	Mydukkur
5	Amalapuram	36	Nandyal
6	Balaga	37	Pattani
7	Bilaspur	38	Panamalur
8	Bullapura	39	Pakistan
9	BSR -1*	40	Perumnadan
10	C-A-72 Udayagiri	41	Prabha†
11	C-A-12	42	Prathibha†
12	CLL - 324	43	Rajapuri
13	CLL - 328	44	Renuka
14	Chinnanadan	45	Ranga†
15	Chayapaspu	46	Rasmi†
16	Co-1*	47	Rajendra Sonia†
17	Deshi	48	Roma†
18	Duggirala	49	Shimla
19	Dundrigam	50	Soni
20	Dughi	51	Sugantham†
21	Erode Local	52	Suguna†
22	Ethamukkala	53	Suvarna†
23	Gorakpur	54	Sudarsana†
24	Guntur	55	Suroma†
25	GL Puram	56	Thekkurpetta
26	Jabedi (G - 67)	57	TSundar
27	Kasturi	58	Thalachira
28	Kasturi Tanaka	59	Yelachage
29	Katpadi Local	60	Vombinitta
30	Krishna	61	Vonimitta
31	Kothapetta	62	Wayanadan

† Improved variety.

Diversity in tree spices

Nutmeg, clove and cinnamon are the common tree spices grown in India (Krishnamoorthy *et al.* 1995). Allspice, another tree spice introduced lately, is also attaining popularity.

Nutmeg: Nutmeg (*Myristica fragrans* Hort. (Myristicacea) is indigenous to the Moluccas Islands in Indonesia. It was introduced into India during the 18th century. At present, the crop is very popular in Kerala, Tamil Nadu and Karnataka states. The tree is dioecious in nature. It is propagated by vegetative propagation methods such as epicotyl grafting and budding, as well as by seed.

The family Myristicaceae has about 18 genera and 300 species. *Myristica* is the most primitive genus of the family (Sinclair 1958). The related species of *Myristica* in India are *M. amygdalina, M. andamanica, M. attenuata, M. dactyloides, M. gibbosa, M. glabra, M. glaucescens, M. irya, M. koingii, M. longifolia, M. magnifica* and *M. malabarica*. The National Repository of nutmeg germplasm at IISR, Calicut has 453 accessions of *Myristica*, including 405 accessions of *M. fragrans* and 18 accessions of related taxa.

The seeds and mace of *M. fragrans* are used as a spice and medicine. Some of the wild *Myristica* spp. are used by the dye industry (e.g. *M. magnifica* and *M. malabarica*) and in tribal medicine.

There are no recognizable agricultural varieties/cultivars. However, many elite trees do exist. A few high-yielding accessions have also been conserved in the IISR germplasm conservatory, Calicut. The lack of genetic variation in the nutmeg population of India has been reported (Krishnamoorthy *et al.* 1994, 1995). This is expected as the present-day population is derived from a narrow genepool, introduced by the British during the 18th century.

Clove: Clove (*Syzygium aromaticum* L.) Merr. & Perry [syn. *Eugenia caryophllata* (Sprengel) Bullock & Harrison] belongs to the family Myrtaceae. Like nutmeg, it is also indigenous to the Moluccas Islands, from where it has spread to many tropical and subtropical countries. It was introduced to India during the 18th century by the British. At present, clove is an important tree spice grown in Kerala, Tamil Nadu and Karnataka. The dried, aromatic, fully grown but unopened flower buds are used as spice and in medicine. The flower is self-pollinated in nature and seed propagation is the general rule.

Clove belongs to the genus *Syzygium* Gaertn. with about 500 species. Many species of *Syzygium* occur in Kerala and in the Western Ghat forests; the more important ones are *S. arnottianum* (Wight) Walp., *S. cuminii* (L.) Skeels, *S.fruticosum* (Roxb.) DC, *S. jambos* (L.) Alston and *S. zeylanicum* (L) DC. However none of these species is closely related to the cultivated clove.

As in nutmeg, no agricultural variety/cultivar has been identified in clove. Clove flowers are bisexual and self-fertilization is common. In fact, lack of exploitable variation for many of the vegetative and reproductive characters of progenies of certain elite trees is reported (Krishnamoorthy and Rema 1994a). However a few distinct morphotypes such as dwarf, bushy and king cloves are observed in India. The national conservatory of clove germplasm at IISR, Calicut maintains 187 accessions, including two exotic collections, one each from Zanzibar and Sri Lanka.

Cinnamon: The true cinnamon comes from *Cinnamomum verum* Presl. (syn. *C. zeylanicum* Blume) belonging to Lauraceae. The genus *Cinnamomum* consists of about 250 species (Willis 1973) comprising evergreen trees and shrubs, occurring in the Asiatic mainland to Formosa, the Pacific Islands and Australia. Hooker (1886) reported 25 species from the Indian subcontinent, mainly from the Western Ghats and North Eastern India. Ridley (1924) reported 10 species in Indo-Malaya, China, Australia and Polynesia. Gamble (1925) described 11 species of *Cinnamomum*, mainly from the Western Ghats forests; Kostermans (1983) described 13 species from South India, most of them from the Western Ghats.

Cinnamon, though considered indigenous to Sri Lanka, occurs rarely in the Western Ghats and this region can be considered as the secondary centre of origin of the species. The crop is adapted to cross-pollination but the structure of the canopy facilitates selfing as well. The tree is propagated through seedlings.

In addition to the true cinnamon (*Cinnamomum verum*), the other economically important species are Chinese cassia [*C. cassia* Bercht. & Presel. (syn. *C. aromaticum* Nees], Indonesian cassia (*C. burmannii* C.G. and Th.Nees) Bl., Saigon cassia (*C. loureirii* Nees) and Indian cassia (*C. tamala* Nees). Among the economically useful related taxa, *C. camphora* L. Bercht. and Presl. is important as a source of camphor.

The wild species of cinnamon (*C. malabatrum, C. macrocarpum, C. riparium* and *C. nicolsonianum*) are in danger of extinction because of indiscriminate bark extraction from them.

The tree spices germplasm conservatory at IISR, Calicut has 206 accessions of *C. verum* and 44 accessions of related taxa.

In cinnamon nine elite lines are identified based on quality analysis and yield (Krishnamoorthy and Rema 1994b), out of which two lines have been released as 'Navashree' and 'Nithyashree'.

Vanilla: Vanilla [*Vanilla planifolia* Andr., syn. *V. fragrans* (Salis Ames) Orchidaceae] is a climbing orchid native to tropical America and was introduced to India in 1835 (Sasikumar *et al.* 1992). This plant is the source for natural vanillin, which is extracted from mature, processed fruits (called pods or beans). *Vanilla walkeriae* Wt., *V. wightiana* Lindi and *V. vatsalae* are leafless forms occurring in India. *Vanilla planifolia, V. vatsalae, V. pilifera* and *V. andamanica* are conserved at IISR, Calicut, Kerala. The Indian Cardamom Research Institute (ICRI), Myladumpara, Kerala, Tropical Botanical Garden and Research Institute (TBGRI), Pacha, Palode, Trivandrum, Kerala is also involved in *Vanilla* germplasm conservation.

Conclusions

Cultivar and species diversity of black pepper in India are fairly rich. Vegetative propagation coupled with viable sexual reproduction (selfing) in black pepper helps to fix any new variation in the population. Variability in the cultivated types has perhaps evolved in this way. The perennial nature of the vines coupled with the vegetative propagation technique help to maintain the diversity without much difficulty. However, deforestation, disease epidemics and the spread of a few elite varieties pose a threat to black pepper diversity. Apart from the collecting and conservation of these landraces, it is also necessary to have species-specific and habitat-specific strategies of *in situ* conservation. This will strengthen *ex situ* and *in vitro* conservation strategies of black pepper. The scenario is equally true for cardamom.

Lack of sexual reproduction, use of seed rhizomes of the previous harvest by the farmers as planting units, and homestead gardening help to maintain the existing diversity in ginger. Though viable sexual reproduction takes place in turmeric, vegetative propagation through rhizomes helps to preserve the diversity. Thus the level of variation in these crops is preserved rather stably and the conservation strategy is evolved accordingly. Currently the diversity is conserved under *ex situ* and *in vitro* conditions.

Cultivar diversity in tree spices like nutmeg, clove and cinnamon is limited. Attempts are being made to collect maximum diversity (cultivar) from farmers' plot and the Western Ghat (species). However, the vegetative mode of propagation coupled with seed propagation is a boon in these crops to generate and preserve the diversity. The collected diversity is now preserved under *ex situ* conditions. In the case of vanilla, concerted efforts are warranted for building up diversity and also for evaluation as well as documentation of the available genetic diversity.

Molecular marker aided characterization is now being used in conjunction with conventional techniques to characterize the spice germplasm.

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