Spices Obtained from Forest and Other Resources

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Contents

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1 Introduction

Spices can be defined as dried roots, aromatic seeds harvested primarily to add flavours in various cuisine. In addition, these are used in medicines, curing health issues, cosmetics and insect repellents. During the last few decades, there has been a phenomenal increase in area, production, productivity and demand for spices all across the globe. Most of the spices which are well adapted to shade are found in the forest of Ethiopia (Furo et al. 2019). Some of the major spice-growing countries are India, Bangladesh, Turkey, China, Pakistan, Iran, Nepal, Colombia, Ethiopia and Sri Lanka (Kunnumakkara et al. 2014). United Food and Agriculture Organization reported that the total world production of various spices in the year 2011 was 2,063,472 metric tons. India is the leading spice-growing country in the world is known to be 'The land of spices'. Moreover, India is the world's largest consumer and exporter of spices. According to an analysis made by the Indian trade portal, in the year 2018–2019, total 1.10 million tons of spices and different spice products of Rs 19,505.81 crore (US $ 2.80 billion) has been exported to other countries. Further, it is an interesting fact to know that during the quarter ending in September 2019, essential spices like ginger showed maximum growth of 31% with 11,910 tons and pepper 21% with 8200 tons (Indian trade portal). Trading of spices in the Indian sub-continent started by the earliest 2000 BCE with prominent spices like cinnamon and black pepper. In the middle ages, spices like black pepper, cinnamon, cumin, nutmeg, ginger and cloves were among the most expensive spices. The importance of spices has been realized since the ancient period from the history that during late middle age, nearly 1000 tons of pepper and other major spices were imported into the Western part of Europe.

Esteemed organisations like World Spice Organisation (WSO) in Kochi (Kerala) deals with safety and sustainability of the spice industry at the field level on global standards. WSO is a non-profit organisation involving various stakeholders, industries and consumers. One of the major objectives of WSO is the availability of safe herbs and spices ensuring its excellent productivity and distribution across its entire supply chain. Another major institute dealing with research on various spices is ICAR–Indian Institute of Spice Research (ICAR-IISR) situated in Kozhikode, Kerala. A National Research Centre for Spices was established in the year 1986 with its headquarter in Kozhikode, Kerala, by merging with regional Station of Central Plantation Crops Research Institute (CPCRI) at Kozhikode and Cardamom Research Centre at Appangala, Karnataka. Spices like cloves, black pepper, turmeric, cardamom and ginger consist of different and essential parts such as seeds, fruits, berries, leaves, or kernels. There are almost 72 spices grown in different parts

of the world, while in India, Kerala is the epicentre of spice production, and India is the prime producer of cardamom to the entire world. Anthropogenic activities like afforestation lead to a reduction in species of different spices; therefore, ICAR-Indian Institute of Spices Research (IISR), Kozhikode promotes collection and conservation of the biological diversity of spices (Saji et al. 2019).

Spices also play a very significant role in industrial use as natural food preservatives. Cinnamon is the most effective alternative to replace industrial preservatives, which are detrimental to human health (De La et al. 2015). On the pharmaceutical aspect, they have been used to flavour medicines. Clove is more often process to produce clove oil, which again is very useful for its medicinal purpose (Chaieb et al. 2007). One cannot deny from the fact that spices and herbs have a huge demand in the world market, as it has several antimicrobial properties to enhance the safety and shelf life of the food products against harmful pathogens and bacteria that can deteriorate the quality of various food products (Table 1). Spices and condiments industry contributed about 4.7% to the GVA. Spices contain volatile essential oils and hydrocarbons, which can stimulate gland-based secretion. According to Statista Research Department, India's total spice production till October 2020 is estimated to be around 9.4 million metric tons. The main objective of this chapter is to emphasize on the multidimensional use and future perspective of forest spices like bay leaf, star anise, curry leaves etc. Many other important aspects of spices are also highlighted, which are spice cultivation practices, current scenario of spices, spice trade and its health benefits.

1.1 Multidimensional Uses of Spices

- *Phytochemicals in spices:* Spices like cumin and fennel seeds consist of phytochemicals like monoterpenes, flavonoids, sterols and phthalides (Sharma 2015), which are aromatic compounds that help in giving peculiar fragrance to different spices (Shahidi and Hossain 2018). Some of the other major phytochemicals are cinnamic acid in cinnamon, eugenol in cloves, curcumin in turmeric etc. as shown in Table 1.
- *Natural preservatives*: Spices consist of essential chemical compounds like phenolic compounds and flavonoids that help in preserving the quality of spices and also protect it from inhibition of growth of harmful microbes (Gottardi et al. 2016).
- *Natural home remedies to enhance beauty*: Spices and herbs are being used to enhance the beauty of the skin from the ancient period. Turmeric has immense anti-microbial and antibiotic properties, which play a significant role in skin care by removing dead cells. Turmeric, cardamom, clove, coriander, saffron, garlic and sage are generally used in cosmetics.

Table 1 Active compounds found in spices and their biological activity

Botanical name of spices (family)	Common name	Activities/usage	Phytochemical/active substances	Key references
Cinnamomum cassia (Lauraceae)	Bay leaf or Tej Patta	Used for chest pain, kidney disorders, high blood pressure, cramps and cancer	The major compounds of the extract were cinnamaldehyde (24.58%), p-methoxy cinnamaldehyde (9.87%), cis-2-methoxy cinnamic acid (9.22%), cinnamic acid (7.39%) and coumarin (5.31%)	Ahmad et al. (2013)
Foeniculum vulgare (Umbelliferae)	Fennel seeds or Saunf	Aromatic and flavour enhancer for dishes, plant widely used as carminative, digestive, lactogogue and diuretic and in treating respiratory and gastrointestinal disorders	Minerals and vitamins present in *F. vulgare* are calcium, potassium, sodium, iron, phosphorus, thiamine, riboflavin, niacin and vitamin C	Rather et al. (2016)
Murraya koenigii (Rutaceae)	Curry leaves	Enhance aroma of food, curry leaves can also be used for weight loss	The oils from the curry leaves were found to contain mostly oxygenated monoterpenes	Rajendran et al. (2014)
Nigella sativa (Ranunculaceae)	Nigella seeds or Kalaunji	Flavour enhancer for many Indian dishes. Used in Indian snacks, breads and savoury dishes	The most important active compounds are thymoquinone (30%-48%), thymohydroquinone, dithymoquinone, p-cymene (7–15%), carvacrol (6–12%), 4-terpineol (2–7%), t-anethol (1–4%), sesquiterpene longifolene (1%-8%) α-pinene and thymol etc. Black seeds also contain some other compounds in trace amounts	Desai et al. (2015)
Piper nigrum (Piperaceae)	Black pepper or Kali Mirch	Important taste and flavouring agent in the majority of Indian dishes especially south Indian preparation and to make spice blends	Pepper contains moderate amounts of vitamin K (13% of the daily value or DV), iron (10% DV) and manganese (18% DV), with trace amounts of other essential nutrients, protein and dietary fibre	Damanhouri and Ahmad (2014)

2 History of Spices

According to Archaeologists' estimate, humans used the special qualities of aromatic plants and spices to help flavour their food since 50,000 BCE. Utilization of the sweet-smelling spices in order to make their food taste better was a common practice. Primitive men offered all sorts of aromatic herbs to their gods. Spices were also used to heal wounds since ancient times. From that moment on, spices played an important role in human beings. Also, trading of spices was developed throughout the Middle East in 2000 BCE with prominent spices like pepper and cinnamon. In 1000 BCE, China and India had a medical system based upon different herbs. India has a famous and profound history regarding excellent husbandry of major spices (Shahidi and Hossain 2018). The ancient Indian epic of 'Ramayana' mentions cloves. It is well known that the Romans utilize cloves in the first century AD as evident from Pliny the Elder' writings about them.

The trade of spices in Middle East made the region phenomenally rich during the middle ages. Spices like black pepper were imported from plantations in Asia and Africa, which made them extremely expensive. During the fifteenth century, the Republic of Venice had the monopoly on spice trade with the Middle East and along with its neighbouring Italian city-states (Shukla and Yadav 2018).

3 Different Spices and its Cultivation

Spices are the prime ingredients of all households, which not only have phenomenal history but also have an incredible future in terms of productivity. Practices regarding the cultivation of spices were prominent since the ancient period, and its yield, trading and demand in global market has been increasing with advancement in technology in the recent years. Some of the major spices and their cultivation details are discussed below:

3.1 Cardamom

Cardamom is used on a wide scale for flavouring the food and it also has a medicinal use. Cardamom is very well known as 'queen of aromatic spices'. IISR-Vijetha-1, IISR-Avinash (RR1) and Kodagu are varieties of small cardamom. It is a shade-loving spice. Well-drained laterite and forest loamy soil are considered best for cardamom. Ideal temperature range required for optimal production of this spice is 22–32°C with annual rainfall amount of 280–300 cm. Best growth of cardamom is observed under tropical rain forest situated mainly at an altitude of 1500 m. India alone accounts for about 80–90% of total cardamom production in the world. Kerala, Karnataka and Tamil Nadu are the major cardamom-producing states of

India. Under rainfed conditions, NPK ratio of 72:72:150 is considered best for cardamom (Jagdish Reddy 2015).

3.2 Curry Leaves

Curry leaves belong to the Rutaceae family, and its scientific name is *Murraya koenigii*. It grows on a wide scale in forest areas and Himalayan foothills. In India, Karnataka, Andhra Pradesh and Tamil Nadu are the leading producer of curry leaves. The aromatic curry leaves are commonly used to add flavour to the food. Apart from leaves, bark and stem of the curry plant are widely used to prepare medicines. Optimum temperature requirement of curry leaves is 26–37°C. This spice is significant as it can tolerate drought up to a certain extent. DWD 1 and DWD 2 are the improved varieties of curry leaves.

3.3 Chillies

Countries like Mexico (3 million tons), Turkey (2.2 million tons), Indonesia (2 million tons) and India (1.5 million tons) are the leading chilli-growing countries. In India, chillies are cultivated in Andhra Pradesh, Maharashtra and Odisha States. Guntur district of Andhra Pradesh is primarily famous for its chillies. Optimum temperatures range from 15 to 30 °C and moderate annual rainfall of 65–122 cm is considered best for chilli growth and development. Heavy to very heavy or less rainfall is detrimental for chillies production. It can be grown on a wide variety of soils like black cotton and loamy soils. It can be grown up to elevations of 1500 m. Application of 5–6 tons/ha of FYM is best suited for better production of chillies (Vikaspedia 2020).

3.4 Bay Leaf

Dried bay leaf is commonly used in various cuisine as it enhances flavour and aroma of food for many years. It has a pungent bitter taste. *Laurus nobilis* is a perennial shrub found on a large scale in various Asian, European, Mediterranean countries and tropical forest. It is a power house of several chemical compounds like alkaloids, tannins, methyl chavicol and eugenol. ‘Tej Patta’ is one of the most popular names of bay leaf. Soil should have good drainage conditions. The essential oil extracted from bay leaves by the steam distillation process has medicinal properties. The ideal temperature for its growth is 65–75°F.

3.5 Long Pepper

Long pepper is spread along the lower hill of Bengal, the forest of Western Ghats, Andaman and Nicobar Island and other tropical forest-covered parts of India. The common name of long pepper is pippali. About 20–25% of shady ambiance is favourable for its proper growth. The most common method of its propagation is by suckers. A total of 20–22 tons/ha of cow dung is essential for its growth. Optimum application of organic manure helps in enhancing the productivity of long pepper. The root and the fruits of long pepper have medicinal properties.

3.6 Star Anise

The scientific name of star anise is *Illicium verum*. The anethole compound present in star anise adds flavour. It is available on a wide scale in the subtropical to temperate forest regions. This spice has a 'star'-shaped appearance. In India, star anise is used on large scale in biryanis to increase its flavour and aroma. It is also known for its medicinal properties from ancient times. The optimum temperature favourable for its growth is 20–25 °C. Star anise belongs to the magnolia family. China is the leading producer of star anise.

3.7 Ginger

India is the leading producer of ginger with an overall production of 1,109,000 tons in an area of around 166,000 hectares. As ginger is a widely grown crop in tropical as well as subtropical areas, temperature range of 15–25 °C is best for its growth. IISR-Varada (180–200 days), Suprabha (230 days), Suruchi (215 days) and Suravi (225 days) are some of the major varieties of ginger. India is also a major exporter of ginger, despite its maximum consumption within the country. Kerala is the leading producer of ginger, as this state alone contributes around one-third of the total ginger production of the country. Ginger can be successfully grown in all types of terrain from sea level up to the height of around 1200 m altitude. In all, 30–35 tons/ha of FYM and 75:50:50 (NPK ratio) is ideal for its optimal growth (Vikaspedia 2020).

3.8 Pepper

Pepper too adds flavour in food. It is also known as the 'king of spices'. An ideal temperature range of 24–32 °C is required for its optimal growth and development. In addition, well-distributed annual rainfall of 135–200 cm is ideal for pepper. As

pepper is a plant that grows well in humid tropics, the soil temperature of 25–28 °C is best for its root growth. Pepper is cultivated on a large scale in Western coast of India. Panniyur-1 and Panniyur-3 are some of the hybrids of pepper. NPK fertilizer application in the ratio of 50:50:150 is recommended for pepper. Serpentine and trench are the main methods for its propagation. Indonesia is the largest producer of pepper after India. Kerala, Karnataka and Tamil Nadu are the leading producers of pepper in India. India exports peppers to several countries like the United States, European countries, Egypt etc. (Homey Cheriyan 2015).

3.9 Turmeric

Turmeric is an important spice and also a natural antibiotic. It belongs to the family Zingiberaceae. Some of the most common varieties of turmeric are Suvarna, IISR-Prabha, IISR-Prathibha, Sudarsana, Co-1, BSR-1 and Suguna. The crop duration of these varieties varies from 190 to 250 days. Tropical climatic conditions favourable for turmeric are with a temperature range of 25–35 °C and annual rainfall around 1600 mm. Well-drained sandy loam soil is best for the growth of turmeric. India, Haiti, Jamaica, Peru, Thailand and Pakistan are some of the major turmeric-growing countries. India alone contributes around 70–80% of the overall world's turmeric production. In India, Andhra Pradesh is the leading turmeric-producing state covering 36% area of the total turmeric production in the country. Pre-sowing activities like land preparation before the arrival of the monsoon is a prerequisite. In all, 35–40 tons of FYM and NPK dose of 65:50:125 is ideal for its cultivation. Removing weeds from turmeric plantations in regular time intervals, i.e. after 65, 90 and 120 days, after sowing can help in giving optimal yield. As turmeric has a rough surface, processes like polishing can help in making the surface smooth. Around 80–90% of turmeric production in India is consumed in the country itself, and the remaining is exported in different parts of the world, which indicates the significance of turmeric among consumers (Vikaspedia 2020).

3.10 Areca Nut

Areca nut is one of the widely cultivated spices used in various religious occasions. The chewable nut of areca nut is also known as 'Supari'. Favourable temperature range for proper growth of areca nut is 25–35 °C and annual rainfall of 250–300 cm. Spacing of 2.8 m × 2.8 m is ideal for the best production of areca nut. India is not only the largest producer but also the largest consumer of areca nut. Leading areca nut growing states in India are Karnataka, Assam, Kerala, Tamil Nadu and West Bengal. Laterite clayey soil or loamy soil is suitable for its growth. Some common areca nut varieties are Vittal Areca Hybrid-1 (VTLAH-1), Swarnamangla (VTL-12), Thirthahalli and Shriwardhan. Thirteen- to 17-month-old seedlings are mostly

recommended for transplantation in the main field, while 110:40:140 dose of NPK helps giving essential nutrients to the crop. Water stress conditions for long period can be detrimental to its growth (Vikaspedia 2020).

3.11 Nutmeg

Indonesia is the leading producer of nutmeg. Nutmeg is a seed ground spice that belongs to the genus Myristica. The amount of dietary fibre content in nutmeg is very high. It contains almost 80% of dietary fibre, which is good for digestion. It is found in dry deciduous and evergreen forest. Humid and warm climatic conditions (28–32 °C) are ideal for its growth. It responds well in clay loam to sandy loamy to red laterite soil. IISR-Viswashree is one of the Indian nutmeg varieties. Waterlogging condition on the field has an adverse effect on this spice. Pre-sowing operations like digging pits of 10 m × 10 m spacing 20 days prior to planting date is suitable for its growth, while 25–30 kg FYM should be applied in the field along with 22g urea, 22 g P_2O_5 and 55g K_2O (Vikaspedia 2020).

3.12 Cloves

Clove is an aromatic spice that mainly grows in clusters. In India, the hilly regions of Tamil Nadu, Karnataka and Kerala are major clove-growing States. It belongs to the family Myrtaceae. Cloves are widely used in Asian, Middle East countries, Africa and other parts of the world to add flavour to food. Mexicans majorly use cloves in their cuisine. Cloves are used since the first-century AD. Eugenol is an important chemical compound found in cloves that is responsible for its aroma. As clove is a tropical spice crop, it requires warm climatic conditions for its ideal growth: 25–30 °C temperature and annual rainfall of 200–250 cm. Application of urea-35–40 g, P_2O_5-100 g and K_2O-80–85 g is suitable for supplying sufficient nutrients to the crop (Vikaspedia 2020).

4 Processing of Spices

Industries play a major role in spice processing. Production, processing and trading of spices have a great impact on boosting the economy of different leading producers of spice-growing countries like India, Sri Lanka and Indonesia. For small- and large-scale production, major operations that are carried out by various spice-processing industries are cleaning, drying, grading, grinding and packaging (Thankamani et al. 2013).

4.1 Cleaning

Cleaning the harvested spices to remove all the dust and dirt particles is the first step and a prerequisite in spice processing. A large amount of water is required to wash the spices after winnowing. Dirty water must be rinsed, and harvested spices must be washed with clean water repeatedly.

4.2 Drying

Drying spices after cleaning is another major and second step carried out in the spice processing industry. Spices are spread properly on a mat under sunlight so that spices are dried up. Proper drying up declines the possibility of mould formation in the spices, which maintains their quality and aroma. If spices are not dried under sunlight for a long time, the mouldy infestation will occur in spices, leading to a huge decline of up to 50–60% in its market value. Different harmful food poisoning–causing bacteria can also develop on spices if proper sun drying is not done after cleaning spices. At the time of sun drying, solar drier is used to remove the dirt and dust particles from the spices. Solar drying also helps in drying of spices if it got drenched in light rainfall. Overdrying of spices can lead to decline in its quality. Overdrying of spices can severely affect the optimum moisture content of different spices (Bala and Janjai 2009)

4.3 Grading

Grading is the third stage of processing, where spices are sorted or separated based on size, colour and texture, the scale of quality or intensity at various standard levels. Grading of spices is essential to get the best price or net return, assuring the quality of spices in separation and milling process.

4.4 Grinding

Grinding of spices is an important processing operation carried out to add value to the product. Manual grinders are commonly used to grind different spices, which have small- to medium-scale production. The grinding mill can grind 25–28 kg/h of spices.

4.5 Packaging

Packaging of spices depends upon several factors as listed below:

- should have good aroma
- quality and size of spices
- ability to sustain spoilage or good shelf life
- spices should not show any adverse physio-chemical changes in any condition
- have optimum resistance against insects and pests infestations
- attractive appearance.

5 Equipment Used in Spice Processing

Texture and appearance of spices vary from berries, twigs, roots, bark and leafy parts. For grinding this complex form of spices into simple edible form in cuisines, various types of equipment are available for its proper and fine mixing, grinding and blending. Some examples of such equipment are Grinding Machine, Automated Coating Machine, Oil filters, Nut Roaster Metal Detector Machine etc.

6 Current Scenario of Indian Spices and Constraints in Spice Production

Chillies, turmeric, coriander, ginger, pepper, fenugreek, garlic, cloves, cumin, cardamom, Areca nut and tamarind are some of the prominent and widely grown spices in India. Karnataka, Kerala and Tamil Nadu are the major states producing pepper (Shinoj and Mathur 2006). In the year 2017–2018, Karnataka was the leading pepper growing state with total production of 35,200 tons in the acreage of 37,000 ha. In the same year, Kerala accounts for the maximum small cardamom production, which was nearly 18,000 tons in 39,000 ha area. Till 2018, the total production of chillies in Andhra Pradesh was recorded 993,000 tons in 209,300 ha land. The total production of ginger witnessed by Assam in 2018 was nearly 167,400 tons in an area of 18,790 ha. States like Rajasthan and Gujarat together produce 80% of the total seed spices of India (Singh et al. 2011). From the past decades, one of the most important spices like turmeric shows an increase in trend in terms of overall production and yield in major turmeric-growing states of India. Total production of turmeric in India during 2009–2010 was approximately 8 lakh tons which got an increase in the year 2018 to 11 lakh tons cultivated in 225,000 ha of land till 2018.

According to state agriculture/horticulture data, the Western States of India like Gujarat is the leading producer of spices like cumin and fennel seeds with an overall production of 291,500 tons and 87,800 tons, respectively, till 2018. Rajasthan is the

leading producer of garlic and fenugreek seeds, with an overall production of around 7.3 lakh tons (in 107,900 ha) and 1.6 lakh tons (in 129,700 ha) in the same year. The southern state of Tamil Nadu is one of the leading producers of cloves with an overall production of around 970 tons in 990 ha of area. With increase in demand for spices in the global market, production, productivity and total area of different spices such as turmeric, ginger, cloves, garlic and Arecanut require an increase to meet the need for increasing population. Sustainable development is the major step to achieve this goal.

6.1 Constraints in Production of Spices

- Poor genetic potential of spices with respect to its quality and yield can more often lead to decline in the overall productivity of spices.
- Application of imbalanced fertilizers due to lack of awareness and poor post-harvest handling of spices (Bhardwaj et al. 2011)
- Lack of farm equipment, technological awareness and insufficient planting material/ seeds can also reduce the production of spices.
- Less flexibility in extension programmes to carry lab to land work.
- Lack of adoption of various insect pest management practices.
- Delay in presowing operations of lack of relevant agronomic practices.
- Not drying of seeds under sunlight before grinding or its processing.
- Hurdles in trading like non-tariff trade restrictions (Muthupandi et al. 2018)

7 Value Addition in Spices

After processing of spices, there is a value addition for its further application and distribution from producer to consumer, which also helps in enhancing economic growth in terms of foreign exchange. Trading operations like exporting the final value-added product of spices in foreign counties can lead to making the spice business and agriculture profitable. Merits of value-added spice products are:

- Its consumption in different cuisines for enhancing flavour all across the globe.
- Maintaining the standard quality of spices to get the best price in the market.
- Value-added products help it gaining foreign exchange.
- Drying spices under sun rays increases its shelf life and can be stored without the threat of any insect infestation. This further is an advantage for value-added products of spices.
- Aroma of spices is also intact after value addition.

7.1 Value-Added Products of Spices and its Application

- *Ground spices*: The coarse form of ground powder of spices is known as ground spices. Grinding mill is used to make this powdery form of spices for which large amount of heat is essential. Turmeric powder, red chilli powder, cumin powder, coriander powder and cinnamon powder are some of the important ground spices, which are used on a large scale in cuisine all over the world. As India is the leading producer of most spices, ground spices have an inevitable contribution in uplifting the quality of Indian cuisine.
- *Spice oils*: Granular extract of spices is widely used in the preparation of different products like shampoos, soaps, perfumes, toothpaste, mouthwashes, detergents and pharmaceuticals products. Spice oils are also used in dairy items like cheese. In the initial stage, spice oils are extracted from spices, before when it is subjected to solvent extraction. Spice oils are extremely volatile that adds flavour and aroma in different final products of processing and manufacturing industries. Steam distillation process plays a vital role in the extraction of oils from different spices. Pepper oil is extracted by steam distillation technique of dried form of black pepper. Seeds of cardamom are also steam distilled to obtain cardamom oil (Macwan et al. 2016).
- *Spice powder*: Different spices like turmeric, coriander, chillies, fennel, fenugreek and black pepper are blended and crushed to transform spices into powdery form. This spice powder is utilized to add flavour in curry paste, curry masala and its mixture. Spice powder also adds to the attractive colour and appearance of various cuisine, especially vegetables, meat and fish.
- *Oleoresin*: Oleoresin is an important value-added product of spices obtained naturally from the perfect combination of oil and resins, which are extracted from plants. It is a concentrated liquid form substance. Oleoresins are used in desserts, meat sauces, hair lotions, candles, soaps and frozen foods for enhancing the appearance/colour of eggs, butter and cheese.
- *Meats and fish*: Spice powder of chillies, black pepper, cloves and coriander are used more often in red meat, sausages, chilli chicken and other meat-relevant cuisine. Spices along with some prominent herbs are widely used in marinating the non-vegetarian delicacies to add more flavour to it. Variety of spices like turmeric, garlic and chillies are used in making fish curry or fried fish.
- *Snacks*: For adding flavour to a variety of snacks, salt and spices are dusted or sprinkled on snacks. Dusting of spices in snacks adds a base to its flavour and makes it crunchy. Seasoning (the process to add salts, spices in food to enhance its flavour) also helps in making the food attractive to consumers.
- *Pharmaceuticals and Cosmetic industries*: Spice oils and oleoresins are used in the manufacturing of medicines, cosmetic products like skin or cold creams, soaps, shampoos and lipstick (Bhagya et al. 2017). Herbal spice like turmeric is used on a wide scale by different pharmaceuticals and cosmetic industries because of its demand for skincare routine and enhancing immunity. Bacteria

present in spices like cloves and garlic gently clean the skin, as it is has antimicrobial properties (Arora and Kaur 1999).

- *Hygienic Products and mouth wash*: Toothpaste and soaps also contain spice oil. Further, mouth-wash available in the market contains spice oil to maintain good oral hygiene. Clove is used to cure several oral disorders. Phytochemicals present in spice and spice oil prevent and cure the attack of harmful microorganisms like *Mutans streptococci*, *Streptococcus mutans Streptococcus sobrinus* and lactobacilli (Sonal Dubey 2017).

7.2 Importance of Spices in Diet

- The essential components present in spices especially turmeric contain anticlotting properties and also play a significant role in increasing immunity.
- Heating or boiling of spices helps in curing severe cold and cough; therefore, it is an important ingredient for a person suffering from cold or cough.
- Spices are rich in mineral content, which helps in controlling blood pressure.
- Thyme water plays an important role in throat gargling during sore throat, and it is also used as an antiseptic mouth-wash.
- Onion, garlic and asafoetida add pungency, flavour and treat minor diseases (Patil et al. 2016).

8 Technologies involved in Spice production:

Spice cultivation activities like presowing, vegetative growth, planting, reproductive growth and harvesting can be severely affected by adverse weather conditions, such as flood, drought, flood, extensive heat or cold temperature or high wind. Excessive humid condition also acts as a catalyst for insect and pest attack on spices. This can drastically lead to gradual decline in spice yield and quality, which eventually leads to immense loss for farmers depending on spice crop production, spice dominant processing, manufacturing industries and agriculture-based trade sector. To overcome such constraints, there is a need for different innovations of new technologies to enhance spice production. Some of such technologies are described below:

- *Technologies to monitor plant health*: Pest Defender ratio or P: D ratio method helps in easily identifying the number of pests and insects (beneficial) that may attack the crop. This helps the farmers to make a decision regarding pest management practices to be undertaken.
- *Agro-Ecosystem Analysis (AESA) Technology*: In modern agriculture-based practices, maximum emphasis is given on AESA technology. This technology primarily helps farmers having large fields. AESA technology relies on nearby environmental conditions like temperature, rainfall, sunshine hours, wind speed,

soil condition, weeds, insect or pest attack on crops. These environmental factors play a vital role in determining crop health at various stages of the crop (Badr 2017).

- *Plant Growth-Promoting Rhizobacteria (PGPR)*: PGPR is a colony of bacteria that sets a colony around the plant root zone which also referred to as plant growth-promoting rhizobacteria. PGPR works efficiently against soil-borne pathogens which can help in regulating the growth and development of various spice crops. Seeds of fenugreek, fennel and coriander are highly susceptible to delay in germination, infestation of insects and pest under adverse conditions. To prevent such condition, this technology helps in coating the seeds of spices with PGPR to enhance the shelf life of seeds. It also protects the seeds from insect/disease attack during storage.
- *Detection of adulterants using DNA barcoding technique*: Any kind of adulteration in spices can be detected using the DNA barcoding technique. Before exporting or importing spices from one country to another, this technique is used to monitor any kind of adulteration in spices to avoid any kind of defamation of brand or nation and also to have a concern regarding the ultimate consumers. Any kind of foreign material detected in spice sample which is being traded can be easily detected using DNA barcoding technique (King et al. 2018).
- *Mechanical-based technologies*: For fabrication of spices, mechanical technology is a prerequisite. The mechanical setup includes machines like gearbox, rods for grinding, sterilization and grinding machines, dryers and oil-extracting machines are some of the major machines developed that helps in the processing of spices into value-added products.
- Infrared drying technology: To avoid any kind of infestation of micro bacteria such as *E. coli,* salmonella and moulds, infrared drying technology is used for sterilization which also helps in preventing overheating of essential oil present in spices.

9 Organic Farming and its Significance in Spice Production

In the recent years, organic farming has gained significant importance in the agriculture sector across the world. Farmers with small and large landholding are also showing awareness regarding adapting the organic method of crop cultivation. Extension workers are also promoting the organic method of farming by organizing training programmes, Kisan-mela and workshops, which helped farmers in switching to organic farming method from traditional methods. The demand for organic-based agriculture products like cereals, spices, fruits and vegetables has increased in the past few decades. At the global level, 51 million hectares of agricultural land is under organic farming. According to Agricultural and Processed Food Products Export Development Authority (APEDA), the total area under organic farming in India is around 5.7 million hectare with cultivable area of 26% till 2016.

In the year 1998, the Spice Board of India had taken initiative to prepare a detailed document regarding the development of organic-based spices. This includes all the guidelines relevant to standards, principles, concepts, certification, inspection and information regarding organic methods of spice cultivation. The board actively promotes farmers, NGOs and other organisations to adopt modern techniques related to organic farming, as it has no chemicals involved to fulfil nutrient demand of spices. The board also focuses on export and quality maintaining aspects of organic spices from India to other countries after the certification process. Besides countries like Vietnam and China, India is a prominent exporter of organic spices to different countries like Germany, United States and the Netherlands. This helps in boosting up the Indian economy by gaining foreign exchange. Input cost of organic farming is a little expensive when compared to chemical fertilizers, but it has no adverse effect on plants or human health while consuming its by-products. Spices obtained after organic farming can be a great source to increase immunity. In addition, organically raised spices do not have any harmful foreign material or toxic substances, high on anti-oxidants and thus prevent soil and water bodies to be contaminated.

10 Health Benefits of Spices

Every spice has its own significant taste and aroma. Every household uses different combinations of spices like black pepper, ginger, turmeric, coriander, fenugreek, cumin seeds and fennel seeds in various countries across the world. Therefore, knowledge regarding health benefits is a prerequisite. Spices not only add flavour to various cuisine but also is an excellent source of nutrients. The Health benefits of various spices are discussed below and presented in Fig. 1.

Pepper: Black pepper is known as 'king of spices'. For a person suffering from obesity, it helps in the reduction of weight and enhances metabolism. Cayenne pepper contains capsaicin which helps in reducing the appetite and thus contributes to weight loss. Pepper when mixed with turmeric has anti-cancer properties. It provides instant relief from cough, cold or sore throat. Pepper eliminates toxic elements from our body and is a great source of detoxification. It also cleans the stomach and intestine, which prevents problems regarding digestion. Black pepper is rich in vitamin B, which treats skin-related problems like wrinkles of skin and skin pigmentation. During winter, if the person is suffering from joint pain, the medicinal property of black pepper helps in curing such joint pain.

Long pepper: It aids health issues due to a lack of proper liver functioning. Long pepper regulates the blood sugar level and thus is helpful for diabetic patients. It protects from bacterial infections. Long pepper has chemicals that provide relief from indigestion and diarrhoea. It also reduces the risk of asthma attack and cures respiratory issues.

Star anise: Star anise is an excellent source of important and essential compounds like gallic acid, quercetin and shikimic acid which have antimicrobial and

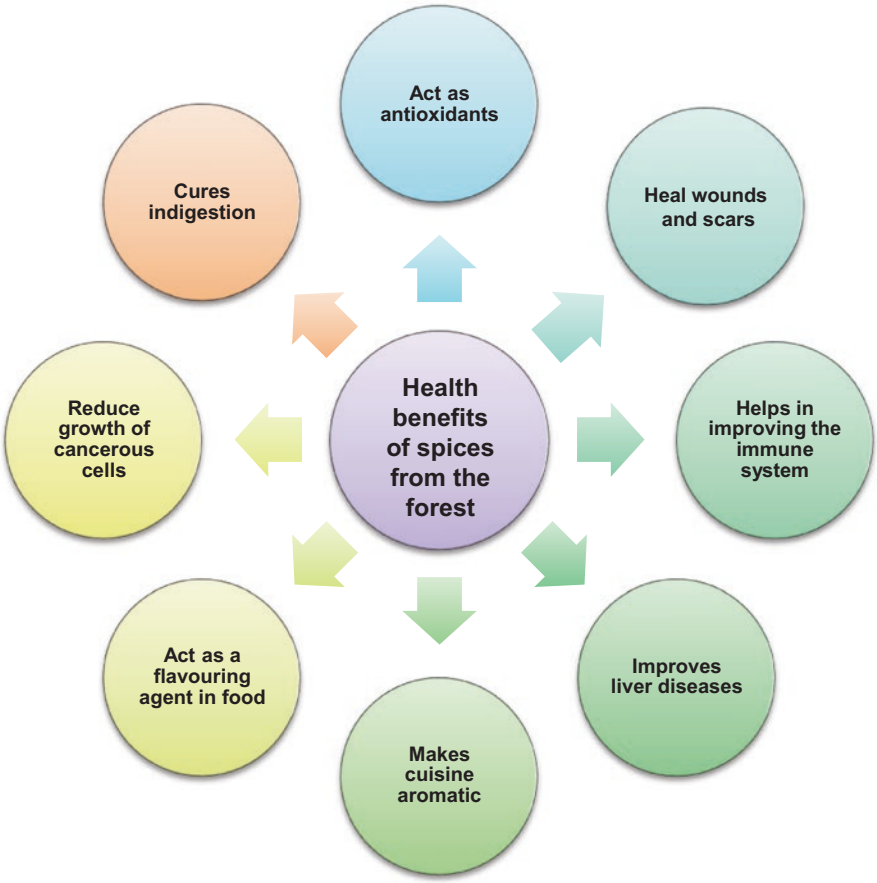

Fig. 1 Health benefits of spices from the forest

antifungal properties. Oil extracted from star anise consists of terpineol that cures cold and cough problem. It has ample amount of vitamins and is rich in antioxidants.

Curry leaves: It is a great source of antioxidants and has antibacterial properties. It protects from heart and liver-related diseases. Curry leaves are a rich source of iron; therefore, it is quite beneficial for anaemic patients. It is also good for eyesight, as curry leaves are rich in vitamin A. It also aids in digestion and is very beneficial for the proper growth of hair. Consuming curry leaves in diet maintains oral hygiene. Curry leaves are also commonly known as 'meetha neem' or 'kadi patta' in India.

Bay leaf: Bay leaf contains rutin and caffeic acid that cures several heart-related problems. It is helpful for diabetic patients by reducing the blood sugar level and protects our body from inflammation. Bay leaves also play a vital role in curing arthritis. As bay leaf has strong antibacterial properties, it helps in wound healing.

Cardamom: Cardamom or elaichi is also known as 'queen of spices'. It is a good source of vitamin A, C, zinc, iron and calcium. India is known to be the origin of cardamom. It is a boon for a patient suffering from blood pressure, as it maintains the blood pressure. Cardamom is rich in fibre and thus helps in digestion. It contains phytochemicals that have anti-bacterial and anti-inflammatory properties. Stomach ulcers can also be cured by consuming cardamom as it heals various kinds of ulcers. To prevent bad breath or maintain oral hygiene, cardamom is used as a mouth freshener. Due to its capability to fight bacteria and treat infections, cardamom is also known to have a great antibacterial effect. It is indeed helpful for diabetic patients, as cardamom can also maintain the blood sugar level. Cardamom protects the liver from getting enlarged and saves a person from fatty liver disease.

Cinnamon: Cinnamon is prepared by extracting the inner bark of the Cinnamomum tree. After drying this extraction, it is rolled to form cinnamon sticks. It lowers the risk of heart disease and controls the blood sugar level. Polyphenol is one of the most important antioxidants present in cinnamon, which protect our body cells against free radicals. Cinnamon also has an excellent anti-inflammatory effect that actively fights against body infections and successfully repairs damaged tissue. The use of cinnamon in cuisines reduces stomach-bloating problem. Adding cinnamon to food ensures the proper functioning of insulin hormone to regulate metabolic activities and decrease the chances of insulin resistance in our body.

Chillies: Chillies are found in the cuisines of almost every household. Red and green chillies are an important source of vitamin C. Presence of capsaicin in chillies gives a spicy touch to the food. Apart from weight loss, chillies also help in regulating blood pressure. Chillies have zero calories and are fully loaded with vitamins. It also has anti-oxidants to fight against free radicals. It enhances the metabolic rate of our body when consumed in optimum amount. Chillies also reduce the blood cholesterol level and help in reducing the chances of heart diseases.

Garlic: Garlic belongs to the allium family, which contains an important compound called allicin. Doctors often recommend eating garlic cloves especially to those having heart-related problems (Kaefer and Milner 2008). Due to its medicinal properties and strong taste, garlic is one of the most common spices used in various cuisines. Garlic fulfils many nutritional demands at it is rich in manganese, vitamin C, vitamin B6, fibre, selenium, calcium, iron and potassium. It is also beneficial to cure common cold (Bozin et al. 2008).

Turmeric: Turmeric is one of the essential spices, which has significant antibiotic properties. It helps in curing skin-related problems like eczema. Drinking milk with half a tablespoon of turmeric powder mixed in it helps in curing joint pain, ulcers and healing wound. Turmeric boosts up brain functioning and reduces the chances of Alzheimer's disease. Curcumin compound present in turmeric acts as a source of natural anti-inflammatory and minimizes the chances of heart stroke. It also helps in controlling the growth of cancer cells. Turmeric intake in food is also recommended to arthritis patients. It strongly improves the immune system and is helpful to provide relief from acute depression (Chattopadhyay et al. 2004).

Cloves: Cloves are grown widely in Southern states of India like Karnataka, Kerala and Tamil Nadu. It is known and is useful for its antiseptic, antimicrobial and

antifungal properties. Cloves are an important spice rich in omega-3 fatty acids, fibre, minerals and vitamins. Due to its antimicrobial properties, it cures mouth ulcers and other oral problems like toothaches. It is recommended for a diabetic patient to maintain the blood sugar level. Cloves act as a medicinal curing agent for any skin-related problems like acne. It also helps in regulating blood circulation, maintains proper digestion, provides relief from cold and cough and respiratory-related problems. The presence of Eugenolin cloves has the property to reduce cancerous cells (Bhowmik et al. 2012).

Cumin: Cumin water helps in digestion. It is best for curing skin-related problems, respiratory problems and sleeping disorders. Cumin oil is an excellent source of antiseptic and antibacterial properties. Cumin water also aids in irritable bowel syndrome (IBS). For curing allergies, black cumin is quite helpful (Fatima et al. 2018).

Coriander: Coriander is also known by the name 'cilantro' in Western countries and 'dhaniya' in India. Coriander seeds have good amount of fibre and manganese. Leaves of coriander have high content of vitamin C, vitamin K and protein. It boosts the immunity and is an excellent source for good eyesight. Minor amounts of phosphorous, potassium, thiamine and calcium are also present in coriander.

Fennel Seeds: Fennel seeds are consumed after meals, as it a rich source of fibre and as a mouth freshener. Despite being low in calories, fennel seeds are considered as powerhouse of nutrition. It contains vitamin C, calcium, iron, magnesium, manganese and potassium. Polyphenol antioxidants present in fennel seeds act as an anti-inflammatory agents that have a positive impact on our health. It also reduces the risk of heart diseases and has anti-bacterial properties. It boosts up prolactin content of blood, which enhances the milk secretion of breast-feeding women.

Ginger: Ginger is widely used to cure cold and cough. An important compound called gingerol helps in curing digestion and nausea-related problems. It acts as a catalyst for improving joint pain and reducing menstrual pain. Ginger keeps bad cholesterol level and blood sugar level of our body in check.

11 Research and Analysis of Spices

Research practices on spices like ginger, turmeric, cardamom, pepper and garlic started from the 1950s. Research Institutes and centres were set up in Karnataka, Kerala, Assam, Maharashtra and Punjab States of India. Initial research activities were carried out on three major spices, namely, ginger, turmeric and cardamom. To stretch the R&D activities, research on other spices like nutmeg and cloves were included in the next 5-year plan. Apex Organisation of Agriculture, Indian Council of Agriculture Research (ICAR) focused on the need to start the detailed research on different spices in the fifth 5-year plan. Organisations like ICAR, Spice Board of India and various State Agriculture Universities played a significant role in providing a platform for different spice-relevant research activities.

For conducting research activities on particular spice like cardamom, in the year 1986, ICAR collaborated with cardamom research centre of Central Plantation Crops Research Institute (CPCRI) located at Appangala, Karnataka as National Research Centre of Spices, which now commonly known as Indian Institute of Spices Research (IISR). IISR strictly follows mandates to conduct successful research activities regarding the cultivation of spices, enhancing its productivity, making spice production profitable to farmers etc. Some of the important mandates for carrying out research on various spices are mentioned below:

- Systematic approach regarding the production of spices with sustainable development with efficient use of split application of fertilizers, sprinkle irrigation method and weed management practices for surplus spice productivity (Singh and Solanki 2015).
- Developing improved varieties of spices to gain maximum productivity, good quality and drought-resistant varieties.
- Collecting and conservation of germplasm of spices for economical aspect.
- Identification of pathogens, diseases and insects that has an adverse impact on spice production.
- Ensuring environmental food safety in spice production food chain and its protection from harmful chemicals and microbial attack (Szekacs et al. 2018)
- Forecasting the possibility of a decline in spice productivity due to weather conditions, insects, pests or any diseases much in advance and its mitigation strategies.
- Value addition in the harvested spices so that producer can get maximum profit.
- Conducting seminars, workshops and training programmes to create awareness among spice-growing farmers and also knowing the field data/ground report regarding sowing dates, cultivation or management practices, varieties that can adapt to climate change (Raziya 2018) and harvesting time of various spices.
- Developing weather and crop-based module expertise system.
- Developing several statistical modelling techniques.
- Detailed study regarding medicinal and nutraceuticals application of spices.
- An analysis is carried out regarding proper pre/ post-processing, marketing of spices.
- Assuring quality and quantity of planting materials.
- Detailed study regarding different cultivars of spices and the impact of current and forecasted weather on spices.

12 Conclusion

Spices have significant importance for cooking as well as for herbal medication across the world. It is widely used in different cuisines to add flavour and aroma to foods. One cannot deny the fact that spices have great demand in the world market, as it has several antimicrobial properties to enhance the food quality against the

harmful pathogens and bacteria that can be harmful to human health. Research and analysis show that a systematic approach regarding the production of spices with sustainable development is very important along with rationalized value addition in spices. A detailed study on forest spices indicates that excess in afforestation activities can decline the major cultivars of spices. Spices like turmeric, nutmeg, bay leaf, ginger, garlic, coriander, cumin seeds, fennel seeds, cloves, cardamom etc. play a significant role in curing various health-related issues like controlling blood sugar level, anti-inflammatory agents, boost digestive system, curing joint pain, ulcers, healing wound, respiratory problems, cold and cough etc. Therefore, cultivation of spices and their trading will always have a wider future perspective because of its endless demand in the world market. In forthcoming years, forecasting the possibility of a decline in spice productivity due to weather and climate change, insects, pests or any diseases much in advance and its mitigation strategies using modelling techniques can help spice-growing farmers, policy makers and industrialists in the decision-making at various stages of socio-economic planning and trade. Sustainable development is also a major step, which adds to the rational development of spice production in the coming years.

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