GENETIC RESOURCES IN SPICES—THEIR DIVERSITY AND UTILISATION IN INDIA

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INTRODUCTION

Spices were major articles of trade between India and the Middle East in the ancient and medieval periods. These found their way to western Europe through the Arab traders. The western powers were vying with one another to establish a trade route to India which culminated in Vasco da Gama's landing in the Malabar coast in the 1498 A.D. The Malabar coast was the centre of the spices trade, as many of the precious spices came from the forest areas of this region. Black pepper, cardamom, cinnamon, ginger and turmeric were regularly exported from this region from ancient times, a tradition which the region still maintains.

CENTRES OF DIVERSITY IN SPICES

About 50 spices are now grown in India, several of these from ancient times. Black pepper, cardamom, ginger and turmeric are the major spices, now grown commercially. Both black pepper and cardamom have their centres of diversity in the evergreen forests of Western Ghats. Wild related taxa of the major spices reported from the Indian sub-continent and from the Western Ghat forest areas are given in Table 1.

The species of *Piper* are distributed mainly in the tropical and sub-tropical regions of the world, main centres being Central and South America and Southern Asia (Trelease and Yuneker, 1950). Two independent centres of distribution are recognised in the Indian sub-continent viz., Trans-Gangetic region and South Deccan. Even though 108 species of *Piper* have been recorded from the Indian sub-continent, only two species viz., *P. nigrum* and *P. longum* are known to be widely cultivated.

Cardamom (*Elettaria cardamomum*) occurs in the evergreen forests of Western Ghats, India and also in Sri Lanka. The genus *Elettaria* has seven species in the Indo-Malaysian region (Willis, 1966). Under cultivation, three distinct varieties are recognised; those having prostrate panicles (*Malabar*), erect panicles (*Mysore*) and the semi-erect panicles

Table 1. Wild relatives of major spices crops

Crop	Number of species (Indian sub-continent)	No. of species (W. Ghats)	Economically important spices
Black pepper	44	13	*Piper nigrum* L. (spice), *P. longum* L., *P. mullesua* Ham., *P. cubeba* L. *P. methysticum* Forst., *P. chaba* Hunter, *P. sylvaticum* Roxb. *P. aurantiacum* Wall, (Medicinal uses) *P. betle* Linn. (in chewing)
Cardamom	1	1	*Elettaria cardamomum* Maton (spice)
Cinnamon	26	15	*Cinnamomum cassia* Presl., *C. verum* Presl. *C. tamala* Nees & Eberm *C. obtusifolium* Nees., *C. malabathrum* Batkn., *C. macaocarpum* Hook, *C. glanduliferum* Meissn. *C. parthenoxylon* Meissn., *C. camphora* (L.) Nees. & Eberm. (spice, aromatic medicinal use)
Ginger	24	7	*Zingiber officinale* Rosc. (Spice & medicinal) *Z. zerumbet* L. (Sm.), *Z. casumunar* Roxb. (medicinal)
Large cardamom	48	5	*Amomum xanthioides* Wall, *A. aromaticum* Roxb. *A. costatum* Benth. (medicinal & aromatic) *A. subulatum* Robx. (medicinal & aromatic)
Turmeric	29	8	*Curcuma domestica* Val. (spice, aromatic & medicinal) *C. aromatica* Salisb. (aromatic & medicinal), *C. zedoaria* (Berg.) Rosc., *C. caesia* Roxb. (medicinal & aromatic) *C. amada* Roxb (mango ginger); *C. anguistifolia* Roxb. (East Indian arrow root) — (Food tubers)

(Vazhuka), the latter being a hybrid between the *Malabar* and *Mysore* types. Abraham and Tulsidas (1958) are of the opinion that the genus *Elettaria* is a 'cenospecies' with a single ecospecies corresponding the taxonomic species—*E. cardamomum* Maton. This ecospecies consists of two ecotypes, *major* and *minor*. They recognised a local type *laxiflora* in the ecotype *major*. The ecotype *minor* is divided by Abraham and Tulsidas (1958) into three main local populations or local types *travancorica*, *oblongata* and *kanarensis* grown in the Western Ghats of Kerala, lower Pulneys and Uttara Kannada area of Karnataka, respectively.

Ginger (*Zingiber officinale*) is found only in cultivation and is native of Tropical Asia. It may be the first oriental spice to be introduced to the New World (Rosengarten, 1973). Though the country of origin is not known with certainty, it is presumed to be in the region of India or China (Purseglove, 1977). Burkill (1935) presumed that the cultivated ginger did not originate in the Malaysian region. *Z. zerumbet*, *Z. cassumunar* and *Z. wightianum* are some of related species widely distributed in the forests of the Western Ghats.

Turmeric (*Curcuma* spp.) also has a wide diversity in species and their variants. Though the source of cultivated species of turmeric is not known with certainty, it has become naturalised in several areas specially in the north eastern parts of India and the Island of Java.

Variability is also available for several tree and minor grain spices which were introduced but later have adapted and built up diversity. These are discussed later.

Germplasm Holdings in Spices and Condiments

In pepper, ginger, turmeric and cardamom, India has the largest collection of germplasm in the world. The present germplasm holdings in spices at various research centres in India are listed in Table 2. These are mostly indigenous collections, barring a few introductions in the case of ginger. In all the spices there is considerable scope for enriching the existing genetic variability through intensive collection and further introductions.

In black pepper, considerable variability exists within and among the cultivars. Table 3 lists variations exhibited in quality characters such as oleoresin, piperine and essential oil content. In the recent past many of the traditional cultivars have been replaced by a few high yielding ones, the high market price of black pepper, having accelerated the process of genetic erosion.

High genetic variability is found in the wild population of *Piper nigrum* as well. Recently, a new bisexual species (*P. silentvalleyensis*)

Table 2. Germplasm holdings in spices at various centres in India

Crop	Centres	Germplasm accessions
Black Pepper	NRCS, Calicut	236
	Panniyur	216
	Sirsi	21
	Chintapalli	27
Ginger	NRCS, Calicut	120
	Pottangi	85
	Solan	25
	Vellanikkara	21
Turmeric	NRCS, Calicut	184
	Pottangi	151
	Solan	47
	Vellanikkara	59
	Jagtial	14
Cumin	Jobner	200
	Jagudan	157
Fennel	Jobner	120
	Jagudan	182
Cardamom	NRCS, Calicut (Appangala)	226 and 13 related taxa
	Pampadumpara	71
	Mudigere	74
	Yercaud	12
	Gangtok	25
Coriander	Jobner	400
	Jagudan	301
	Guntur	505
	Coimbatore	230
Fenugreek	Jobner	115
	Jagudan	170
	Guntur	34
	Coimbatore	399
Nutmeg	NRCS, Calicut	303*
Clove	—do—	152*
Cinnamon	—do—	170

*The genetic variability available in India is negligible. These are only progenies from certain mother trees.

and a new variety of *P. nigrum* (*P. nigrum* var. *virtellosum*) were reported by the authors from the Silent Valley forests of Kerala (P. N. Ravindran, M. K. Nair and R. Asokan Nair—under publication).

For cardamom, NRCS and the centres of the All India Co-ordinated Scheme on Spices together have a rich collection of genetic variability.

Table 3. Variability in quality characters in some selected *Piper* cultivars

Cultivar	Vol. of 1000 berries (cc)	Wt. of 100 berries (gm)	Dryage %	Oleoresin %	Oil %	Piperine %	Starch %
Arakkulam Munda	107	117.500	37.5	12.90	4.75	4.50	24.66
Balancotta	131	138.200	30.0	9.35	5.10	4.26	25.20
Ceylon	76	80.340	40.0	13.50	3.75	7.60	15.70
Cheriakaniakkadan	75	82.30	30.0	9.05	3.75	3.4	24.80
Chumala	150	162.480	33.3	5.45	2.15	3.3	46.60
Doddegya	170	178.300	30.00	7.10	2.50	2.85	36.00
Kalluvally (1)	115	117.100	37.5	8.77	3.25	4.24	31.50
Kalluvally (PTB)	109	118.930	35.0	10.86	0.40	4.65	29.00
Kaniakkadan	91	95.210	30.0	11.60	4.75	6.00	12.40
Karimunda	108	113.450	35.0	11.00	4.00	4.40	39.60
Karivilanchy	134	144.700	32.50	9.70	3.50	4.30	27.00
Kottanandan	103	108.600	37.50	17.80	2.50	6.60	23.40
Kuthiravally	98	103.070	35.70	19.90	4.50	6.00	14.00
Munda	103	114.080	33.30	7.50	3.30	3.60	23.40
Narayakkodi	92	97.150	37.50	10.85	4.00	5.40	24.50
Nilgiris	131	166.050	30.00	15.50	5.50	6.05	23.60
Palulauta	93	99.670	30.40	7.60	3.00	3.60	19.30
Panniyur-1	148	165.640	36.40	9.52	3.50	3.60	35.10
Perumkodi	108	102.310	33.30	8.56	3.00	4.00	28.80
Shimoga	99	105.830	40.00	7.20	2.50	4.56	17.60
Perumunda	99	112.310	33.30	7.97	4.00	7.40	26.60
Sullia	120	229.450	32.50	6.80	4.00	3.60	20.70
Taliparamba-11	105	192.770	35.00	10.80	2.50	5.80	32.60
Uthirancotta	180	188.270	42.81	8.55	4.75	3.92	28.80
Vally	140	146.390	30.00	6.53	2.50	4.90	16.00

(Raju, Ravindran and Nair, 1983)

Variation in quality traits and composition have also been observed, especially in the main constituents of the essential oil—1-8 Cineole and alpha terpinylacetate. 1-8 Cineole gives a harsh camphoraceous flavour to the oil, and the lower the content of this, the better will be the flavour.

Ginger and turmeric are cultivated in many parts of India. Large numbers of types are known to occur in various tracts differing in rhizome characters, yield and quality characters. Several wild species are used in indigenous medicines (*Z. zerumbet*, *C. aromatica*), in toiletory (*C. aromatica*) and as food (*C. zeodaria* and *C. angustifolia*).

The tree spices grown in India, mainly in the State of Kerala, are nutmeg, cloves and cinnamon. The prevalent variability is negligible.

This has been assembled at NRCS, Calicut. Enrichment of the genetic base of these crops is essential for carrying out any meaningful crop improvement programme.

The nutmeg tree (*Myristica fragrans*) is currently grown in India in isolated pockets in Kerala, Tamil Nadu and Karnataka. The present trees are direct descendents of introductions made by the Europeans about 150 years ago. This species is dioecious and male and female trees occur in almost equal proportions in progenies. Since the species is an obligatory cross-fertilised crop, the variability available for growth and vigour, size and shape of nutmeg and weight of mace is considerable. In order to broaden the genetic base, introductions from the centres of origin/ diversity would be of immense value. Clove, *Eugenia caryophyllus* is grown mainly in Tamil Nadu and Kerala, and the present populations have been derived from the limited introductions by missionaries towards the end of eighteenth century from Mauritius. Cinnamon (*Cinnamomum* sp.) has comparatively wider genetic base in India among the tree spices. 16 species are reported from peninsular India. In *Cinnamomum verum*, variations in leaf shape, flush colour, inflorescence size, leaf and bark, oil contents, etc. are common in the germplasm collections available at NRCS. Fifteen taxa allied to *C. verum* are reported from South India (Kostermans, 1983). The bark of some of these (*C. malabaricum, C. macrocarpum*) are used for adulterating the bark of *C. verum*, and are also used in the manufacture of agarbathi.

Chinese cassia (*Cassia aromaticum*) is used synonymously with cinnamon in the American market. In the 1950's India was the second largest importer of *Cassia* in the world (after the US), but now only a negligible quantity is being imported (Pruthi, 1980). A few trees of *C. aromaticum* are available with a private plantation in the Nilgiris, and limited number is also known to be present in the Himachal Pradesh and Darjeeling areas. There is much scope for the cultivation of this species in hill areas of South India, and for introducing better types from the centre of diversity to enrich further the existing genetic variability.

Saffron (*Crocus sativus*), the costliest of all spices, is grown exclusively in the Kashmir Valley, India (Anon., 1986). It occupies an area of about 2000 ha and the annual production is around 5500 kg. Introduction of improved lines from Spain, Italy and France may be considered to enrich the germplasm base (Nauriyal *et al.*, 1977).

Coriander, cumin, fennel and fenugreek are the most common minor spices grown in India and are all introduced but have become major crops. Rajasthan, Andhra Pradesh, Madhya Pradesh and Tamil

Nadu are the main coriander producing states. Both the bold-seeded type (*Coriandrum sativum* var. *vulgare*) and the small-seeded types (*C. sativum* var. *microcarpum*) are under cultivation. Though the germplasm holdings in India contain many accessions introduced from other countries, much scope exists for further enrichment of the genetic resources by introduction from Morocco, Soviet Union and the Mediterranean countries. For cumin (357), accessions in Jobner and Jagudan exhibit much variability. Considerable scope exists to broaden the genetic base for improving yield and quality and resistance to diseases. Fennel is a perennial herb native to the Mediterranean region. In India, an estimated 20,000 tonnes of fennel seed is produced annually (Anon. 1986); crop is mainly grown in Rajasthan, Uttar Pradesh and Gujarat. Over 300 accessions of fennel are available at the Jobner and Jagudan centres of the All India Co-ordinated Spices Improvement Project exhibiting much variation. Selection work has led to the identification of certain high yielding lines such as UF 101 and UF 112. Fenugreek is an erect growing annual herb indigenous to the Western Asia and South eastern Europe. This spice has been under cultivation in India, North Africa and in the Mediterranean countries for a long time and India, France, Egypt and Argentina are the main fenugreek producing countries. At present, 718 germplasm accessions are available at four centres viz., Jagudan, Jobner, Guntur and Coimbatore.

Utilisation of Genetic Variability

Black pepper germplasm assembled at NRCS is being used for crop improvement work for evolving high yielding lines with resistance/ tolerance to diseases and pests affecting black pepper production: the quick wilt (foot rot) caused by *Phytophthora palmivora* (Sharma *et al.*, 1980), the slow wilt (pepper yellow) caused by the nematode *Radopholus similis* and *Meloidogyne incognita*, another major endoparasitic nematode; and to 'pollu beetle', a major pest of pepper. *P. colubrinum* a distantly related species, was found to be resistant to *P. palmivora*; while one cultivar was found tolerant to *M. incognita*, all the cultivars screened so far were susceptible to *R. similis* (Ramana and Mohandas, 1986). Inter-cultivar hybridisation, induced mutation and selection in segregating population are used for locating tolerance/resistance to the above mentioned pathogens. The germplasm collections are also being screened for drought tolerance. Most of the cultivars have been evaluated for adaptability and quality parameters (piperine, essential oil and oleoresin) and the cultivars have been grouped under low, medium and high quality classes (Gopalam and Ravindran, 1986). Certain high quality types such as Kottanadan, Kumbhakkodi and Aimpiriyan have been incorporated into the breeding programmes.

In turmeric, evaluation of over 180 germplasm lines at NRCS has led to the selection of a new high yielding cultivar PCT-8-Suvarna. From Coimbatore also, a new turmeric cultivar has been recently released.

Ginger germplasm has been screened for rhizome rot caused by *Pythium* sp. (Sharma and Nambiar, 1979) but no resistant lines were obtained. Indrasenan *et al.*, (1982) screened the germplasm lines against the bacterial wilt pathogen, *Pseudomonas solanacearum* and identified three mildly susceptible lines and 13 moderately susceptible lines. Relative tolerance to *Phyllosticta* causing severe leaf spot of ginger, has been recorded for two cultivars only. It may also be mentioned here that the omnipresence of the *Pythium* rot and bacterial wilt makes it difficult even to maintain the germplasm of ginger, and methods like *in vitro* conservation may have to be used for germplasm maintenance. Efforts are now being concentrated to create large scale somaclonal variations through tissue culture and screening for disease resistance.

In cardamom, evaluation of the germplasm for yield was carried out at the Co-ordinated Project centres of Mudigere, and Pampadumpara and at the NRCS, Appangala. Some of the superior lines developed in these centres are now under evaluation in multilocation trials. The collections are also being screened for quality characters especially to locate lines having high essential oil and low 1-8 cineole. Mutation breeding was used to identify 12 'Katte' resistant lines, which are undergoing yield evaluation. Both induced mutations and somaclonal variations through tissue culture are being employed to generate more variability. Collection of escapes from hot spot areas of 'Katte' virus disease and evaluation for drought tolerance is also being done. In cinnamon, selection for high leaf oil and bark oil contents was carried out and ten high quality lines identified.

In the grain spices (coriander, cumin, fennel and fenugreek) the germplasm resources were utilised mainly for yield improvement. In all over 1,400 coriander accessions are available in the various centres (Jobner, Jagudan, Guntur, Coimbatore and all centres of the All India Co-ordinated Spices Improvement Project). The Mysore variety of coriander having high content of geranyl acetate and giving a sweet floral odour (instead of the sharp spicy odour of common coriander oil) definitely needs attention, and should be introduced into the breeding programmes. There is also a need to introduce high yielding cultivars from Morocco, as these are fetching higher value in the world market due to better quality. Not much effort has so far been made to utilise the germplasm to evolve varieties resistant to *Fusarium* wilt. This also requires immediate attention.

The gene pool of saffron is very poor in India and its enrichment is urgently required. One worthwhile attempt here is to breed varieties adapted to semi-temperate types that can be grown during the winter season in the north Indian plains. Moreover, in the Kashmir valley there is considerable scope for extending the cultivation of saffron.

Conclusion

The genetic resources of the spice crops require further enrichment from diverse sources. Preservation of the existing gene pool resources is of vital importance in the context of the rapid gene erosion due to a variety of causes. In crops like ginger, where even the maintenance of germplasm has become difficult as a result of diseases, alternate methods are to be developed for the preservation of rhizomes. Efforts should be made by all the organisations concerned, to collect and preserve the genetic variability in the various spice crops to maintain the country's pre-eminence position in spices production and export.

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