# Plant Diversity and Ethnobotanical Knowledge of Spices and Condiments

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#### 12.1 Introduction

Spices and condiments are used for flavoring the food and beverages. They may be defined variously that "Spices are plant parts like seed, bark, berries, buds, floral parts, fruits, kernels, leaves, rhizome, latex etc., which impart strong flavor or aroma to food or drinks" [1]. These aromatic vegetable products are used in the whole, broken, or in ground form to season food rather than for nutrients [2]. The meaning of spice derived from Latin term *spec*, the noun alluding to appearance or kind. Traditional medicinal practices are using herbs including spices, in Indian subcontinent and Chinese proximities dating back to at least 4000 BCE. In popular culture, spices usage was also connected with magic, religion, tradition, and cultural rituals. Condiments on the other hand are usually a combination of herbs and spices blended in a liquid form. Condiments are prepared food, mainly preserved or fermented and used in invariable quantities depending on diner's taste [3]. However, International Organization for Standardization [4] defines spices and condiments, do not show any clear-cut differences, and can be clubbed together under one term "spices and condiments," whichever used for flavoring and seasoning, including meat preparation, baking, confectioning, and other food processing and preserving.

India is bestowed with rich ethnic and cultural diversity. There are about 440 ethnic communities in this region [5]. India is also one of the mega biodiversity countries that has the one of the world's richest plant diversity reservoir supporting about 50% of India's biodiversity [6]. Most of the ethnic communities residing in hilly tracts and slopes form small, isolated remote villages. The ethnic people mostly depend on natural resources from the nearby forest for their food, livelihood, and ailments. They are repository of indigenous knowledge system belonging to agriculture, food, medicine, etc. As they have very good knowledge of their natural resources, the local crops, wild plants, ethnic vegetables, and indigenous fruits are mainly used in their local diet for food [7]. They use varieties of plants

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in ethnic food for flavoring, seasoning, coloring, and food preservation as well. About 60 varieties of spices are grown in India [8], which are well-documented from ancient period onward [9].

The important spices traditionally traded throughout the world are mostly products of tropical environments. The major exceptions to this group are the capsicums (chilli, paprika) and coriander, which are grown over a much wider range of tropical and nontropical environments as well. Production of spices and essential oils in these wet and humid environments brings special difficulties for crop and product management. Drying the crop to ensure a stable stored product is of particular importance, and in wet humid environments, this creates the need for efficient and effective drying systems. In the passage of time, the uses of the spices have steadily increased; in culinary art, beverages, confectionery, liquors and cordials, perfumery, cosmetic industry, and even notably as medicines. Today, the principal uses of spices in medicine lie with their adjuvant and alleviative qualities [10].

Spices are even more important today all around the world for improving taste and clamor of food items. Most of the spices are rich sources of essential oils. Essential oils are volatile liquid products of steam or water distillation of plant parts such as leaves, stems, bark, seeds, fruits, roots, and plant exudates. An essential oil may contain up to several hundred chemical compounds, and this complex mixture of compounds gives the oil its characteristic fragrance and flavor. Usually spices are used directly or indirectly in several industries such as cosmetics, perfumery, medicine, and pharmaceutical. The main properties of spices are antioxidants, antimicrobial, antibiotic, and preservatives. Spices are also used for coloring the foodstuff [11]. Many leafy spices are sometimes used as "herbal" teas for improving general health. Apart from enhancing the taste and flavor of food, spices have been widely believed to exert digestive stimulant action. A few medicinal properties of spices such as tonic, carminative, stomachic, diuretic, and antispasmodic have long been recognized [12].

# **12.2** Habitat and Diversity of Major Spices and Condiments in India

India is historically known as the "The home of spices." India has produced the largest quantity spices and condiments and also consumed and exported highest level significantly when compared to other countries. The diverse agroclimatic regions across the subcontinent offer tropical, subtropical, and temperate conditions, suitable to grow almost all such species [13]. Among the 109 spices listed by International Organization for Standardization [4], India grows about 60 species and Indian spices flavor foods in over 130 countries of the world [14]. In India, at least 52 spices are being cultivated including tree spices, seed spices, and herbal spices. Most of these spices can be grown alone or in combination with other crops as a system. The choice of crops depends on the physiography, topography, soil, climate, and the market demands. Major spices, namely black pepper, cardamom, vanilla, ginger, turmeric; tree spices nutmeg, clove, cinnamon, allspice (dried unripe berry of Pimenta dioica) and garcinia; and seed spices, coriander, fennel, mustard are ideal crops for inter or mixed cropping [15]. Some of the important Indian spices and condiments with scientific name, family name, useful part, common name, distribution in Indian states, and their cultivation status are summarized family-wise in Table 12.1. Phenotypic images of selected spice plants also provided in Figure 12.1.

 Table 12.1
 Diversity and distribution of spices and condiments in India.

Family	Botanical name	Part(s) used	Common name(s)	Distribution	Cultivation status
Acoraceae	Acorus calamus L.	Rhizome	Sweet flag, myrtie flag, calamus, flag root	Throughout India	Cultivated
Amaryllidaceae	Allium ascalonicum L.	Bulb	Shallot	Assam, Tripura	Cultivated
Amaryllidaceae	Allium cepa L.	Bulb	Onion	Throughout India	Cultivated
Amaryllidaceae	Allium cepa var. aggregatum	Bulb	Potato onion	Assam, Maharashtra	Cultivated
Amaryllidaceae	Allium fistulosum L.	Bulb, leaves	Japanese bunching onion, stony leek	North eastern India	Cultivated
Amaryllidaceae	Allium porrum L.	Bulb, Leaves	Leek, winter leek	Northeastern States	Cultivated
Amaryllidaceae	Allium sativum L.	Bulb	Garlic	Throughout India	Cultivated
Amaryllidaceae	Allium tuberosum Rottler.	Bulb	Indian leek	Assam	Cultivated
Anacardiaceae	Buchanania lanzan Spreng.	Seed	Cuddapah almond	Andhra Pradesh, Tamil Nadu	Wild
Anacardiaceae	Mangifera indica L.	Immature fruit	Mango	Throughout India	Cultivated
Anacardiaceae	Schinus molle L.	Fruit	Californian pepper tree	Karnataka, Kerala, Tamil Nadu	Wild
Anacardiaceae	Schinus terebinthifolia Radde.	Fruit	Brazilien pepper tree	Maharashtra	Cultivated
Annonaceae	<i>Xylopia aethiopica</i> (Dunal) A. Rich.	Fruit	Negro pepper	Arunachal Pradesh, Assam	Cultivated
Apiaceae	Anethum graveolens L.	Leaves	Dill	Andhra Pradesh, Madhya Pradesh, Kerala, Tamil Nadu	Cultivated
Apiaceae	Anethum sowa Kurz.	Fruit	Indian Dill	Rajasthan, Gujarat, Odisha	Cultivated
Apiaceae	Angelica archangelica L.	Fruit, petiole, root	Garden angelica	Assam, Meghalaya, Tripura	Cultivated
Apiaceae	Anthriscus cerasifolium (L.) Hoffm.	Leaf	Chervil	Assam, Arunachal Pradesh	Wild

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Family	Botanical name	Part(s) used	Common name(s)	Distribution	Cultivation status
Apiaceae	Apium graveolens L.	Seeds, root, leaves	Celery	Assam, Nagaland, Maharashtra, Gujarat	Cultivated
Apiaceae	<i>Bunium persicum</i> (Boiss) Fedtsch.	Fruit, bulb	Black caraway	Rajasthan, Assam, West Bengal	Cultivated
Apiaceae	Carum bulbocastanum L.	Fruit, Bulb	Black caraway	Assam, Tripura, Meghalaya	Wild
Apiaceae	Coriandrum sativum L.	Leaves and fruits	Coriander	Andhra Pradesh, Madhya Pradesh Telangana, Tamil Nadu	Cultivated
Apiaceae	Carum copticum L.	Fruits	Ajowan caraway, blond caraway	Tamil Nadu, Kerala, Karnataka	Cultivated
Apiaceae	Cuminum cyminum L.	Fruits	Cumin	Throughout India	Cultivated
Apiaceae	Eryngium foetidum L.	Fruits	Elephant pepper	Kerala, Arunachal Pradesh	Wild
Apiaceae	Ferula asa foetida L.	Rhizome exudates	Asafoetida	Rajasthan	Cultivated
Apiaceae	Foeniculum vulgare Miller.	Seeds	Fennel	Kerala, Madhya Pradesh	Cultivated
Apiaceae	Levisticum officinale Koch.	Leaves	Lovage	Northern India	Cultivated
Apiaceae	Pimpinella anisum L.	Fruits	Aniseed	Assam, Tripura, Rajasthan, Gujarat, Odisha	Cultivated
Asteraceae	Artemisia dracunculus L.	Leaves	Tarragon	Arunachal Pradesh	Wild
Brassicaceae	Armoracia rusticana Gaertn.	Root	Horse radish	Assam, Arunachal Pradesh	Cultivated
Brassicaceae	<i>Brassica juncea</i> (L.) Czernj. et Cosson.	Seeds	Mustard	Andhra Pradesh, Bihar, Madhya Pradesh, Uttar Pradesh	Cultivated
Brassicaceae	Brassica nigra (L.) Koch.	Seeds	Black mustard	Bihar, Uttar Pradesh	Cultivated
Brassicaceae	Brassica rapa (L.) Hanelt.	Seed	Field mustard	Uttar Pradesh, Haryana, Chhattisgarh	Cultivated
Brassicaceae	Sinapis alba L.	Seeds	White mustard	Northern India	Cultivated
Caesalpiniaceae	Tamarindus indica L.	Fruit	Tamarind	Throughout India	Cultivated

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Capparidaceae	Capparis spinosa L.	Flower bud	Caper bud	Tamil Nadu	Wild, rarely cultivated
Cleomaceae	Cleome viscosa L.	Seeds	Jakhiya	Throughout in India	Wild
Clusiaceae	Garcinia gummi-gutta (L.) Robson.	Fruit	Malabar tamarind, camboge	Kerala, Karnataka	Cultivated and wild
Clusiaceae	Garcinia indica (Thouars) Choisy.	Fruit	Kokam	Kerala	Wild
Cupressaceae	Juniperus communis L.	Fruit	Juniper berry (technically seed cone)	Assam, Meghalaya	Cultivated
Fabaceae	Abrus precatorius L.	Root	Indian liquorice, rosary pea	Throughout India	Wild
Fabaceae	Glycyrrhiza glabra L.	Root	Liquorice	Odisha, Andhra Pradesh, Tamil Nadu	Cultivated
Fabaceae	Trigonella foenum-graecum L.	Leaves, seeds	Fenugreek	Throughout India	Cultivated
Illiciaceae	Illicium verum Hook.f.	Fruit	Star anise	Sikkim, Meghalaya	Cultivated
Iridaceae	Crocus sativus L.	Anther and filament	Saffron	Jammu and Kashmir	Cultivated
Lamiaceae	Hyssopus officinalis L.	Leaves	Hysopp	Northeastern India	Cultivated
Lamiaceae	Lippia graveolens Kunth.	Leaves, terminal shoot	Mexican oregano	Northern India	Cultivated
Lamiaceae	Melissa officinalis L.	Leaves	Balm, Lemon balm	Kerala, Maharashtra, Karnataka	Cultivated
Lamiaceae	Mentha arvensis L.	Leaves	Mint, field mint	Throughout India	Wild
Lamiaceae	Mentha citrata L.	Leaves	Bergamol	Northeastern India	Cultivated
Lamiaceae	Mentha piperita L.	Leaves	Pepper mint	Throughout India	Cultivated

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Family	Botanical name	Part(s) used	Common name(s)	Distribution	Cultivation status
Lamiaceae	Mentha spicata L.	Leaves	Spear mint, garden mint	Throughout India	Cultivated
Lamiaceae	Ocimum bascilicum L.	Leaves	Sweet basil	Throughout India	Cultivated
Lamiaceae	Ocimum sanctum L.	Leaves	Holy basil	Throughout India	Cultivated
Lamiaceae	Origanum hortensis L.	Leafy shoots	Marjoram	Andhra Pradesh, Tamil Nadu	Cultivated
Lamiaceae	Origanum vulgare L.	Leaves	Origano	Throughout India	Cultivated
Lamiaceae	Petroselinum crispum (Miller) Nyman.	Leaves	Parsley	Kerala, Karnataka, Maharashtra	Cultivated
Lamiaceae	Rosmarinus officinalis L.	Leaves	Rosemary	Kerala, Tamil Nadu, Maharashtra, Assam	Cultivated
Lamiaceae	Salvia officinalis L.	Leaves	Garden sage, Dalmatian sage	Kerala, Tamil Nadu, Maharashtra	Cultivated
Lamiaceae	Satureja hortensis L.	Leaves	Summer savory	Northern India	Cultivated
Lamiaceae	Thymus vulgaris L.	Leaves	Thyme	Throughout India	Cultivated
Lauraceae	<i>Cinnamomum burmanii</i> Blume.	Bark	Indonesian Cassia	Meghalaya, West Bengal	Cultivated
Lauraceae	Cinnamomum cassia L.	Bark	Cinnamon cassia	Kerala	Cultivated
Lauraceae	Cinnamomum loureiroi Nees.	Bark	Vietnamese cassia bark	Kerala, Karnataka	Cultivated
Lauraceae	Cinnamomum tamala Nees.	Leaves	Indian cassia bark	Kerala, Karnataka, Tamil Nadu	Cultivated
Lauraceae	Cinnamomum verum Blume.	Leaves	Sri Lankan cinnamon, common cinnamon	Kerala, Tamil Nadu	Wild
Lauraceae	Laurus nobilis L.	Leaves	Bay leaf, true laurel	Meghalaya, Nagaland	Cultivated
Lauraceae	<i>Phoebe cooperiana</i> Kanjlal& Das	Leaves	Assamese mekhali	Arunachal Pradesh, Assam	Wild
Malvaceae	Bombax ceiba L.	Fruit	Maratimokka, cotton tree	Kerala, Tamil Nadu	Wild

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Moringaceae	Moringa pterygosperma Gaertn.	Leaves	Drumstick leaf	Throughout India	Cultivated
Myristicaceae	Myristica argenteaWarb.	Kernal and mace	Papuan nutmeg	Gujarat, Odisha, Assam	Cultivated
Myristicaceae	Myristica fragrans Houtt.	Kernal and mace	Nut meg	Throughout India	Cultivated
Myrtaceae	Syzygium aromaticum Thunb.	Flower bud	Clove	Kerala, Tamil Nadu	Cultivated
Myrtaceae	Pimenta dioica (L.) Merr.	Leaves	Allspice	Tamil Nadu	Cultivated
Myrtaceae	Pimenta racemosa (Miller) J. Moore.	Leaves	West Indian bay	Arunachal Pradesh	Cultivated
Orchidaceae	Vanilla planifolia Andrews.	Fruit	Vanilla	Kerala, Tamil Nadu	Cultivated
Orchidaceae	Vanilla tahitensis J. Moore.	Fruit	Tahitian vanilla	West Bengal, Assam	Cultivated
Orchidaceae	Vanilla pompona Schiede.	Fruit	Pompona vanilla	Arunachal Pradesh, Nagaland	Cultivated
Pandanaceae	Pandanus amaryllifolius Roxb.	Leaves	Pandanwangi	Maharashtra	Wild
Papaveraceae	Papaver somniferum L.	Seeds	Poppy, blue maw	Jammu and Kashmir, Sikkim	Cultivated
Parmeliaceae	Parmotrema perlatum (Huds.) Choisy.	Thallus	Kalpasi, black stone flower, lichens	Northeastern India	Wild
Pedaliaceae	Sesamum indicum L.	Seeds	Sesame	Throughout India	Cultivated
Piperaceae	Piper guineense Schum.	Fruits	West African pepper	Assam, Arunachal Pradesh	Cultivated
Piperaceae	Piper longum L.	Fruits	Long pepper	Kerala, Tamil Nadu	Cultivated
Piperaceae	Piper mullesua BuchHam. ex D.Don.	Fruits	Wild pepper	Maharashtra, Karnataka, Kerala, Tamil Nadu	Wild
Piperaceae	Piper nigrum L.	Fruits	Black pepper	Kerala, Tamil Nadu	Cultivated

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Family	Botanical name	Part(s) used	Common name(s)	Distribution	Cultivation status
Poaceae	Cymbopogon citratus (DC.) Stapf.	Leaves	Lemon grass, West Indian lemon grass	Throughout India	Wild
Poaceae	Cymbopogon nardus L.	Leaves	Sri Lankan citronella	Throughout India	Wild
Punicaceae	Punica granatum L.	Seeds	Pomegranate	Throughout India	Cultivated
Ranunculaceae	Nigella damascena L.	Seeds	Damas black cumin	Rajasthan	Cultivated
Ranunculaceae	Nigella sativa L.	Seeds	Black cumin	Jammu and Kashmir, Rajasthan	Cultivated
Rutaceae	<i>Murraya koenigii</i> (L.) Sprengel.	Leaves	Curry leaf	Throughout India	Cultivated
Rutaceae	Zanthoxylum armatum DC.	Fruit	Mountain prickle pepper	Arunachal Pradesh	Wild
Rutaceae	Zanthoxylum bungee Planch.	Fruit	Chinese prickly ash pepper	Arunachal Pradesh	Wild
Rutaceae	Zanthoxylum acanthopodium DC.	Fruit	Chinese pepper	Arunachal Pradesh,	Wild
Rutaceae	Zanthoxylum oxyphyllum Edgew.	Fruit	Wild thorn pepper	Arunachal Pradesh	Wild
Rutaceae	ZanthoxylumrhetsaDC.	Fruit	Small thorn pepper	Karnataka, Odisha, Kerala, Arunachal Pradesh	Wild
Solanaceae	Capsicum annuum L.	Fruit	Wild chilli, capsicum	Throughout India	Cultivated
Solanaceae	Capsicum frutescens L.	Fruit	Bird eye chilli	Throughout India	Cultivated
Zigiberaceae	Kaempferia galanga L.	Rhizome	Galanga	Kerala	Cultivated
Zingiberaceae	Aframomum angustifolium Schum.	Fruit, seeds	Madagascar cardamom	Assam, Meghalaya, Tripura	Cultivated
Zingiberaceae	Aframomum hanburyi Schum.	Fruit, seeds	Cameroon cardamom	Assam, Tripura, Nagaland, Maharashtra	Cultivated
Zingiberaceae	Aframomum corrorim Engl.	Fruit, Seeds	Korarima cardamom	Assam, Meghalaya, Nagaland	Cultivated

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Zingiberaceae	Aframomum melegueta Schum.	Fruit, seeds	Grain of paradise, guinea grains	Assam, Manipur, Mizoram, Nagaland	Cultivated
Zingiberaceae	Alpinia calcarata Roscoe.	Rhizome	Galanga	Southern states, Assam	Wild
Zingiberaceae	Alpinia galanga (L.) Willd.	Rhizome	Greater galangal	Throughout India	Cultivated
Zingiberaceae	Alpinia officinarum Hance.	Rhizome	Lesser galangal	Assam, Nagaland, Tripura	Cultivated
Zingiberaceae	Amomum aromaticum Roxb.	Fruit, seeds	Bengal cardamom	Throughout India	Cultivated
Zingiberaceae	Amomum kepulaga Sparague.	Fruit, seeds	Round cardamom, chester cardamom, Siamese cardamom	Arunachal Pradesh	Cultivated
Zingiberaceae	Amomum subulatum Roxb.	Fruit	Large cardamom	Arunachal Pradesh, Kerala, Sikkim, Tamil Nadu	Cultivated
Zingiberaceae	Curcuma amada Roxb.	Rhizome	Mango ginger	Arunachal, Maharashtra, Kerala	Cultivated
Zingiberaceae	Curcuma longa L.	Rhizome	Turmeric	Telangana, Tamil Nadu	Cultivated
Zingiberaceae	Curcuma zedoaria Roscoe.	Rhizome	Zedoary	Kerala	Cultivated
Zingiberaceae	Elettaria cardamomum (L.) Maton.	Fruits	Cardamom, Green cardamom, small cardamom	Kerala, Karnataka, Tamil Nadu	Cultivated
Zingiberaceae	Zingiber montanum (Koenig.) Link.	Rhizome	Wild ginger, mountain ginger	Arunachal Pradesh	Wild
Zingiberaceae	Zingiber officinale Roscoe.	Rhizome	Ginger	Throughout India	Cultivated

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**Figure 12.1** Selected Indian spice and condiment plants. (a) *Alipnia calcarata*, (b) *Cinnamomum zeylanicum*, (c) *Costus speciosus*, (d) *Curucuma neilgherrensis*, (e) *Elettaria cardamomum*, (f) *Melissa officinalis*, (g) *Pimenta dioica*, (h) *Piper longum*, (i) *Piper nigrum*, (j) *Piper mileusa*, (k) *Zanthoxylum armatum*. *Source:* Santosh Kumar Upadhyay.

Ethnobotanical evidences indicate that the use of turmeric in India has begun in ancient time in connection with Goddess Sakthi worship of divine mother and later as a commodity of trade as coloring material and as a condiment [16]. The genus originated in

Indo-Malayan region and has spread from Southeast Asia to tropical West Africa and East Africa and later introduced to Caribbean islands and to Americas. Turmeric is popular among rice-eating people of South Asia, Southeast Asia, and Indochina (continental portion of Southeast Asia) as a spice and condiment. Turmeric is the main cash crop in the tribal dominated districts of Kandhamal, Gajapati, Ganjam, Mayurbhanj, and Koraput in Orissa since time immemorial [17].

The cardamoms are the capsules of dried fruits in different genera of the Zingiberaceae family, primarily *Elettaria, Amomum*, and *Aframomum*. Among them, *Elettaria cardamo-mum* (cardamom/green cardamom/small cardamom) is the most important and is grown predominantly in southern India [18]. The false cardamom, large cardamom, and black cardamom from the allied genus *Amomum* are native to Nepal, Sikkim, Bengal, and Southeast Asian countries. African cardamom, which is botanically known as *Aframomum danielli*, is native to Southeast Africa especially in Tanzania, Cameroon, Madagascar, and Guinea. Small cardamom is extensively cultivated in Nepal and Sikkim and to a limited extent with the large cardamom (*Amomum subulatum*). However, international trade is now limited to Asian countries as far as small and large cardamoms are concerned because of high prices. Worldwide, cardamom is recognized as the "queen of spices" for its pleasant aroma and taste and is the third most expensive spice after saffron and vanilla [19, 20].

Spices produced from tree crops are called "Tree spices." Tamil Nadu, Kerala, Andhra Pradesh, Maharashtra, and Karnataka are the major states cultivating tree spices in larger areas of India. There are 17 tree spices, commonly grown in India, which are clove, nut-meg, cinnamon, tamarind, garcinia, curry leaf, and allspice [12]. The commercially important products have been obtained from whole spice, ground spice oil, and oleoresin. The Western Ghats belt of Kanyakumari and Nilgiris districts of Tamil Nadu and in a few areas in Karnataka and Kerala are cultivating the clove crop. Nutmeg cultivation is more common in Kerala and limited areas of Tamil Nadu and Karnataka. All spice was cultivated rarely in the gardens of Kerala, Tamil Nadu, Karnataka, West Bengal, and Odisha [21].

In India, Kerala is highly suitable for the cultivation of spices. Important spices cultivated are black pepper, cardamom, ginger, turmeric, clove, garcinia, nutmeg, and mace. Out of this 95% of the total production is contributed by pepper, cardamom, ginger, and turmeric. Pepper and cardamom are cultivated in the high ranges, while ginger and turmeric predominate in plains. The major production centers are Idukki and Wayanad districts [12].

# **12.3** Ethnobotanical Context of Spices and Condiments in India

The earliest literary record in India on spices is the Rig Veda (at least or before 4000 BCE), one of the ancient Hindu scriptures, listing more than a thousand healing plants including spices and condiments. Thus, the story of Indian spices dates back to at least 6000 years into the past. In the modem world, major trade is related to eating, and the spices provide the major thrust – traditionally a country of agriculture [15, 22]. Domestication of turmeric is probably much earlier to Indus valley civilization [23]. In the current scenario of ever-increasing human stress, ethnomedicinal plants having antioxidant properties are thought

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to be extremely fruitful to relieve stress and improve health and eventually economy. Many Indian spice plants have been investigated for their beneficial use as antioxidants or source of antioxidants using presently available experimental techniques [24]. This plant-based traditional knowledge has become a recognized tool in the search for new sources of drugs and nutraceuticals [25].

Tribals of Eastern Ghats in Andhra Pradesh make use of some rare plants for their condiments and culinary purposes that are specific to that region, including dried fruits of Tacca leontopetaloides and tubers of Decalepis hamiltonii, which are rare spices [26]. Arunachal Pradesh was inhabited by Adi, Apatani, Nyishi, Galo, Khampti, Khowa, Mishmi, Idu, Taroan, Momba, Sherdukpen, Singpho, Hrusso, Tagin, Khamba [27]. Some of the plant species are recorded in tribal belts of Arunachal Pradesh as new source of spice plants such as Acmella paniculata, Dendrocalamus hamiltonii, Etlingera linguiformis, Gynura prcoumbens, Hydrocotyle sibthorpioides, Magnolia oblonga, Oenanthe javanica, Paederia foetida, Perilla frutescens, Persicaria nepalensis, Phyllostachys bambusoides, and Spilanthes acmella. Some ethnic tribal communities of Assam, namely Ahom, Deori, Mishing, Sonowal-kachari use 51 species as spices and condiments, including Garcinia pedunculata, Hibiscus sabdariffa, Houttuvnia cordata. Neocinnamomum caudatum and Peperomia pellucida, which are new spice species [28]. Tribes in Maharashtra such as Pawara, Bhil, Mavachi, Kokani, and Tadavi use 26 common spices and added a new spice species of Guizotia abyssinica as used in food flavoring [29].

Owing to their aromatic properties, three species, namely Artemisia scoparia (seeds, flowers, and leaves), Carum carvi (fruits, seeds), and Murraya koenigii (leaves), are added to pulses and vegetables as condiment and spice in Jammu and Kashmir region. Ar. scoparia is a locally grown wild spice [30]. The Tangkhul people of Manipur region are mainly dependent on the forest, as forest plants are gathered for food, medicinal, spices, fuel, etc. They use at least 30 plant species as spice belonging to 17 genera of 8 families. Several plant species used by them are recorded as new spice species such as Allium hookeri, Allium tuberosum, Costus speciosus, Curcuma cassia, Elshotzia blanda, Elshotzia communis, Hedychium coronarium, Hedychium marginatum, Persicaria posumbu, Zingiber cassumunar and Zingiber zerumbet [31]. Babu et al. [8] assessed the status of traditional practices of farmers and women, in particular for storage of spices and condiments in Odisha especially for ginger (Zingiber officinale), turmeric (Curcuma longa), chilli (Capsicum annuum), onion (Allium cepa), garlic (Allium sativum), and coriander (Coriandrum sativum). Observations revealed that a large number of farmers still practice the traditional storage system. Ginger and turmeric are stored in pit method, heap method and in situ method while chilli, onion, and garlic are stored in mesh bags and hanging method. In traditional method of storage, farmers primarily rely on traditional practices using local resources [8].

The Sikkim state was inhibited by various ethnic tribes such as Lepcha, Bhutis, Limboo, and Nepalese [32]. The tribes live mostly on hilltops and on slopes, forming small and isolated villages. It is important to save this traditional knowledge of biological heritage and explore new resources. Traditional and ethnic knowledge has played a significant role in the discovery of novel ideas about conservation of natural resources. Spices have good antioxidant and preservative properties as well as antimicrobial and antibiotic properties, and therefore, are also used for medicinal purposes, 14 such species are used by tribes of Sikkim [7]. Spices and condiments used by traditional communities of Tripura were also record [33]. In West Bengal, local communities using 32 spices distributed in 27 families including some wild plants such as *Zanthoxylum armatum* were recorded [34].

Western Ghats are tribal-dominated areas in southern India where Kadar, Malasars, Mudhuvan, Kurumbans, Kaatunaickens, Thodar, Kanis, and Paliyars reside. Still they follow traditional way of life with close association of forest vegetation for their livelihood materials including food. Several local spice and condiments species are recorded as they are used for preservation, flavoring, and coloring material of the food stuffs. Some of the plants such as *Costus speciosus, Garcinia gummi-gutta, Curcuma neilgherrensis, Syzygium palghatense, Curculigo orchioides, Cleome monophylla* are exclusively used as spice plants in this region [35]. In Kerala and Tamil Nadu, crushed cardamom capsules are boiled with tea and water to impart a pleasant aroma to tea, which is popularly called "*Elakkai tea*," and which has been used to relieve tiredness and depression. Cardamom capsules contain significant concentration of  $\beta$ -carotene [36]. In traditional medicine, consumption of cardamom daily with a table spoon of honey improves the eyesight [37]. However, some people believe that excessive uses of cardamom capsules may cause impotency [20]. A total of 11 spices out of 109 ISO approved spices are most frequently used in South Indian cuisines, particularly in Kerala and Tamil Nadu [38].

### 12.4 Major Spices and Condiments in India

#### 12.4.1 Black Pepper

*Piper nigrum* is a perennial climbing vine grown for its berries. The matured and dried berries are used in flavoring and medicinal purposes. India is a main producer, consumer, and exporter of black pepper in the world. Annually it produces 17,563 tonnes of black pepper worth Rs. 150.95 crore that were exported to various other countries mainly from Kerala and Karnataka and Tamil Nadu [11]. It is used in different medicines from very ancient periods. Long pepper (*Piper longum*) is a slender aromatic climber whose spike is widely used in Siddha, Ayurvedic, and Unani systems of medicines particularly for diseases of respiratory tract. Pipalarishta, Pippalyasava, Panchakola, Pippalayadilauha, and Lavanabhaskarchuran, which include contributions from both *P. nigrum* and *P. longum*, are common ayurvedic preparations [10]. Combination of *sukku* (dried *Z. officinale*) *milagu* (dried fruits of *P. nigrum*), and *thippili* (dried fruits of *P. longum*), generally referred as *sukku-milagu-thippili*, is a common home medicine for cold in South India, especially Tamil Nadu.

#### 12.4.2 Capsicums

Capsicums are dried and processed fruits of annual peppers (*Ca. annuum* var. *annuum*; *Capsicum chinense; Capsicum frutescens*) commonly referred as chilli or chili pepper or Chile pepper or bell pepper. A rainfall of 600–1250 mm is desirable. Rainfall is needed over the growing season but is not needed as the fruits ripen. Heavy rain during flowering adversely affects pollination and wetness at ripening encourages fungal spoilage. Capsicums

flourish in warm sunny conditions, require 3–5 months with a temperature range of 18–30 °C; growth retards at below 5 °C, and frost kills the plants at any growth stage. A seedbed temperature of 20–28 °C is optimum for germination. Red chili powder, a common spice, is dried and powdered red chilli fruits. Being the hottest part of the chili, the powder is exceptionally strong and used in small quantities. Originating in the Americas, chillies were then introduced to India by the Portuguese and since then became an integral part of Indian cooking. Chillies are used as powder, crushed, and in its whole form in various South Indian curries.

#### 12.4.3 Cinnamomum

*Cinnamomum verum* bark is widely used in aromatic rice preparations such as Biriyani and Pulao in India. It is a sweet-tasting spice with a warm and woody aroma. These properties make it a great ingredient to be used in cakes and desserts. Cinnamomum bark powder is highly favored for flavoring processed drinks in western hemisphere. Apart from adding flavor to food, cinnamon also has various health benefits; thought to help prevent cancer and lower blood pressure. It is predominantly grown along the Western Ghats of Kerala and Tamil Nadu [39]. While the origins of this spice can be traced back to India, it is also native to Sri Lanka. *Ci. verum* is an evergreen tree of Lauraceae family whose bark and leaves are strongly aromatic. It is useful in bronchitis, asthma, cephalalgia odontalgia, cardiac diseases, diarrhea, uropathy, nausea and vomiting, flatulence, fever, halitosis, and skin protection [40].

#### 12.4.4 Coriander

*Coriandrum sativum*, is a member of the parsley family, and its seeds are oval-shaped, ridged, and turn from bright green to beige when ripe. This spice tastes sweet and tangy, with a slightly citrusy flavor. This omnipresent spice is probably the oldest in the world and is widely grown in the states of Rajasthan, Madhya Pradesh, and Tamil Nadu. Coriander seeds are also used as an alternative to salt. Seeds and leaves contain essential oils ranging from 0.1 to 1.0%, which is used for preparation of soaps of pleasant odor and good leathering property. The dried fruit powder is used to flavor foods, such as pickles, sauces, and confectionery. The fresh leaves are added in almost all-sauce-like preparations in Tamil Nadu. The distilled essential oils from the fruits are used in perfumes, soaps, candy, chocolates, tobacco, meat products, baked food, canned foods, liquors and alcoholic beverages, and also in pharmaceutical preparations.

#### 12.4.5 Cumin

*Cuminum cyminum* L., another Apiaceae member, is used to add a smoky note and a robust aroma to most Indian curries and vegetables. Fried in its dry form or roasted before use, cumin seed is usually the first spice added while cooking Indian dishes. It is also dry roasted and converted to powder before being added to dishes such as pudding and buttermilk. It is used to flavor rice, stuffed vegetables, many savory dishes, and curries. Since it burns easily and can become overpowering, it is used sparingly. Cuminol or cuminaldehyde is the

typical volatile principle present in the cumin seeds, which is the reason for characteristic aroma of the cumin. The cumin seeds are used for flavoring vegetables, pickles, soups, sausages, cheese and for seasoning breads, cakes, and biscuits. The seeds are also used for the preparation of traditional and homeopathy medicines prescribed for several common ailments. The seeds have major properties such as carminative, stimulant, astringent, and emmenagogue.

#### 12.4.6 Cardamom

*Elettaria cardamomum* (green/small cardamom) is the concerned species, a tall growing perennial herb from Zingiberaceae. The fruits borne on panicles at the base of the plants have trilocular capsule with 15–20 seeds. The natural altitudinal growing range is between 750 and 1500 m while the most productive cultivated zone is 1000–1200 m. The annual rainfall required is usually 2500–4000 mm in the monsoon belt. A temperature range of 10–35 °C occurs over the production areas with a lower limit of about 17 °C, and an optimum temperature between 22 and 24 °C is favored. Cardamom grows naturally in shade but will produce good yields in only partial shade if well-watered. It is an indigenous spice of the land of the Malabar Coast in India. This is the third most expensive spice in the world, mainly because it is hand-harvested and requires a lot of manual work [41]. While the green cardamom has a mild and light eucalyptus tone to it, the black/large cardamom (*A. subulatum*) is spicy, smoky, and generally used only for its seeds. The most common use for cardamom is to enhance the flavor of tea and puddings [11].

#### 12.4.7 Fennel

*Foeniculum vulgare* is an annual crop from Apiaceae, which is commonly cultivated in frost-free area of Rajasthan and Gujarat. The fennels are aromatic fruits and used in most kinds of Indian foods. Fennel seeds for their fragrant odor and pleasant aromatic taste due to the presence of aromatic volatile oil principles are widely used in soaps, pickles, meat dishes, sauces, pastries, confectioneries, etc. Besides fruits, the tender leaves are used in salads. The seeds are used in several Allopathic, Siddha, and Ayurvedic medicines, which are administered in diseases such as cholera, piles, gripping, constipation, dysentery, and diarrhea.

#### 12.4.8 Ginger

Zingiber officinale is an herbaceous perennial from Zingiberaceae, the rhizome of which is used as a spice, and it is also one important spice native of South and Southeast Asia. It is recommended as a medicine in Siddha and Ayurveda for curing liver complaints, flatulence, anemia, rheumatism, piles, and jaundice. Kerala and Meghalaya are major ginger-growing states in India. India exported 7,250 tonnes of ginger to the value of the Rs. 40.755 cores annually [11]. Dried ginger in locally called as sukku, and the decoction is the first home remedy for illness in much of southern parts of the country. Sukku decoction is also taken with milk and jaggery (a locally processed sugar), also a traditional greeting drink for guests.

#### 12.4.9 Mustard Seed

In Indian cooking, brown mustard (*Brassica juncea* L.) seeds are more commonly used than the black mustard (*Brassica nigra* L.) seeds. They belong to Brassicaceae. These seeds can be fried whole in order to flavor oil that is then used for cooking raw food. This favored oil can also be used as a garnish. While the seeds are native to Rome, the earliest reference to their use is in stories of Buddha, where it refers the seeds to justify death as a natural phenomenon [42]. Rapeseed cultivation is confined only to northern India because of late maturity and shattering of pods owing to high temperature prevailing during harvest in February–March.

#### 12.4.10 Nutmeg

*Myristica fragrans* of Myristicaceae is the common nutmeg, while *Myristica argentea*, the papuan nutmeg also is referred as nutmeg. Nutmeg is a perennial tree, reaching up to 20 m in height. The useful part of the nutmeg is kernel of the seed, while mace is the net-like crimson-colored leathery outer growth (aril) covering the shell of the seed. Nutmeg pickle is one of the favorites in southern parts of India. The tree requires an optimal growing temperature between 20 and 30 °C and the annual rainfall should be between1500 and 2500 mm. The common nutmeg cultivating areas of India are Kerala and parts of Tamil Nadu [11]. The seed and mace of nutmeg, *M. fragrans* are useful in vitiated conditions of kapa and vata, inflammations, cephalalgia, helminthiasis, dyspepsia, flatulence, cough, asthma, diarrhea, vomiting, ulcer, hepatopathy, skin diseases, cardiac disorders, fever, and generally debility. Thriphaladichoorna, Karppooradichoorna, Athisaragrahanichoorna, jeerakadichoorna, etc., in Siddha and Ayurveda contain nutmeg kernel as well as mace.

#### 12.4.11 Saffron

*Crocus sativus* is the most expensive spice in the world. It is cultivated predominantly in the regions of Jammu and Kashmir and to a lesser extent in Himachal Pradesh and Ladakh regions. Saffron is derived from the stigma of crocus flowers. Saffron is believed to be more valuable than gold. The most striking feature of this spice is its pungent, honey-like aroma. The deeper the color of saffron, the purer it is. It is often used after being soaked in water or milk, which softens its strong aroma and taste. The glycosides crocin and picrocrocin are the coloring principles and the bitter substance of saffron. Saffron is an important ingredient of the Ayurvedic and Unani systems of medicine in India other than food additives and coloring agent. The major properties of saffron are nervous stimulant, helping in urinary, digestive, and uterine troubles.

#### 12.4.12 Turmeric

*Curcuma longa*, another spice belonging to the ginger family, turmeric is probably the most commonly used spice in India. Turmeric was predominantly used as a dye and in Siddha medicine for thousands of years. Derived from the roots of *C. longa*, a leafy plant native to India, turmeric has an earthy consistency and a warm aroma and taste. Mainly used for its

flavor and color, turmeric also has antiseptic qualities and is therefore used for its health benefits as well. Turmeric forms an integral part of the rituals, ceremonies, and cuisine. Due to the strong antiseptic properties, turmeric has been used as a remedy for all kinds of poisonous affections, ulcers, and wounds. It gives good complexion to the skin. The rhizomes of mango ginger (*Curcuma amada*) are useful in vitiated conditions of pitta, anorexia, dyspepsia, flatulence, colic, bruises, wounds, chronic ulcers, skin diseases, pruritus, fever, constipations, strangury, hiccough, cough, bronchitis, sprains, gout, halitosis, otalgia, and inflammations [16]. *C. aromatica* is another Zingiberaceous perennial tuberous herb with aromatic yellow rhizome, which is internally creamy in color and the fresh root has a camphoraceous odor. Rhizomes are used in combination with astringents and aromatics for bruises, sprains, hiccough, bronchitis, cough, leukoderma, and skin eruptions. Maximum area under turmeric is in Andhra Pradesh, followed by Maharashtra, Tamil Nadu, Odisha, Karnataka, and Kerala [23].

#### 12.4.13 Vanilla

Vanilla belongs to the member of Orchidaceae with potential economic values due to its unique flavor and pleasant aroma of its fruits. Vanillin is an aromatic substance obtained from the unripe fruits of *Vanilla planifolia*. This plant is native to South-Eastern Mexico and Central America. *Vanilla tahitensis* (Tahitian vanilla) and *Vanilla pompon* are also cultivated in some parts of the South Pacific Islands for vanillin extraction. Vanilla was introduced in India during 1990s for covering an area of 90 hectares. At present, it is widely cultivated in Kerala and Tamil Nadu as an intercrop of coconut, areca nut, and black pepper plantations.

#### 12.5 Importance of Indian Spices

Indian spices possess varieties of phytochemicals, for example, in curry leaves:  $\alpha$ -Amorphene,  $\gamma$ -Eudesmol,  $\beta$ -Pinene,  $\alpha$ -Terpinolene, Limonene, (Z)- $\beta$ -Ocimene. Terpenes, Sesquiterpenes, Eucalyptol, Terpinyl acetate are found in bay leaves. In hemp seeds, Cannabinol, Tetrahydrocannabinol, Cannabidiol, Tetrahydrocannabivarin, Cannabivarin, Cannabichromene are found. Black pepper seeds contain Piperine, Guineensine, Piperamide, and PiperoleinB [43]. Some pharmaceutically important compounds are Eugenol (allspice, cinnamon, cassia, clove), Piperine (black pepper), Gingerol (ginger), Myristin (nutmeg), Curcumin (turmeric), and Vanillin (vanilla) (Table 12.2).

These are phytochemical compounds that are accumulated in the usable spice and condiments and are essential for the quality of the spices [44]. Almost all the spices and condiments are aromatic in nature, and it is by their respective volatile phytochemical usually essential oils with composition of several terpenoids and oleoresins. The essential oils and oleoresins help to impart specific aroma to the food, act as antioxidants, are active against microbes, preserve from chemical deterioration, and increase shelf-life of the food. They act as natural preservative. Quality of the spice is determined by the quality of respective phytochemicals present in them. Indian spices and condiments possess quality aromatic chemicals with superior quality [45]. Flavonoids and essential oils present in spice and

Spice	Important flavor compound(s)
Allspice	Eugenol, β-caryophyllene
Anise	(E)-Anethole, Methyl chavicol
Sweet basil	Methyl chavicol, Linalool, Methyl eugenol
Bay laurel	1,8-Cineole
Black pepper	Piperine, S-3-Carene, $\beta$ -caryophyllene
Caraway	d-Carvone, Carvone derivatives
Cardamom	α-Terpinyl acetate, 1-8-Cineole, Linalool
Chilli	Capsaicin, Dihydrocapsaicin
Cinnamon cassia	Cinnamaldehyde, Eugenol
Clove	Eugenol, Eugenyl acetate
Coriander	d-Linalool, C10-C14-2-alkenals
Cumin	Cuminaldehyde, p-1,3-Mentha-dienal
Dill	d-Carvone
Fennel	(E)-Anethole, Fenchone
Ginger	Gingerol, Shogaol, Neral, Geranial
Mace	α-Pinene, Sabinene, 1-Terpinen-4-ol
Marjoram	e- and t-Sabinene hydrates, 1-Terpinen-4-ol
Mustard	Allyl isothiocyanate
Nutmeg	Sabinene, α-Pinene, Myristicin
Oregano	Carvacrol, Thymol
Origanum	Thymol, Carvacrol
Parsley	Apiole
Peppermint	1-menthol, Menthone, Menthofuran
Rosemary	Verbenone, 1-8-cineole, Camphor, linanool
Saffron	Safranal
Sage, Clary	Salvial-4 (14)-en-1-one, Linalool
Savory	Carvacrol
Spear mint	1-Carvone, Carvone derivatives
Tarragon	Methyl chavicol, Anethole
Thyme	Thymol, Carvacrol
Turmeric	Turmerone, Zingiberene, 1,8-Cineole
Vanilla	Vanillin, p-OH-Benzyl-methyl ether

 Table 12.2
 Important flavor compounds in selected Indian spices and condiments.

condiments act against a range of human illness including cancer, cardiovascular disease, nervous diseases, and digestive problems [46]. Gingerol in ginger is also an intestinal stimulant and promoter of the bioactivity of drugs. Capsaicin in chilli is an effective counterirritant used in both pharmaceuticals and cosmetics. Fenugreek, onion, and garlic help

to lower cholesterol levels. A number of spices have also been identified as having antimicrobial properties. All these compounds are rich in Indian spices [47].

Selection of germplasm for cultivation is an important step for maintaining the quality of spice species. The classic sage is *Salvia officinalis* but widely traded *Salvia triloba* and *Salvia tomentosa* are commercial sages. Similarly, thyme is usually referred to as *Thymus vulgaris*, but most thymes traded are a mixture of *Thymus capitatus*, *Thymus serpyllum*, and *T. vulgaris*. The well-known turmeric is botanically defined as *C. longa*, but there are many subspecies such as Alleppy turmeric and Cuddapah turmeric used to market with varied qualities. The qualities of spices determined the trade niche. Hence, several spices are gathered from their natural habitat where mixing of their coped one and wild varieties occurred in that location [48].

Currently, biomedical efforts are focused on their scientific merits, to provide sciencebased evidence for the traditional uses and to develop either functional foods or nutraceuticals. The Indian traditional medical systems use turmeric for wound healing, rheumatic disorders, gastrointestinal symptoms, deworming, rhinitis, and as a cosmetic. Studies in India have explored its anti-inflammatory, cholekinetic, and antioxidant potentials with the recent investigations focusing on its preventive effect on pre-carcinogenic, antiinflammatory, and anti-atherosclerotic effects in biological systems. Both turmeric and curcumin were found to increase detoxifying enzymes, prevent DNA damage, improve DNA repair, decrease mutations rate and tumor formation, and exhibit antioxidative potential [49]. Recently several molecular targets have been identified for therapeutic or preventive effects of turmeric. Fenugreek seeds, a rich source of soluble fiber used in Indian cuisine, reduce blood glucose and lipids and can be used as a food adjuvant in diabetes. Similarly garlic, onions, and ginger have been found to modulate favorably the process of anti-carcinogenesis [50].

#### 12.6 Spice Plantation and Cultivation in India

India produces 75 varieties of spices of the 109 listed by ISO and is also the world's largest producer. According to the Spices Board of India, every state of India is cultivating at least 10 varieties of spice plants, which are utilized in domestic use and export. The black pepper production in Kerala (94.1%) and followed by Karnataka (3.6%) contributed major production in India [3]. India is particularly suitable for cultivation of many spices due to existing various soil-related parameters such as soil moisture, water content, soil temperature, and soil nutrients, environmental parameters such as climate and rainfall [51].

As a result of diverse agroclimatic conditions, India produces more than 20 seed spices. Cumin, coriander, dill seeds, fenugreek, and fennel are the major seed spices cultivated in the country. Different states are known for different spices, but seed spices are mostly grown in Rajasthan and Gujarat with more than 80% contribution. [52]. India has been producing 7.07 million tonnes of spices, coming from 3.52 mha area during 2015–2016. Seed spices play a crucial role in Indian spice economy contributing 50.31 and 21.30% area and production share to nation's total spices. Individually chillies, cumin, coriander, garlic, and fenugreek are the largest grown spices in the India with

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23.05, 22.79, 17.48, 8.39, and 6.42% area share to total spice and 21.88, 7.25, 8.06, 23.07, and 3.56 % production share to total spices production, respectively [53]. Tamil Nadu state occupies the second position in both production and area under turmeric among all the states in India after Odisha [54]. Small cardamom is cultivated in the states of Kerala, Karnataka, and Tami Nadu in India about 50,000 hectares intercropping with black pepper plantations [55]. In India, cardamom is being cultivated majorly in Cardamom hill range of Western Ghats covering an area of 1050 km<sup>2</sup> designated as Cardamom hill reserves [41].

Mustard cultivation is also being extended to nontraditional areas of southern states such as Karnataka, Tamil Nadu, and Andhra Pradesh. It is cultivated in 26 states in the northern and eastern plains of the country, about 6.8 mha is occupied under these crops. Rajasthan is the giant mustard-growing state and alone contributes 43% of the total mustard seed production in India. The cultivation of brown sarson, which once dominated the entire rapeseed–mustard-growing region is now shadowed by Indian mustard (*B. juncea*). There are two different ecotypes of brown sarson (*Brassica rapa* var. brown sarson) and lotni (selfincompatible). The lotni is predominantly cultivated in colder regions of the country particularly in Kashmir and Himachal valley. Yellow sarson (*Brassica rapa* var yellow sarson) is now mainly grown in Assam, Bihar, north-eastern states, Odisha, eastern Uttar Pradesh, and West Bengal [56].

A recent analysis showed that growth and instability are there in spice cultivation in India. For example, chilli registered a higher production and yield growth in Andhra Pradesh, Karnataka, and at all India level. The area growth was 1.32% per annum in Andhra Pradesh and negative in Karnataka (-1.05%), Maharashtra (-1.85%), and at all India level (-0.06%). However, West Bengal registered a positive and significant growth in area, production, and yield of chilli during 2008–2009. Black pepper has registered a substantial growth in both area and production in Karnataka and Kerala states and also at all India level. Interestingly, yield growth was found to be negative in Karnataka. Turmeric production growth was found to be the highest in Andhra Pradesh (7.58%) and about 4–5% in Karnataka, Odisha, and at the national level, while it is Odisha that registered highest growth in turmeric yield [57].

#### 12.7 Cultivation Technology of Caper Bud in India

Capers (*Capparis spinosa*) of commerce are immature flower buds, which have been pickled in vinegar or preserved in granular salt, and it is a new spice crop for India. Semimature fruits (caperberries) and young shoots with small leaves may also be pickled for use as a condiment. Capers are said to reduce flatulence and to be antirheumatic in effect. In Ayurvedic system, capers are recorded as hepatic stimulants and protectors, improving liver function. Capers have reported uses for arteriosclerosis, as diuretics, kidney disinfectants, vermifuges, and tonics. Infusions and decoctions from caper root bark have been traditionally used for dropsy, anemia, arthritis, and gout. Capers contain considerable amounts of the antioxidant bioflavonoid rutin [58]. Capers probably originated from dry regions in west or central Asia. Known to be used millennia, capers were mentioned by Dioscorides as being a marketable product of the ancient Greeks. In India, the plant is growing in wild almost in all the states of dry and arid regions. Indians are not aware of the use of caper buds as spice except some local medicinal uses [59]. Recently the plant is under cultivation in Tamil Nadu after recognizing its trade importance.

Ecological conditions are needed for the caper plants in dry heat and intense sunlight that make the preferred environment for caper plants. Plants are productive in zones having 350 mm annual precipitation (precipitating mostly in winter and spring months) and easily survive summer temperatures higher than 37 °C (100 °F). Caper plants are small shrubs and may reach about 1 m upright. However, uncultivated caper plants are more often seen hanging, draped, and sprawling as they scramble over soil and rocks (Figure 12.2a and b). The caper's vegetative canopy covers soil surfaces, which help to conserve soil water reserves. Leaf stipules may be transformed into spines. Flowers are born on year-old branches. The cultivated variety is thornless and developed through in vitro technique by selecting somaclonal variants. In Tamil Nadu, the stem cuttings were procured from the Argentina and the variety is known as "inermis."

Caper plants propagated usually through the stem cuttings. Cuttings are collected in February, March, or April. Basal stem portions, greater than 1 cm diameter and 8 cm in length with 6-10 buds, are used. A dip in IBA solution of 1.5-3.0 ppm is recommended (15 seconds). A 70% rooting percentage would be considered good. Transplanting is carried out during the wet winter and spring periods, and first-year plants are mulched with stones. In India, plants are spaced 1-1.5 m apart (depending on the roughness of the topography; about 2000 plants per hectare). A full yield is expected from second or three year. Plants are pruned back in winter to remove dead wood and water sprouts. Pruning is crucial to high yield. Heavy branch pruning is necessary, as flower buds arise on one-yearold branches. Three-year-old plants will yield 1-3 kg of caper flower buds per plant. The unopened flower buds should be picked on a dry days. Harvesting is carried out regularly throughout the growing season. Caper flower buds (Figure 12.2c) are collected by hand mechanically about every 8-12 days, resulting in 9-12 harvest times per season. Immature flower buds are preserved either in vinegar or under layers of salt in a jar (Figure 12.2d). Raw capers are bland flavored and need to be cured to develop their piquant flavor. Mechanized screens are used to sort out the various-sized capers after being hand-picked from the cultivation. After processing the dried flower buds are preserved in air-tight packs and are ready for exports.

#### 12.8 Export of Indian Spices

Spices trade is a big business from time immemorial. Spices from India and far Eastern Asia were in demand from ancient times. Caravan carried them from India and China to the ports of the Mediterranean Sea or the Persian Gulf and then to the marketplaces of Athens, Rome, and other cities, where they were sold at exorbitant Prices. When the Mongols and Turks cut off overland trade routes from Asia, the European demand for spices was a major factor in motivating a search for new trade routes around Africa and across the Atlantic and Pacific oceans. The high price obtainable for spices was partially responsible for the bitter rivalry of European powers for the control of spice-producing areas and of trade routes. Even after adequate supplies of spices were found and means of

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**Figure 12.2** Caper bud form in Tamil Nadu. (a) Farm field, (b) *Capparis spinosa* – caper plant, (c) fresh caper buds, (d) processed Caper buds in US market (Whole Foods Market, Gainesville, FL, dt. 24th May 2020). *Source:* Santosh Kumar Upadhyay.

transportation made available, the cost long remained very high in Europe and America. This was largely because of the transportation costs, expenses incident to attempts to retain monopoly of markets and to limit crops in order to secure high prices. The Indian spices are having high demand in the global market due to their geographically indicative quality principles [3].

India as "the land of spices" plays a significant role in the global spices as quality spices come from Kerala. Some of the spices such as chillies, coriander seeds, cumin, fenugreek, fennels are coming from other parts of India. At present, India produces around 2.75 million tonnes of different spices valued at approximately 4.2 billion US\$ and holds the premier position in the world spices market. Climatic diversity of India is from tropical to subtropical with varied temperature gradient (45-0 °C), suitable for growing several spice crops in this country. In almost all of the 28 states and eight union territories of India, at least one spice is grown in abundance. About 4,00,000 tonnes equivalent to \$1.5 billion worth of spices are traded worldwide annually [12]. In 2009–2010, the export of spices from India has been 502750 tonnes valued Rs. 5560 crores [60]. Though every state of the country grows at least a few spice crops, the states of peninsular India and bordering region, Kerala, Andhra Pradesh, Odisha, Gujarat, Maharashtra, West Bengal, Karnataka, Tamil Nadu, and Madhya Pradesh are the major states in spice production. Odisha grows several spices such as chillies, ginger, turmeric, coriander, garlic in the area of 2.37 lakh ha with a production of 2.17 lakh tonnes. Turmeric and ginger are two most important spice crops grown in Odisha and more than 50% of these crop growers are tribals [8].

Initially, the trade of export was mostly confined with black peeper, cumin, and cardamom, but later covered a number of spices. Out of 109 spices listed by ISO, about 75 are produced by India. The average export touches around 550 thousand tonnes of spices annually. Major share is contributed by chilly, ginger, cumin, and turmeric in terms of volume. Other important products are cardamom, black pepper, and nutmeg. In terms of value, mint and mint products stand first followed by chilly and oleoresins. In the past 10 years, the Indian spice exports increased substantially in terms of volume and value [61].

Among the agricultural commodities, total export contributes around 7% and spices exports contribute around 3% in India [11]. In world trade of spices, India is at number three with 8.8% of the share. The major spices exported by India are chillies (40%), turmeric (10%), cumin (10%), coriander (9.5%), fenugreek (4.2%), black pepper (4%), and others constitute up to 19%. Though these spices provide innumerable benefits, they should be used sparingly [3]. India is a leading producer, consumer, and exporter of black pepper in the world. Andhra Pradesh leads in chilly and turmeric production in the country with 49 and 57%. In coriander, cumin, and fenugreek production, Rajasthan stands as the largest producer in the country with 63, 56, and 87% of domestic production [62].

Turmeric of India has tremendous demand in the market of foreign countries. India was the largest producer (4.35 lakh tonnes) and exporter (24900 tonnes) of turmeric during 1996–1997. The yellow coloring chemical 'Curcumin' is gaining wider use in the food industry, pharmaceuticals, in preservatives, and in health and body care. The Alleppey Finger Turmeric (AFT) with a curcumin content of more than 5.5% is in great demand abroad. India exports turmeric to the foreign countries such as UAE, Iran, Japan, Bangladesh, and South Africa. India exported about 6580 tonnes of turmeric worth Rs. 2296 crores during2009–2010. Though, growth and instability fluctuated in area, production, productivity, and export of major seed spices, namely cumin, coriander, and fenugreek, grown along with total spices from 1985 to 2015 [53].

The main export centers in India are Spice Board, Cochin, Kerala; Agricultural and Processed Food Products Export Development Authority, New Delhi; All India Spices Exporters Forum (AISEF), Cochin, Kerala; Directorate of Marketing and Inspection, Faridabad, Haryana.

# 12.9 Conservation Efforts Against Selected Uncultivated Wild Spices and Condiments

India has a good amount of diversity in spices such as black pepper, cardamom, ginger, turmeric, cinnamon, tamarind and, garcinia. The other important spices relevant to India are coriander, fennel, fenugreek, cumin, nutmeg, clove, and vanilla. Apart from these common spices and condiments, some of the plants and plant products are used for preservation and flavoring of foods by traditional knowledge or folklore system. These spice or condiment plants are available locally and use of the plants in such a way for purpose for spices in addition to medicinal and local therapeutic applications. India is a land of spice, where several spice genera originated in the diversity hotspots of either The Himalayas or The Western Ghats. Considering gingers (Zingiberaceae), reports indicate that around eight tuber-bearing, one stoloniferous, and 16 non-tuberous species of gingers are found in The Western Ghats and most of the genera are indigenous to India [63].

Nearly 25% of spice and condiment plants are growing in wild and collected from local vegetation. Several local spices are wild relatives of the known valuable spice, for example, *Allium, Alpinia, Cinnamomum, Curcuma, Hedychium, Zanthoxylum*, etc. Wild germplasms of cultivated spice plants and wild relatives of the usable spice species are much important for the improvement and development of quality spice varieties [62]. Many research centers are actively engaged in collection, cultivation, and agronomic development of wild relatives of the usable spice plants. Collection and conservation of valuable wild spice species in Indian region have become imperative due to increasing interest in herbal spices for health care across the globe. India alone contributes 140 species and condiments plant species used locally as well export to other countries from which 60 spices are used in industries for making drugs [27, 28].

# **12.10** Institutions and Organization Dedicated for Research and Development in Spices and Condiments in India

The Indian Institute of Spices Research (IISR), Kozhikode (Calicut), a constituent body of Indian Council of Agricultural Research (ICAR), is a major institute devoted to research on spices and condiments. Regional station of the Central Plantation Crops Research Institute (CPCRI), Kasaragod, engaged in research on spices since 1976. A National Research Centre for Spices was established in 1986 with its headquarters at Kozhikode, Kerala, by merging the erstwhile Regional Station of CPCRI at Kozhikode and Cardamom Research Centre at Appangala, Karnataka. Realizing the importance of Spices Research in India, this Research Centre was upgraded to Indian Institute of Spices Research in 1995. The National Research Centre on Seed Spices, at Ajmer, Rajasthan, is an apex center of ICAR working on improvement of seed spices and betterment of their stakeholders since its inception in 2000. Government of India has notified the formation of 10 spice development agencies (SDAS) in the main spice-growing regions for the overall development of spices grown in the region. These agencies will be chaired by the Chief Secretary of the concerned State Government and consist of members from Ministry of Commerce and Industry, the State/ Central Agriculture/Horticulture Ministry, other related Central/State organizations, Agri university, Member of Spices Board from the region, and various stakeholders of the industry, namely growers, traders, and exporters of spices. Indian government has also formed the "Saffron Production and Export Development Agency" (SPEDA) for the overall development in the saffron industry in the state of Jammu and Kashmir in 2015. SPEDA acts as a subordinate agency under Ministry of Commerce.

Other institutions and research organizations in India for development of spice and condiments crops are Indian Cardamom Research in Myladumpara, Kerala; Jawaharlal Nehru Tropical Botanical Garden and Research Institute, Palode, Kerala; Cardamom Research Centre (ICAR), Appangala, Karnataka; Central Institute of Medicinal and Aromatic Plants (CSIR), Lucknow, Uttar Pradesh; Central Food Technological Research Institute (CSIR), Mysore, Karnataka; Several state- and central-funded agriculture, science, and technical universities are also engaged in spices research, with focus on localized species concerned with localized problems and development.

#### 12.11 Recent Researches on Spices and Condiments

Plants used as spices and condiments are usually aromatic and pungent. Most of the spice plants have been reported that they owe these properties to the presence of varying types of essential oils. Several studies indicated that the rich presence of essential oils and oleoresins determines the aromatic, flavoring, coloring, and pungent properties of spices and condiments [2] (Table 12.2). Indian spices are "part and parcel" of traditional health care for thousands of years. Over the couple of decades, largely due to the growth in popularity of complementary and alternative medicine, spices have regained attention due to their physiological and functional benefits. By applying modern research methods to traditional remedies, it is possible to discover what made these spices such effective ailment treatments [64].

Low productivity in the spice sector is one of the serious problems facing the Indian spice industry, resulting in low competitiveness in the international markets. The rapid disappearance of some indigenous varieties of spices due to mixing of planting material results in loss of genetic purity; examples are varieties contributing to the production of Cochin ginger (namely Kuruppampady, Ellackal), Alleppey finger turmeric (namely Elanji), and Byadagichilli [65]. Major challenges facing seed spices production in India are low productivity, lack of high-yielding varieties. Such challenges should be overcome by developing fertilizer-responsive varieties and developing pests and disease resistance. Introduction of germplasm of spices from their centers of diversity both in general and for specific characters will help in broadening the genetic base and for attempting meaningful crop improvement programs [66]. India being the primary and secondary center of diversity for many spices, the genetic variability in major spices such as black pepper, cardamom, cumin, coriander, nigella can be addresses by assessing diverse germplasm and integrating beneficial agronomic trait into cultivable varieties. Genetic resource enhancement, its evaluation, and valuation for effective use to meet the challenges of biotic and abiotic stresses to sustain the impact of climate change are also the need of the hour besides yield quality and nutritional value.

## 12.12 Conclusion and Future Perspectives

Spices are rich source for phytochemicals having precise health benefits. Spices are used individually or in combination as food adjuncts to impart flavor, color, and aroma. Traditional knowledge prevailing in countries such as India has shown the medicinal properties of many spices for treating wounds, cough and cold, fever, hyperglycemic, and hyperlipidemic conditions. Some of the important bioactive compounds of spices that are shown to possess medicinal value include curcumin from turmeric, capsaicin from red pepper, piperine from black pepper, eugenol from cloves, allyl sulfides from garlic and onion. These compounds are shown to possess antioxidant, anti-inflammatory, antimicrobial, hypolipidemic, and anti-lithogenic activities and pro-anti-cancer properties as well. There is need to increase the productivity to fulfill the domestic requirement and for export of valued spices and condiments. It has been observed that technological interventions such as rhizome treatment, soil application of biocontrol agents, manures, fertilizers, micronutrients, crop rotation, mulching, and correct form of plant protection measures increase the yield performance. Reintroducing the germplasm from the centers of diversity in crops such as paprika, nutmeg, clove, allspice, and vanilla will improve our genetic stocks for future utilization. Popular spices such as lavender, anise, dill, oregano, marjoram etc. need to be introduced to help in diversifying Indian spices production. Introduction of spices species to nontraditional areas must be done in order to conserve the germplasm. To recognize the climate-dependent high-yielding spice varieties, new improved spice crops for Indian climates are to be developed through modern research tools. Introduction of suitable modern hybrids, considering the market demand and more emphasis on utilization of exotic wild species in breeding programs, is to be considered. To enhance the productivity of spices and condiments, integration of advanced farming practices with novel technologies and coupling it with ecofriendly traditional production technologies among the farming community is the need of the hour.

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# **Authors' Contribution**

SK and TRR designed the work. SK did major contributions, compiled the information, and written the manuscript. TRR did minor contributions and formatted the manuscript.

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