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# Post-harvest technology of tree spices

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**Abstract**
Tree spices in addition to adding taste, flavour, scent, and colour, also serve as preservatives by preventing food and beverage goods from getting deteriorated. Their is a vast source of aromatic compounds and essential oils, which are in high demand in the pharmaceutical and cosmetics industries in both domestic and international trade. They are recognised as one of the most functionally significant food ingredients since, they also have nutritional, antibacterial, antioxidant, and medicinal qualities. Therefore, efforts are focused on upgrading the area, raising productivity, and enhancing tree spice quality. However, in the current environment, we face major obstacles not only in maintaining the output of tree spices but also in minimising their losses. Here, post-harvest management of tree spices seems to be more important. The majority of freshly picked spices contains high moisture content, they are highly perishable, and are microbially contaminated. When it comes to reducing post-harvest losses, actions like picking produce at the right time, moving it safely to processing facilities, cleaning, blanching and treating it with the proper chemicals, dehydrating it, packaging it for storage or processing it into value-added products, etc., are all very important practices.

**Keywords:** Post-harvest technology, tree spices, processing, quality, packaging

## Introduction
India plays a significant role in the export of tree spices. It has been observed that Europe and the USA demand higher quality spices. The main obstacle is to convince people to accept food safety standards on the global market. Therefore, in order to fulfil standards, sufficient care must be taken during various activities like harvesting, primary processing, which includes washing, threshing, blanching, drying, cleaning, grading, and packaging. Mechanization is necessary for spice growers to maintain the requirements for quality and food safety in post-harvest management. (Thankamani *et al*. 2015) [16].

Twenty to Twenty five percent of horticultural produce is lost due to improper procedures being used in the various post-harvest operations, including as harvesting, storage, packaging, and grading. Through a variety of scientific post-harvest management techniques, this percentage of losses can be controlled. Post-harvest management and technology for product value addition are fundamental requirements for marketing as a secondary production. Collection, curing, pre-treatment, grading, packaging, pre-cooling, cold storage, transport, and pallet loading are crucial post-harvest procedures depending on the type of crop. (Narendra, 2013) [43].

This review presents the better technique for managing tree spices after harvest.

Similar to other horticultural goods, spices have varyingly high moisture content when they are first harvested (between 55 and 85 percent), which must then be reduced to 8 to 12 percent. Tree spices differ from one another as well as berries, barks, seeds, leaves, rhizomes, roots, unopened flower buds, and other floral components in texture, size, colour, etc. Due to these variations in tree spices, pre-treatments like curing, depulping, and other processing techniques vary. In the course of their post-harvest processing, the Tree spices are put through a variety of unit processes like as peeling, curing, drying, cleaning, grading, and packaging until they are suitable for consumption or sale. The basic features of tree spices, such as scent, flavour, and pungency or bite, are well preserved by such processing technology. **(**Pruthi 1980, Purseglove 1981) [53, 76].

The issues with post-harvest technologies for tree spices are also briefly explored in this chapter. The following chart shows the overall trend of India's tree spice production, area, and productivity from 2020 to 2021.

**Table 1:** Important Tree spices grown in India (Haldankar *et al.*, 2013) [23]

| Sr. No. | Common name | Family | Botanical name | Part used |
|---|---|---|---|---|
| 1. | Bilimbi | Averrhoaceae | *Averrhoa bilimbi* L | Fruit |
| 2. | Carambola | Averrhoaceae | *A. carambola* L | Fruit |
| 3 | Chinese cassia | Lauraceae | *Cinnamomum aromaticum* Nees | Leaf, Bark |
| 4. | Tejpat, Indian cassia | Lauraceae | *C. tamala* Nees | Leaf, bark |
| 5. | Cinnamon | Lauraceae | *C. verum* Bercht &Presl | Leaf, Bark |
| 6. | Garcinia, Cambogia | Clusiaceae | *Garcinia gummi-gutta* (L.) Robs. | Pericarp of fruit |
| 7. | Garcinia, kokum | Clusiaceae | *G. indica* (Thouars) Choisy | Pericarp of fruit |
| 8. | Star anise | Illiciaceae | *Illicium verum* Hook | Fruit |
| 9. | Juniper | Cupressaceae | *Juniperus communis* L. | Fruit |
| 10 | Bay leaf | Lauraceae | *Laurus nobilis* L. | Leaf |
| 11. | Mango | Anacardiaceae | *Mangifera indica* L. | Rind of immature Fruit |
| 12. | Curry leaf | Rutaceae | *Murraya koenigii* (L.) Sprengel | Leaf |
| 13. | Nutmeg | Myristicaceae | *Myristica fragrans* Houtt. | Kernel, Aril |
| 14. | Allspice, Jamaica pepper | Myrtaceae | *Pimenta dioica* (L.) Merr. | Immature fruit, Leaf |
| 15. | Pomegranate | Punicaceae | *Punica granatum* (L.) | Dried seed with flesh |
| 16. | Clove | Myrtaceae | *Syzigium aromaticum* (L.) | Flower bud |
| 17. | Tamarind | Fabaceae | *Tamarindus indica* L. | Fruit |

**Table 2:** Trend in area, production and productivity of Major Tree spices

| Year | Clove | | | Tamarind | | | Nutmeg | | |
|---|---|---|---|---|---|---|---|---|---|
| | Area ('000 ha) | Production ('000 tonnes) | Yield (kg/ha) | Area ('000 ha) | Production ('000 tonnes) | Yield (kg/ha) | Area ('000 ha) | Production ('000 tonnes) | Yield (kg/ha) |
| 2020-21 | 2.151 | 1.192 | 554 | 43.617 | 158.502 | 3634 | 23.347 | 14.923 | 639 |

**Table 3:** Trend in import of major tree spices in India

| Year | Cassia | | Star anise | | Nutmeg | | Mace | | Clove | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity (tonnes) | Value Rs in lakhs | Quantity (tonnes) | Value Rs in lakhs | Quantity (tonnes) | Value Rs in lakhs | Quantity (tonnes) | Value Rs in lakhs | Quantity (tonnes) | Value Rs in lakhs |
| 2019-20 | 30000 | 57288 | 6600 | 24758 | 1645 | 5545 | 1910 | 21137 | 27190 | 112867 |

**Table 4:** Trend in export of Nutmeg and Mace for the year 2020-21

| Year | Crop | Quantity (tonnes) | Value (Rs in lakhs) |
|---|---|---|---|
| 2020-21 | Nutmeg and Mace | 3,875 | 19,000 |

(Anonymous, 2021) [6]

## 1. Bilimbi (*Averrhoa bilimbi*)

### 1.1 Introduction

The star fruit family includes the bilimbi (*Averrhoa bilimbi*). It is originated from the American continent. In its country of origin, this tree spice grows well. According to reports, bilmbi produces fruit all year round, this is collected three times a year. Using Bilimbi can treat conditions like hypertension, whooping cough, bleeding gums, sprue, acne, and tinea versicolor. (Anuar and Salleh, 2019) [9].

### 1.2 Cultivars

Bilimbi has two cultivar sweet and sour types have been identified.

### 1.3 Postharvest considerations

The Bilimbi fruit has a limited shelf life of up to 4 or 5 days due to its perishable nature. Bilimbi has an extended shelf life of 7-8 days. Fruits can refrigerated in the field. Bilimbi's frozen fruits are dried and kept in storage for further use.


Postharvest considerations

### 1.4 Harvest Maturity

Ripe fruits of the bilimbi tree spice have a thin skin, a yellowish-green colour, a soft texture, and a distinctive smell that is similar to the carambola fruit, which is a member of the same botanical family. Fruits that aren't ripe have a hard texture. The number of seeds in Bilimbi Fruits varies from 3 (in small fruits) to 15 at both stages of maturity (in large fruits). Juice production from the delicious bilimbi fruit is 76.14 percent. (De lima *et al*., 2001) [37].

### 1.5 Harvesting and storage

After being planted for two to three years, bilimbi trees begin to bear fruits. In India and Sri Lanka, there are two distinct fruiting seasons, each lasting approximately for two months. Time requires for flowers to open is 80–100 days. Fruits are manually harvested. Bilimbi fruits need to be handled gently since they are perishable. They cannot be stored for an extended period of time at ambient conditions. The ideal time to pick Bilimbi fruits are when they are fully matured because this affects fruits physicochemical characteristics. (Galvao de Lima *et al*., 2001).

### 1.6 Packaging

Bilimbi with a sour taste is prefered by consumers in market and grocery stores. Typically, frozen and dried Bilimbi fruits are kept in bulk or in little plastic "clamshells."

## 2. Carambola (*Averrhoa carambola*)

### 2.1 Introduction

In India, the carambola is an important tree spice. As it's fruits resemblance to a star in a cross-section, it is also known as starfruit. Slices of this smooth, juicy, crispy, sour-sweet delicacy are used mostly to garnish dishes and salads due to

its distinctive feature, which makes a valuable exotic fruits. It is frequently consumed fresh and is also processed into jam, jelly, sweets, fresh juice, and cordial concentrates. It is also called as "carambola," which translates to "food appetiser" in Portuguese. Carambola fruits are strong in vitamin B and C content, have a very low fat level, and are a good source of potassium and fibre.

Although the fruits are often eaten fresh, making juice from them is becoming more and more popular. Additionally, it can be transformed into jellies, jams, and preserves. It is used in part to make starfruit wine and brandy, as well as an infusion of black tea. Additionally, starfruit has been used in concoctions to treat headache, nausea, coughing, and restlessness as well as being connected to some theories that suggest it may lower blood pressure. By providing pollen and nectar, trees in bloom can help hobbyist apiculture, producing high-quality honey.

### 2.2 Major types/varieties of star fruit in India

In India, there are only the sweet and sour types of star fruit grown. There are no improved variations. Hawaii and Taiwan both provide improved sweet variants. Sweet fruits can be consumed raw, while sour fruits can be used to make pickles or as a tamarind alternative.

### 2.3 Maturity indices

To ensure optimum eating quality, carambolas should be plucked when fully yellow. However, because these fruits are tougher and simpler to handle, colour break (half to 3/4 of the fruit is yellow) is regarded as the commercial maturity index.

### 2.4 Harvesting in star fruit

Compared to seedlings, which can take up to 4 years to bear fruit, grafted trees will be ready for harvest in 1 to 2 years. Even on the trunks, these trees blossom and produce fruit. Although these trees often produce fruit throughout the year, the peak period is from January to February and from September to October. Fruits are ripe for harvesting when their colour changes from green to yellow. Picking by hand is suggested.

Carambola fruits Carambola Ripe fruits

### 2.5 Harvesting Indices

Depending on different types and the weather, the fruits can be harvested 45–90 days following flower anthesis. Type B10 takes 60–65 days to reach the colour index 3 whereas Type B17 takes 77–90 days following anthesis. The carambola fruits ripens 2-3 days earlier on rainy days as compared to sunny days.

### 2.6 Post harvest handling and storage

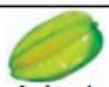
Carambola fruits handling after harvest should be done carefully because the skin is tender. Selected fruits are collected with their original packaging, and placed in a basket. To prevent insect pest infestation, the fruits are laid out horizontally in special insect-proof plastic baskets or corrugated paper boxes. Damaged fruits of carambola by fruit flies are removed from the collection and thrown away after inspection.

After this operation, in order to maintain fruits freshness, they are transported to the packing house in cold vans. The fruit are graded for size, colour, and quality at the packaging facility once the wrappers are taken off. Prior to shipping, carefully selected fruits are individually wrapped and boxed. To prevent the fruits from damage during shipping, polystyrene mats or other safeguards are placed all around the boxes. To stop the infestation of fruit flies and other insects, plastic netting is placed over the air holes in the boxes.

#### 2.6.1 Grading of carambola fruits as given by (Amirulah *et al.* 2010) [2]

| Grade | Specification | Range of Flexibility (Maximum) |
|---|---|---|
| Premium | Fruits are collected from same cultivar, fresh and clean. Uniform size and maturity index and free from damages. | Maturity ≤ 3%<br>Freshness ≤5%<br>Damages ≤3%<br>Abnormility ≤3%<br>Size uniformity≤ 5% |
| 1 | Fruits are collected from same cultivar, fresh and clean. Uniform size and maturity index and slight or free from damages. | Maturity ≤ 3%<br>Freshness ≤5%<br>Damages ≤3%<br>Abnormility ≤3%<br>Size uniformity≤ 10% |
| 2 | Fruits are collected from same cultivar, fresh and clean. Uniform size and maturity index and slight damaged. | Maturity ≤ 10%<br>Freshness ≤10%<br>Damages ≤10%<br>Abnormility ≤10%<br>Size uniformity≤ 10% |

(Amirulah *et al*., 2010) [2]

| Index | Explanation |
|---|---|
|  Index 1 | **Dark green**. Fruit is immature. Not Suitable for harvesting. |
|  Index 2 | **Green with a little yellow**. Matured. Suitable for harvesting for far export from sea. |
|  Index 3 | **Green more than yellow**. Matured. Suitable for harvesting for far export from sea. |
|  Index 4 | **Yellow green**. Far exporting using air transport. |
|  Index 5 | **Yellow with a little green**. Still can be sent for far export using air transport. |
|  Index 6 | **Orange**. Not suitable for far exported. Local marketing. |

(Amirulah *et al*., 2010) [2]

### 2.6.2 Labeling of boxes

The farm's name and address are included in the boxes along with information about the produce's origin. If some samples don't meet plant quarantine rules, this approach enables selective rejection of a consignment.

## 3. *Cinnamomum* (*Cinnamomum zeylanicum*)

### 3.1 Introduction

Cinnamon is an evergreen tree spice bark belongs to the Lauraceae family. Sri Lanka, Myanmar (Burma), and the southern coastline region of India are the places where cinnamon first spotted. It is also grown in South America, the West Indies, the Seychelles, and Reunion. Cinnamon of exceptional grade is produced in Sri Lanka. Cinnamon has a higher quality, cassia it is a bark of the evergreen tree Cinnamomum cassia, is coarser in texture and less aromatic in fragrance. The bark of cinnamon contains a volatile oil that gives characteristic aroma. Bark, leaves, and roots are typically used to produce oil. Before storage and commercialization, it is essential to dry cinnamon.

The dried cinnamon tree's bark is sold as powder or quills. Harvesting can be done at interval of 12 to 18 months after the second or third year of planting. The cinnamon shoot with thin, uniformly coloured bark that is 1.0 - 1.2 metres long and 1.25 centimetres in diameter yields the best bark quality. A sign of maturity is when newly formed leaves' crimson flush changes to a greenish hue.

Peeling, rolling, and piping are the steps involved in making quills for the market. Quill production yields a number of byproducts. (Quillings, Feathering, Chips) these are utilised for additional processing. (Thankamani *et al*., 2013) [72].

### 3.2 Major Commercial varieties of cinnamon grown in India- Navashree, Konkan Tej, Yercaud 1, and Nithyashree.

### 3.3 Harvesting of Cinnamon

Cinnamon is harvested twice a year following each rainy season due to the high humidity during the monsoon that makes it easier to peel the bark. It attains maturity at three years for harvesting. The side stems are cut off by removing the bark. Bark with a diameter of between 1.2 and 5 cm is preferred for cinnamon.

Cinnamon quills and powder

### 3.4 Processing of cinnamon

Since cinnamon peeling is done manually by expert pillers, it involves a lot of labour. To obtain high-quality cinnamon, it takes skill to separate the stem's bark. Quills or larger fragments are preferable over shattered smaller pieces. A small mechanical device for removing the bark from cinnamon stems has been created in Sri Lanka. In order to produce cinnamon of the highest quality, drying is an important step in the manufacturing process.

### 3.4.1 Preparation of best cinnamon quills

The delicate stems with diameters less than 1.2 cm are cut off. Cinnamon bark larger than 5 cm in diameter is not preferred to extract oil. A small, rounded knife is used to remove the exterior, soft bark. A brass rod is used to brush the stripped stem in order to dislodge the inner bark. To prevent the bark from turning discoloured, it is advised to use a metal rod. Using a small, sharp knife, the cuts are made around the stem at intervals of 30 cm. To avoid staining the bark, the knife blade should be made of brass or stainless steel. Long cuts are made along the stem's length, exposing the bark.

### 3.4.2 Drying of cinnamon

Cinnamon quills are dried in the shade on coir rope racks. The quills are rolled on a board to tighten the bark after 4-5 days of drying, then placed in gentle sunshine to continue drying. Since, the weather is humid during the rainy season, a mechanical dryer is required to dry the cinnamon. Different dryers are used, which includes those are powered by electricity, gas, biomass, etc.

### 3.4.3 Grinding of cinnamon

Grinding adds value, since ground spices are more susceptible to deterioration, grinding is not recommended. As they are volatile, the flavour and fragrance ingredients are not sustain in the ground products. As compared to ground spices, whole spices have a far longer shelf life. Consumers find it challenging to evaluate a ground spice's quality. Therefore, most customers choose to purchase entire spices. Sometimes, before being sold, cinnamon is processed into a powder. To preserve the flavour, ground powder is packaged in moisture-proof (polypropylene bags).

### 3.5 Packaging of Cinnamon

Cinnamon quills are divided into pieces up to 10 cm long and placed in moisture-proof polypropylene bags before sold. Bag sealing is crucial to preventing moisture gain. Product labels

must be visually appealing. The label should include all necessary product and legal information, including the product's name, brand, manufacturer's contact information (including name and address), date of manufacture, expiry date, weight of the contents, and any additional ingredients that may be needed (a barcode, producer code and packer code are all extra information that is required in some countries for traceability). (Ali, 2007) [11].

## 4. Kokum (*Garcina indica)*


Kokum (Garcina indica)

### 4.1 Introduction
Kokum is a plant that grows extensively in Konkan's Western Ghat. The Kokum fruit's rind and seed are both inexpensive parts. Fresh fruit has an approximate one-week shelf life. To give curries an acidic flavour, kokum is used as a dried rind. Juice from fresh fruits is used to make kokum syrup. In traditional medicine based on Ayurveda, the fruit has been shown to offer a variety of therapeutic properties. The Kokum fruit is harvested for use in manufacturing Kokum Syrup, or "Amrit Kokum," a beverage that is beneficial in fever and makes a delicious sharbat.
Kokum seed is used to make "Kokum Butter," which is a healthy fat source. Both food and non-food uses exist for kokum butter. The kokum oil is traditionally extracted by boiling the dried kernel powder in water and skimming off the oil that collects on top. About 25 to 30 percent of the oil (fat) can be recovered. Chocolates and other confections are prepared with kokum fat. Due to its intriguing chemical composition, kokum fruit is reportedly a prospective industrial raw material for commercial use.

### 4.2 Commercial Varieties
Konkan Amruta, Konkan Hatis, CHES GI V 8, CHES GI V 4, CHES GI VIII 8.

### 4.3 Maturity Indices
When a fruit is mature, its colour changes from green to light green and from red to purplish red.

### 4.4 Post harvest handling
The Kokum fruit has a shelf life of 4-5 days when stored at room temperature. When applied with Waxol 12 percent and stored in a cool environment, it can be extended to 15 days. Paddy straw and CFB boxes provide excellent kokum packaging materials.

## 5. Star anise (*Illicium* sp.)
### 5.1 Introduction
The evergreen, small to medium-sized star anise tree (Illicium verum) is a member of the family illiciaceae. Dry, star-shaped fruit with 11–13 luminous boat-shaped seed pods/carpels, and small, incurved beaks.

Star anise (*Illicium* sp.)

Starts from January to April, The flowering and fruiting seasons begin. Fruit reaches maturity in September, and the harvesting season runs from October to December. The fruits are stimulating, carminative, stomachic, and galactagogic. They are fragrant, taste is slightly bitter and astringent. It is used as incense, to flavour tea, to make butter salted or sugared tea for a sweet scent, and to boost the potency and strength of alcohol. (Mukhia, 2006) [39].

### 5.2 Maturity Indices
Fading of leaves and drying are signs that the star anise is mature. After sowing, the star anise crop matures and is available for harvesting nine to ten months later.

### 5.3 Harves
Mature green fruits are plucked straight from the tree, dried in the sun and the shade. A fully developed tree may produce 8–12 kg of fresh fruit each season, compared to 4-5 kg of fresh fruit that typically yields 1 kg of dried star anise fruits.

### 5.4 Post-harvest technology of star anise
Well mature fruits of star anise are collected in the summertime once they have ripened, later they are sun-dried. March to May is the season when flowers bloom, and September to October is season when fruits reach full maturity. The timing of the star anise harvest affects the yield of essential oil. The star anise seeds are harvested after the fruit has grown fully and matured for 30 days. Before storage, seeds are spread out on fabric for 48 hours to dry out in the presence of sunlight. Seeds are placed in containers without an excessive humidity because this will change the nature of the seed. Because of its rough surface, star anise should be stored in a sealed container. (Boota *et al*. 2018) [70].

### 5.5 Storage
Both whole and ground spices is stored in an airtight container out of the reach of moisture, heat, and sunlight. Ground spices start to lose flavour after around six months, whole star anise will stay fresh and flavorful for almost a year. Sometimes the flavour is enhanced by toasting the ground spice before using it.

### 5.6 Processing and Handling
In the month of October, star anise fruits are harvested. When they become brown, star anise should not be opened. Manual seed extraction is done after sundrying.

## 6. Juniper (*Juniperus communis* L.)

Juniper (*Juniperus communis* L.)

### 6.1 Introduction

Juniper is a dense perennial shrub that can reach a height upto 1.5 metres and it is a member of the Cupressaceae family. Its leaves are 5-13 mm long, arranged in whorls, linear, sharply pointed, and spread almost at right angles from the branchlets. They are convex on the back and concave and glaucous bluish white on the upper surface, joined at the base and continued down the stem with a large gland on the decurrent portion.

From Srinagar to Kumaon at 1700-4200 m MSL, forests of the temperate Juniperus species can be found throughout the Western Himalaya.

### 6.2 Commercial Varieties

***California Juniper***

At the time of food scarcity, Native Americans used the berries of the California juniper (Juniperus californica) as a food source. Californians utilise the berries and other plant parts to treat conditions like the flu, constipation, high blood pressure, and hiccup.

The berries of the California juniper are consumed raw, boiled, or powdered into flavoured powder.

***Eastern Red Cedar***

The Eastern red cedar botanically (Juniperus virginiana), also known as cedar, is a juniper species that grows natively throughout the Northeastern United States.

Berries from the Eastern red cedar are safe to eat and can be consumed by people. The palatable berries of the red juniper are not as aromatic as those of the common juniper, and they are not as bitter as those of the majority of juniper species.

### 6.3 Harvest Management

#### 6.3.1 Crop Maturity and Harvesting

C. Juniper begins to produce blooms and fruit when it is about five years old. Fruits ripen between September and October, so this is the ideal time to harvest. In the month of October, it is also possible to harvest bark and leaves.

#### 6.3.2 Post-harvest Management

Bark, leaf and fruits can be air dried and stored at room temperature in a dry place.

#### 6.3.3 Extraction of essential oil

Berries are used to make essential oils. Although essential oil is primarily produced from berries, needles, and branches, it is found in the majority of J. communis organs. Traditionally, the oil is obtained through the distillation of crushed, dried, partially dried, or fermented berries. This technique uses organic solvents like methanol and n-hexane to collect the oil. Large performance recovery procedures are needed to generate high oil yields because juniper essential oil is typically found in berries in very low amounts (0.2-3.42%). The extraction of juniper oil has been done using a variety of methods, including hydrodistillation, supercritical carbon dioxide extraction, solvent extraction, and simultaneous distillation.

The uses and advantages in juniper berries essential oil:

Typically, hydrodistillation is used to produce the essential oil. Depending on the origin of the plant and the specific plant, there is a large variation in the chemical makeup of the oil (both quantitatively and qualitatively). Monoterpenes, primarily -pinene, myrcene, and sabinene, is the content of the oil; sesquiterpenes and other fragrant chemicals are present in minor levels. Berry essential oils are used in the culinary, pharmaceutical, and cosmetic industries because they have antibacterial and antioxidant properties. (Majewska *et al*., 2017) [77].

### 6.4 Chemical Constituents

Major ingredient of plant includes 4-terpineol (18.14%), marpol (7.96%), -pinene (6.96%), terpinen (4.46%), -fenchyl alcohol (1.53%), and oplopenone (0.69%). Sabinene (48.8%), -pinene (6.2%), and endofenchyl acetate (58.8%) are the three main ingredients of the essential oil extracted from it. Fruit produces 8 percent resin and 0.8 to 1.2 percent essential oil. It also includes the astringent compound juniperin.

### 6.5 Therapeutic Uses

Folk cures for cancer, indurations, swellings, tumours, and warts often include berries, wood, and oil. Carminative, stimulant, deobstruent, diaphoretic, digestive, and diuretic characteristics can be found in the fruit and essential oil of this plant.

## 7. Bay leaves (*Laurus nobillis* L.)

### 7.1 Introduction

The evergreen perennial shrub known as bay leaf (*Laurus nobilis*) is a member of the laurel family (Lauraceae). It has been used for more than a thousand years, and many traditional practises and recipes depend on it.

(Parthasarathy *et al*., 2008) [49].

There are between 24,000 and 25,000 species in the genus Laurus, and they are indigenous to the Southern Mediterranean region, Eastern Asia's subtropics and tropics, South and North America, the Balkans, and Asia Minor. Variability is discovered due to morphology, flower colour, growing habitat, leaves, stems, and chemical content. There are two types of laurel that are commonly found: Laurus azorica and L. nobilis. The term "bay laurel" is used for a variety of plants that are not members of the genus Laurus, such as the bay rum tree or just the bay (Pimenta racemosa) (Akgul *et al*. 1989) [1].

L. nobilis is referred by a variety of names. It is referred to as Tejpatta in Urdu. It is frequently referred to as sweet bay or bay leaf in English. It is referred to as teejpatta in India, specifically in Hindi.

### 7.2 Area of Cultivation according to national horticulture board

State of Meghalaya, the annual production of dry bay leaves per tree ranges from 30 to 70 kg, in Nepal, the average yield is only 13 kg. Similarly, Bay leaf production in the Udaipur

district amounts to 900 tonnes, and Nepal exports 2100 tonnes to India. (Choudhary *et al*., 2014) [14]. Aegean and Eastern Mediterranean regions are the biggest collection areas of bay leaf for export (Nurbas and Bal, 2005) [45].

### 7.2 Major Commercial Varieties

**7.2.1** ***California Bay*** **Leaf:** *Umbellularia californica* – This types should be less used in cooking because it has a more nuanced flavour than bay laurel.

**7.2.2** ***Bay laurel*****:** *Laurus nobilis* – This type is also known as "sweet bay" or "laurel tree." A more popular spice, the California bay leaf is milder. Excellent for stewed meats, veggies, soups, and other hot dishes.

**7.2.3** ***Indian bay*** **leaf:** *Cinnamomum tamala* – With its distinctive flavour profile, this bay species can give light cinnamon flavour to preparation. The leaves veining differs from the bay laurel's in that they have three vertical veins along the length of the leaf rather than one central vein. This tree's bark is occasionally used in recipes.

### 7.3 Harvesting

Manual labour should be used to remove defective or immature material from the process of separating the leaf from the stem and removing the leaf from the stem.

### 7.4 Post-harvest operations

Producing high-quality produce that will command a high market price is in the best interests of the grower and the industry. Harvesting is the important procedure. The collected raw plant material should be transported quickly, in a clean and dry environment.

#### 7.4.1 Cleaning

Goal is to major authenticate the spice is of the greatest calibre and will command the maximum price (Washing and disinfection) In the process of making dried herbs, drying is the step that must be done perfectly. It is change from an 80–90% water–water content in the harvested bay leaf to a 5–10% water–water content in the finished product. The amount of time between harvest and drying must be kept to a minimum, and the temperature must be controlled since, volatile ingredients could be lost or depleted at lower temperatures.

#### 7.4.2 Different methods of drying

a) The simplest method of drying a Murraya crop is to spread it out on a surface that is exposed to the sun. Utilizing a fuel source (wood, diesel, gas, or electricity) to heat the drying space is an enhanced way for accelerating drying. The primary drawback of traditional drying techniques is the significant crop loss and poor product quality caused by insufficient drying, prolonged drying times, fungal spoilage, insect infestation, bird and rodent damage, contamination, and the impacts of sunlight and weather.

b) Solar energy drying systems- solar dryers can be classified into two generic groups,

- Passive / natural air circulation solar dryers
- Active/ forced convection solar energy dryers

Bay leaves

### 7.5 Post harvesting Technology

A fully grown plant can produce bay leaf at any time of the year. Bay leaves should be dried before use because they have a bitter and pungent flavour when they are fresh. The leaf should be dried after being picked for 48 to 72 hours. Freshly dried leaves exhibit a better and richer flavour.

### 7.6 Processing

Bay is used for a multipurpose and in a variety of ways. Along with its fresh leaves, bay is frequently processed into whole dry leaves, frozen, powdered leaves, and essential oils. It is use for a longer period of time than their fresh shelf life, leaves can be frozen. There are different drying techniques for bay leaves. Traditionally, it is dried for 10 to 12 days outside. Due to natural colour loss and essential oil loss caused by sun drying, bay leaves have a poor market value. The best way to produce bay leaves is using hot air drying at 60°C. The best technique for recovering essential oils from the bay leaf plant is by steam distillation.

### 7.7 Grinding

It is conventional processing practise to use defined sieve apertures to grind herbs like bay leaves to a specific particle size. Grinding makes it simpler to combine ingredients in the finished food product and helps flavours spread evenly in the dish.

### 7.8 Essential oil extraction

There are various techniques used for extracting essential oils from bay leaf. There are five primary extraction techniques. 1. Expression 2. Hydro-water distillation 3. Water and steam distillation 4. Steam distillation 5. Solvent extraction. The most cost-effective way to extract essential oils from herbs, spices, and aromatic plant material is still distillation. The primary benefit of distillation is that it may be done at the place of plant production with some basic equipment.

## 8. Mango (*Magnifera indica*)

### 8.1 Introduction

Due to its nutritional qualities for health and good flavour, the mango ranks third among tropical fruits in importance. Due to its climacteric characteristics, it reduces the quality and shelf life, the fruit is extremely perishable. One of the most important ways to meet human dietary needs is to maintain fruit quality and reduce losses throughout the postharvest period.

**8.2 Major Commercial Varieties**
Alphonso, Banganapalli, Bombay Green, Chausa, Dashehari, Fazli, Kesar, Langra, Neelum, Totapuri.

**8.3 Harvesting**
The mango is one of the most consumed fruits in tropical nations all over the world and is known as the apple of the tropics. Mangoes must be harvested and handled in accordance with precise guidelines in order to preserve their quality and freshness before being delivered commercially. To protect insect pests from destroying the fruits, fruit is bagged while it is still on the tree.

**8.4 Maturity**
The best markers of maturity are the fruit's colour changing from green to yellow and the formation of "shoulders" on the fruit's stem end. Additionally, during maturation, the fruit flesh changes from white to yellow beginning at the endocarp and moving outward to the skin. The fruit can be taken and will ripen normally off-tree when the flesh is yellow to half that distance. Fruit that has been harvested firm in order to endure shipping are not fully ripe. Before this point, the flavour has not yet developed, and the fruit is more vulnerable to damage from chilling and hot water during post-harvest fruit fly control. When fruit is allowed to ripen on the tree, they frequently experience physiological disintegration known as "soft nose," "jelly seed," or "spongy tissue."

**8.5 Harvest Method**
Mangoes are harvested by hand, either by snapping the fruits off the peduncles or by pruning the peduncles 4 inches above the fruit when the fruit is destined for export. As a result, the milky, poisonous latex can flow off the stem without coming in contact with the fruit's surface. To reach fruit high in the tree, pickers utilise poles with fabric bags at the end, or in industrialised nations, ladders and hydraulic lifts. 120 days after the induction of the blossom, mango is harvested.

**8.6 Post-harvest operations**
Higher profitability for producers and marketers are the outcome of improved post-harvest techniques since they reduce losses, raise quality overall, lengthen shelf life, and improve overall quality. The only post-harvest operation often required for mangoes to be sold in local markets is a simple water wash to remove the latex and dust. They may occasionally be dipped in hot water that contains fungicide for the management of illnesses when produced commercially or for export. However, mangoes respond well to hot water treatment (HWT) after harvest. Hot water treatment reduces fruit fly damage, anthracnose, and stem-end rot infections in freshly harvested fruits. The crucial post-harvest operations include curing, washing, grading, packaging, storage, transportation, processing, and marketing, among others.

**8.7 Grading**
Fruits are graded based on their weight, colour, size, and level of maturity. Larger fruits take 2-4 days longer to ripen than smaller ones, according to observations. Therefore, it is best to avoid packaging smaller fruits with larger ones in order to achieve uniform ripening. Fruits that are immature, overripe, harmed, or sick should be thrown away.

**8.8 Packaging**
Mango fruit is frequently transported and packaged in wooden boxes. Vibration under dynamic transport conditions causes bruising, deterioration, and reduced fruit prices. Furthermore, excessive ventilation degrades fruit quality by causing shrinkage, weight loss, colour loss, and other issues. To solve these issues CFB Mango fruits have been successfully packed and shipped in boxes with a capacity of 5 kg and 10 kg for export purposes.
Fruits are frequently packaged with cushioning materials like paper scraps, newspapers, etc. to minimise bruising and spoilage during storage and transportation. It has also been discovered that polythene (LDPE) lining is advantageous because it preserves humidity, causing less shrinking during storage. Individual fruit packaging (Unipack) using newspaper.

**8.9 Storage**
Storage is necessary to increase the shelf life of fruits, control their supply to the market, and facilitate long-distance transportation. Depending on the variety, mature green fruits can be stored at room temperature for anywhere between 4 and 10 days. Fruits' shelf lives may be increased through precooling, chemical processes, low temperatures, etc.
The fruits are collected, pre-cooled to 10 to 12 degrees Celsius, and then stored at the proper temperature. The fruits could be kept at a low temperature for three to four weeks without losing any quality. Fruits should be stored in 0.5% ventilated polythene bags to prevent chilling damage at low temperatures.
An improved method for increasing the shelf life of fruits is calcium infiltration. The fruits are maintained in a calcium chloride solution (4%) at 500 mm Hg below atmospheric pressure for 5 minutes. The treated fruits can be kept for 27 days at a low temperature (12$^{o}$ C).
Fruits are typically harvested early in the season (premature stage) to gain early market share. Without a ripening treatment, these fruits do not ripen evenly. Such fruits might be consistently ripened in 4–8 days under ambient circumstances by being submerged in hot water with 750 ppm ethrel (1.8 ml/litre) for 5 minutes. For homogeneous colour development, mature fruits can be similarly ripened with lesser doses of ethrel.

**8.10 Transportation**
Due to its straightforward approach from the orchards, the truck has been chosen as the most practical form of transportation; nevertheless, because of the pressure it puts on the fruits, trucks are not suited for transporting live animals. Therefore, as they would aid in lowering postharvest losses, refrigerated vans and containers may be advantageous for long distance transportation and export purposes.

**8.11 Ripening**
For forced air chilling to maximise storage life and retain fruit quality, field heat must be removed. Fruit should be kept at 13 °C for the longest possible shelf life. It is safest to travel at this temperature without running the risk of chilling the skin.

*Murrya koenigii* (L.) Sprengel

### 9.1 Introduction
Ancient literature has documented the use of Indian spices in preventive and therapeutic medicine (Tapsell, 2006) [71]. Curry leaf, also known as "Kadipatta," is a significant leaf spice that is used in curries, pickles, and chutneys as a natural taste. (Rao *et al*., 2007; Khedkar, 2015) [56, 30].

The leaves have a mildly cooling, slightly bitter, and acidic flavour. Its distinctive aroma is caused by the presence of volatile oils. The leaves are used both fresh and dried since they retain their colour and flavour even after drying (Ramalakshmi *et al*., 2000) [58]. The tree can be found in tropical and subtropical locations, including those in the Pacific, from the Mariana Islands to Vanatau and New Caledonia, as well as Sri Lanka, India, China, Malaysia, and Australia (Smith, 1985) [69]. The tree is indigenous to India, Bangladesh, Sri Lanka, and the Andaman Islands. Indian immigrants eventually introduced the tree to other regions of the world. It is commonly grown up to an altitude of 1650 metres virtually everywhere in India. It is frequently found in fields where its fragrant leaves are grown. (Joseph and Peter, 1985) [63].

### 9.2 Major Commercial Varieties: Sen Kaampa, Dharwad-1 and Dharwad-2
### 9.3 Post harvest management
Harvested young shoots with matured leaves are then bundled in gunny sacks or tied into bundles before being shipped. On the bundles and bags, water is sprinkled. The post-harvest handling of curry leaf has not been studied. The dried, ground-up leaves are used to make curry leaf powder.

After one year from transplanting, a leaf yield of 250 to 375 kg/ha is expected. The leaf production is 1500 to 2000 kg/ha every four months during the second and third years following planting. The yield gradually rises to 2500 kg/ha at three-month intervals in the fourth year and 3000 to 3500 kg/ha at two-and-a-half-month intervals from the fifth year on.

## 10. Nutmeg (*Myristica fragrans)* Houtt.
### 10.1 Introduction
One of the rarest and most expensive spices in the world, nutmeg produces two spices: mace and nut, each with a distinct flavour and aroma. It is a member of the Myristicaceae family and goes by the scientific name Myristica fragans. Numerous chemical elements found in nutmeg and mace are recognised to have anti-inflammatory, disease-fighting, and antioxidant capabilities. Due to its antifungal, antidepressant, digestive, and carminative characteristics, nutmeg has a wide range of medicinal uses in traditional medicines.

Nutmeg (*Myristica fragrans)* Houtt.

### 10.2 Area and Production
Nutmeg thrives profusely in Kerala's tropical climate as an intercrop in the homesteads. A significant portion of nutmeg production and selling occurs in Kerala's Trissur and Ernakulam districts. Kerala accounts for more than 90% of India's annual production of nutmeg, which totals about 12,000 tonnes. Just thirty percent of the overall production has been exported.

### 10.3 Major Commercial varieties
IISR Viswashree, IISR- A9-20, A9-22, A9-25, A9-69, A9-150, A4-12, A4-22, A4-52, A11- 23, A11-70

### 10.4 Harvesting
Nutmeg fruits are picked when they split open after maturing. A hook is used, the split fruits are either pulled from the tree or quickly retrieved once, they hit the ground. Since, this crop is gathered in Kerala during the rainy season, sun drying is challenging, which leads to incorrect drying of the nutmeg and mace. Fruiting starts in the fifth or sixth year but can take up to eight or nine years to fully mature. (Vergheese, 1990) [73].

Near about 15 years, productivity reaches its peak. According to reports, fruits of nutmeg ripen 6 to 9 months after blossoming (Nazeem, 1979) [44]. India harvests fruits that split open on the tree, revealing a crimson-colored aril (Nair *et al*., 1977) [42]. While Kerala's prime harvesting season is from June to July, Konkan region's is limited to June to October (Nybe *et al*., 2006) [46]. Between the 15$^{th}$ and 30$^{th}$ year of growth, the average yield of a good tree in full bearing is stated to be 3000 fruits. A single fruit typically weighs 60g, of which the seed makes up 6-7g, the mace 3-4 g, and the remaining weight is pericarp. Mace to nutmeg ratio is 1:8. Every day, fruits are picked from the tree by hand, with hooked sticks, or by letting them fall to the ground naturally (Krishnamoorthy, 1987) [32].

### 10.5 Drying
Drying rooms are used to dry medium to large amounts of nutmeg. In the drying chamber, warm air is circulated through pipes as the harvested nutmeg is spread out on a raised wire mesh floor. Nutmeg should not be dried continuously since the oil will flow out if it is not dried properly. In Kalady, a significant nutmeg farming region, drying nutmeg is done by passing hot air over it for one or two days (8 hours each), after this it is left to dry naturally for a week. Once more, the heated air is circulated for one or two days before being dried for a week or ten days. The nutmegs are dried to the point where the seeds begin to shake. This takes at least 15 days.

By manually or mechanically cracking the dense seed coat, the seed cover can be removed. Some of the nutmegs that are incorrectly dried using this procedure have several fungal illnesses, and the exporters have also mentioned difficulties with aflatoxins. The drying time for nutmeg samples dried in a solar tunnel dryer was significantly reduced. It took around 8 hours to dry from an initial moisture content of 42.6% to 7.2%, compared to the 13 days required for conventional drying. (Joy *et al*. 2000) [27].

Pulsed Microwave Assisted Hot Air Drying of Mace

**10.6 Processing**

After harvest, the mace that covers the shell is peeled off and the pericarp, or outer fleshy rind, is removed. The peelings, sometimes known as "blades of mace," are stretched out to dry in the sun after being flattened by hand or between boards. A proper sample of mace should have whole double blades that are not broken, flattened, or too small. It should also have horny texture that is not too brittle, and it should be of nice, clear, and bright colour. The nut is dried in the sun or in drying ovens while still in the shell.

Nutmeg is ground at room temperature to create powder. Soon after harvest, mace is carefully separated from the nut, washed, and flattened by hand or between boards before being sun dried until it becomes brittle. Drying can be done in hot air ovens, and this has a much better effect on the mace's colour than sun drying does. Studies carried out at the IISR in Calicut revealed that blanching mace in hot water at 75 °C for two minutes kept its characteristics throughout drying (Amaladhas *et al*. 2002) [10].

**10.7 Packaging**

Most frequently, double-layered jute or polythene bags are used to package nutmeg. If different packing materials are used, caution must be taken to prevent using those that could cause "sweating" and the growth of mould. (Thankamani *et al*., 2013) [72].

**11. Allspice (*Pimenta dioica*)**

**11.1 Introduction**

Originally from the tropical America, allspice (Pimenta dioica Linn.) is a tree spice. The immature fruit of allspice used in commerce is dried. The name is derived from the flavour, which tastes like a blend of nutmeg, cinnamon, and clove. Since the spice (fruit) resembles pepper corns, the word "pimento" was taken from the Spanish word "pimenta," which means the pepper corn. Jamaica, the country is the major producer is said to have an abundant supply of the plant. Additionally, southern Mexico, Honduras, Guatemala, Cuba, and Costa Rica have allspice grown. Several Indian states, including Kerala, Karnataka, Tamil Nadu, West Bengal, Bihar, and Orissa, where the plant is grown.

Pimenta dioica (L.) Merr., is the botanical name of allspice, is a member of the Myrtaceae family. A little evergreen tree called allspice. The flowers have a peculiar scent and are tiny and pale. They can be found in cyme clusters. Though functionally dioecious, they are hermaphrodite structurally. Male trees are those that don't produce fruit; their flowers typically have over 100 stamens, whereas female trees that produce fruit have flowers with about 50 stamens. The receptacle bears four persistent, cream-colored calyx lobes that spread at anthesis. Four, white, rapidly deciduous petals are present.

Leaves of allspice

**11.2 Uses:** The dried green, unripe berries are known as allspice and are used extensively in both sweet and savoury cuisines all across the world, either whole or in powder form. Steamed fish, stews, soups, salty pickling brines for meats like corned beef, and vinegar pickling brines for fish and vegetables all commonly use them as flavourings. In addition, allspice is frequently used as a flavouring agent in sauces such as tomato ketchup, barbecue sauces, and marinades. It can also be used in place of other spices in sweet foods, such as nutmeg (Myristica fragrans).

**11.3 Types of Allspice**

Several unrelated fragrant shrubs are called "Carolina allspice" (Calycanthus floridus), "Japanese allspice" (Chimonanthus praecox), or "wild allspice" (Lindera benzoin).

### 11.4 Post-harvest management

In India, the typical flowering season starts from March to June. Male trees often flower earlier than female trees. Generally flowering takes 5–6 years. After 3–4 months of blossoming, fruits are ready for harvest. The berries are clustered and are perfect for making spice when they are green and fully developed but not quite ripe. The flavour of the unripe berry is hotter and more peppery. Through the use of a ladder, they are gathered. Ripe berries are distinguished from unripe ones after harvest. To ensure even drying, the berries are spread out in the sun and raked over with a wooden rake. Three to twelve days are needed for drying. The drying process is accelerated by a strong, dry wind. Drying is complete when a handful is shook close to the ear and makes sharp, dry, and crisp rattling noises. When the dust has been removed, berries are then cleaned by winnowing and preserved. Each year, a healthy tree produces 20–25 kilogramme of dry berries.

## 12. Pomegranate (*Punica granatum* L.)

### 12.1 Introduction

Pomegranates are a significant fruit crop in the world's dry and semiarid regions. It is a very lucrative crop that can take the place of subsistence farming and reduce poverty. Pomegranates have been grown by humans as a fruit crop since ancient times. Pomegranate use is well-documented in human history, with references to both its culinary and medicinal uses in numerous prehistoric cultures. It has ties to the Middle East's ancient civilizations. In the western Himalayan regions of India (Himachal Pradesh, Jammu & Kashmir, and Uttarakhand), as well as Pakistan, it grows natively wild. One of the earliest known edible fruits is the pomegranate.

### 12.2 Commercial Varieties- Ganesh, Bhagwa, Mridula, Ruby, Arakta

### 12.3 Maturity Indices

Maturity indices, such as exterior skin colour, juice colour, acidity, soluble solids concentration, etc., might differ and depends on variety. The primary sugars in pomegranate juice are glucose or fructose. Fruits mature to their typical reddish colour for the Bhagwa type and yellowish green colour for the Ganesh variety, both with waxy glossy surfaces. When a fruit reaches maturity, the calyx at the front end may become curled inside and hard and dry. Fruit shapes condense and are simple targets for fingernail scratches. Fruits rings a metallic sound when tapped. In cv. Bhagwa and Ganesh, the arials turns a bright crimson colour. Similarly juice turns red for Bhagwa, Arakta, Mridula, and Ruby and pink for Ganesh. The juice's TSS ranges from 13 to 16.5 o Brix, with a brix acidity ratio of 25 to 40 and a titrable acidity of less than 0.8%. Pomegranate fruits are only harvested when they reach maturity in the tree because they do not ripen after being harvested. One of the most accurate maturity markers is the ratio of total soluble solids to acid. In particular during rainy weather, the fruits should be picked before they grow overripe and split open. One of the reasons for the poor quality of pomegranates in India is early harvesting to prevent cracking (induced by an abrupt change in soil moisture, a protracted dry spell followed by a strong downpour).

**Table 5:** Flowering and Harvesting Period of Pomogranate *(Punica granatum)* in India

| Name of Bahar | Period of Flowering | Period of Harvesting |
|---|---|---|
| Ambe bahar | Jan-Feb | July-Aug |
| Mrig bahar | June-July | Dec-Jan |
| Hasth bahar | Sep-Oct | Mar-Apr |

### 12.4 Harvesting

Pomegranates often split open their fully mature seeds are naturally released and dispersed. One of the causes of India's low quality pomegranates is the habit of early premature harvesting to reduce fruit cracking at the mature stage. On the other hand, fruit that is harvested too late has a physiological issue. The spoiling rate of pomegranate fruits in India is between 25 and 30 percent, which lowers the growers' profit margins.

Fruits are typically hand selected, assembled at the grading platform, and graded and packed on the farm. Harvesters select pomegranate fruit with clippers in industrialised nations like the USA, where the fruit is then put in picking bags before being transferred to harvest bins that are then taken to the packing house. After that, the fruits are sorted to get rid of major flaws like splitting, rotting, cuts, or scuffs. The remaining fruits are then divided based on the severity of the physical flaw. Fruits with minor to no flaws are sold fresh, while those with substantial flaws are utilised to make juice. The latter fruits are cleaned, dried by air to remove surface moisture, treated with fungicide, waxed, graded according to size, and placed in shipping containers.

### 12.5 Post-harvest Management

Pomegranates is not a perishable crop that spoils easily, proper post-harvest handling is essential for maintaining post-harvest quality and maximum returns. At any given time, between 50 and 60 percent of the pomegranate yield is suitable for export. In the local market, the remaining 35 to 40 percent of the produce is sold. About 10 to 15 percent of the fruits, is not in demand well due to factors including poor colour, reduced size, deformity, cracking, sunburn, etc. Therefore, it is necessary to have an integrated strategy for postharvest handling, sorting, and grading together with value addition that would generate higher returns.

#### 12.5.1 Sorting and Grading prior reqirement for anardana

At the farm level, pre-cooling of the fruits are preparation done preferably in a cool chamber or in the shade. To get a fair price for the produce from the export and local markets, pomegranate fruits must be sorted and graded. Fruits that are split, sick, cracked, or borer-infested are removed. The fruits are ranked according to their size, weight, and rind colour.

#### 12.5.2 Grading

Pomegranate grading is crucial, for export and the local market to get a fair price. Fruits with cracks, splits, diseases, and borer infestations need to be separated. At the farm level, precooling of the fruits is done preferably in a cool chamber or in the shade. The well mature fruits are ranked according to their size, weight, and rind colour. The grading of pomegranate fruit produced in the state of Maharashtra are Super, King, Queen, and Prince.

**Table 6:** Shows Grade and Characteristics of the fruits

| Sr. No | Grade | Characteristics of the fruits. |
|---|---|---|
| 1 | Super | Attractive red colour fruits, > 750g / fruit, free from spot in the rind |
| 2 | King | Attractive red colour fruits, 500-750g/ fruit |
| 3 | Queen | Bright red colour fruits, 400-500g/fruit, free from spot |
| 4 | Prince | Red colour fruits, fully ripe fruits, 300-400g/ fruit |

Additionally, there are grades 12A and 12B. Fruits that weigh between 250 and 300g are rated as 12A (fruits without spots) and 12 B. (with spots). In general, southern and northern India prefer fruits of grade 12A. The fruits are generally given ethyloleate treatment after grading to add shine. Pomegranate packets vary in size according to their grade.

### 12.6 Packaging
After harvested, fruits are sized, paper-wrapped, and placed in corrugated fibre board (CFB) boxes or bamboo baskets. Fruits are stacked in wooden boxes that hold roughly 16–18 kg of fruit apiece when being stored in bulk. Paper, rice straws, or dry grass are all utilised as padding. The four grades of pomegranate fruit produced in the state of Maharashtra are Super, King, Queen, and Prince. After that, the fruits are put into corrugated fibre board (CFB) boxes. 4-5 fruits of the Super size, 6 fruits of the King size, 9 fruits of the Queen size, and 12 fruits of the Prince size are typically packed in a single box (Waskar, 1997) [59].
The fruits are placed in two rows and wrapped in tissue paper for shipping. In most cases, waste paper that has been sliced into smaller pieces is used as padding. The boxes are covered with a lovely red colour paper after the fruits have been sorted and set on padding. Additionally utilised for shipping are boxes made of light wood and bamboo baskets. At the bottom and top of a box or basket, padding materials like dry grass, rice straws, or paper are employed. Each fruit basket can hold up to 6 dozen fruits and is designed for truck delivery. Fruits with high surface-to-volume ratios are particularly vulnerable to water loss.

### 12.7 Storage
Fruits are assessed after they are harvested based on their size, weight, and colour before being packed in paper cartons, bamboo boxes, or wooden boxes with padding materials. Compared to other tropical fruits like the mango, grape, and banana, pomegranate fruits keep better. If treated with a fungicide, the fruits can be kept for more than two months at 4-5 C. The fruits could potentially be kept for longer periods of time. As pomegranate fruits are prone to moisture loss, the fruits are subjected to the following procedures after being plucked from the tree: Quick delivery of plucked fruits to the packhouse with available transport capability.

## 13. Clove (*Syzigium aromaticum* L.)
### 13.1 Introduction
Clove is a powerful antioxidant and owing to its antibacterial properties set it aparts from other spices, clove in particular has drawn attention. (Han *et al*. 2005) Clove is the common name for the medium-sized tree (8–12 m) Syzygium aromaticum (S. aromaticum), this is native to the Maluku islands in eastern Indonesia and it is also known as Eugenia cariophylata. The commerce of cloves and the hunt for this priceless spice have long fueled this Asian region's economic growth.

Clove trees are typically grown in coastal regions at elevations not more than 200 m above sea level. After four years of planting, the tree is commercially valuable part the generation of blossom buds begins. Prior to flowering, flower buds are harvested during the maturing stage. The collection could be carried out manually or chemically utilising a natural phytohormone that causes precocious maturity by releasing ethylene in the vegetal tissue.
The major clove-producing nations now a days are Tanzania, especially the island of Zanzibar, and Indonesia, India, Malaysia, Sri Lanka, and Madagascar. Clove is grown in Brazil's north east, in the states of Bahia, in the regions of Valenca, Itubera, Tapero,a Camamu, and Nilo Pecanha. There, 8 000 hectares of clove are grown, yielding close to 2 500 tonnes annually.

Clove (*Syzigium aromaticum* L.)

### 13.2 Major Commercial Varieties
Penang, Zanjibar, Amboyan

### 13.3 Harvesting and Post-Harvest practices
In fertile soil and under appropriate management, clove trees begin to bloom after their fourth year of growth. However, it takes near about 15 years to reach the full bearing stage. In the plains, flowering occurs between September and October, whereas at high elevations, it occurs between December and January.

**Harvesting**
The unopened buds are plumb, spherical, and picked before they turn pink. They are less than 2 cm long at this stage. In this spice, the opening blossoms are not prized. When flower petals turn from olive green to golden pink, that is the ideal time to harvest clove buds. The stalks and flower clusters are both plucked at the same time. Depending on the region, the harvesting season often starts in the month of December and lasts until the end of April month. The branches must be harvested carefully to avoid injury, as this stunts the plants' future growth. A clove tree typically generates between 3.5 and 7.0 kg each year, depending on the age, size, and health of the clove. (Parle *et al*. 2011) [51].

### 13.4 Processing
The flower buds should be separated from the stalks, and then both the buds and the stalks should be dried in the sun or an artificial dryer until they are hard and dark brown. Poorly dried cloves are soft and pale brown with a yellowish appearance and are known as "khuker" cloves. Well-dried, high-quality cloves are golden brown in colour. About 30% of dry cloves are produced by green clove buds at the proper

stage. When the bud stem is dark brown and the rest of the bud is light brown, it has reached the proper stage of drying. Fresh cloves weigh nearly three times as much as well-dried cloves. One kilogramme of dried cloves weighs between 11,000 and 15,000.

### 13.4 Grading

Faulty cloves are referred to as Khoker cloves, Headless cloves, Mother cloves, Extraneous materials, etc., whole cloves are classed as special (Hand-picked), Grade-2, Grade-3, ground (powdered).

When a clove bud reaches 1.5 to 2 cm in length, it is manually plucked up. It is then sun-dried and assessed for size, colour, and appearance, including the presence of clove stems and headless cloves.

## 14. Tamarind *(Tamarindus indica* L.)

Tamarind is one of the auspicious, versatile trees in the Indian subcontinent is the tamarind, also known as Imli, which is particularly plentiful in the states of Madhya Pradesh, Bihar, Andhra Pradesh, Chhattisgarh, Karnataka, Tamil Nadu, and West Bengal (Singh *et al*., 2007) [67]. The fruit has a rhomboid or flattened form that is atypical (Muzaffar and kumar, 2017) [40]. In a normal fruit, the percentages of pulp, seeds, and fibres are respectively 55%, 34%, and 11%. (Rao *et al*., 2007; De Caluwe *et al*., 2010) [56, 17]. The tamarind pulp plays a significant role in dishes like tamarind fish, chutney, pickle, jam, curries, sauces, ice cream, and sarbat. It has been used in medicine as an expectorant, antidiabetic, digestive, antipyretic, and antimalarial drug (Isha and Millind, 2012) [25]. The three main processes in post-harvest operations are dehulling, defibring, and deseeding.

In the months of February and March, tamarind fruits start to ripen (Duke, 1981; Rao *et al*., 1999) [20, 57]. The pods are left on the tree to mature until the exterior is dry and can be readily detached from the interior without sticking (Shankaracharya, 1998; Muzaffar and Kumar, 2017) [66, 40] The pulp shrinks as a result of moisture loss during the ripe stage, turns reddish brown, and becomes. To make it easier to separate the shell from the pulp, fruit should be collected while the moisture content is under 20%. (Salih and Elhadi, 2011) [62].

### 14.1 Commercial varieties- Urigam, PKM-1, Vantoor, Red, Sweet

### 14.2 Harvesting

Pods can be collected manually, using a hook attached to a stick, or by shaking the branches of tree.

### 14.3 Drying of pods

To remove extra moisture and stop the development of mould, dry the pods in the sun for 3-4 days. When a dry pod is cracked, the pulp and fibres are separated, and the seeds are extracted, curved fruits that are considered to be of inferior quality than straight pods are the result of acute dehydration caused by sharp water loss (Yahia, 2006; Salih and Elhadi 2011) [75, 62].

### 14.4 Dehulling, defibering and deseeding of tamarind pods

Tamarind pod dehulling, defibering, and deseeding can be done manually or mechanically, by using conventional methods. The farmers often process the tamarind fruit by hitting it with a wooden mallet, stone, or hammer to expel the seeds. By employing labourers, the entire post-harvest process, including dehulling, defibring, and deseeding, completed simultaneously. It can also be manually pounded to remove the seeds using a stone mortar doused with oil, with castor oil, and a wooden pestle to apply impact force on the fruit. In certain places, deseeding is done with a knife (Kumar *et al*. 2015; Karpoora, 2010) [78, 28].

**Mechanical practices**

Several authors have designed and built machines for mechanical tamarind pod dehuling, defibering, and deseeding (Igathinathane, 1990; Sahu and Gulhane, 2005; Lende and chandak, 2012 and Karthickumar *et al*., 2015) [24, 61, 35, 29]. The traditional procedures used are inefficient, labor-intensive, unsanitary, and time-consuming. By implementing a mechanical dehulling and deseeding in tamarind, this drudgery can be reduced (Kumar *et al*. 2015) [78]. Automation of this procedure is essential to help these businesses and enhance their efficiency. Each of the three parts of the machine performs a different function, such as cover braking, cover separation, or seed removal. (Lende and Chandak 2012) [35].

### 14.5 Packaging and storage of tamarind pulp

Long-term storage under unfavourable circumstances, such as exposure to temperature and humidity extremes, results in progressive colour changes from brown or yellowish brown to black (FAO, 1989; Salih and Elhadi 2011; Kotecha and Kadam, 2003 b; Nagalakshmi and Chezhiyan, 2001) [21, 62, 31, 41]. Particularly in humid conditions, the pulp becomes mushy and gooey as moisture is absorbed and pectolytic breakdown occurs (Lewis and Neelakantan, 1964) [36]. The tamarind pods are shelled and sorted either manually or mechanically. Reduction in moisture content, the pulp is done by removal from the seed and they are dried in the sun for a few days. The dried pulp is then placed in bamboo or wooden boxes, polythene, jute bags, leaf mats, and cool, dry areas to be stored.

**Conclusion**

The literature reviewed here highlighted the improved tree spices on post-harvest technology. As a result, efforts are concentrated on improving the area, increasing productivity, and improving the quality of tree spices. However, in the current situation, it is extremely difficult for us to both sustain the output of tree spices and reduce their losses. In this case, tree spice post-harvest management appears to be more

crucial. Picking produce at the right time, transporting it safely to processing facilities, cleaning it, blanching it, treating it with the appropriate chemicals, dehydrating it, packaging it for storage, processing it into value-added products, etc. are all crucial procedures when it comes to lowering post-harvest losses. More efforts must be taken to introduce improved practices to enhance shelf life.

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