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REVIEW ARTICLE

ORIGIN, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETIC DIVERSITY, BREEDING AND CULTIVATION OF NUTMEG

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ABSTRACT

Nutmeg belongs to the family Myristicaceae, genus *Myristica* and species *Myristica fragrans.* Indian Name of Spices is in Hindi : Jaiphal Bengali : Jaiphal Gujarati : Jaiphal Kannada : Jayikai Kashmiri : Zaaphal Malayalam : Jathikka Marathi : Jaiphal Oriya : Jaiphala Punjabi : Jaiphal Sanskrit : Jatiphala Tamil : Jathikai Telugu : Jajikai Urdu : Jaiphal. Other Name(s) are in Jaatipatree, Jaiphal, Jatiphal, Jatiphala, Jatiphalam, Muscade, Muscade et Macis, Muscadier, Muskatbaum, Muskatnuss, Myristica, Myristica fragrans, Myristica officinalis, Myristicae Semen, Noix de Muscade, Noix de Muscade et Macis, Nuez Moscada, Nuez Moscada y Macis,Nutmeg, Nux Moschata, Ron Dau Kou. Foreign name of spices are in Arabic : Jouza at-Teeb Chinese : Dou kou shu Dutch : Nootmuskaat French : Muscade German : Muskatnu Greek : Moschokarido Indonesia : Pala Italian : Noce moscata Spanish : Moscada. Nutmeg is the spice made by grinding the seed of the fragrant nutmeg tree into powder. The spice has a distinctive pungent fragrance and a warm, slightly sweet taste; it is used to flavor many kinds of baked goods, confections, puddings, potatoes, meats, sausages, sauces, and vegetables, and beverages such as eggnog. The seeds are dried gradually in the sun over a period of 15 to 30 weeks. During this time, the nutmeg shrinks away from its hard seed coat until the kernels rattle in their shells when shaken. The shell is then broken with a wooden club and the nutmegs are picked out. Dried nutmegs are greenish brown ovoids with furrowed surfaces. The nutmegs are roughly egg-shaped, about 20.5–30 mm long and 15–18 mm wide, weighing 5–10 g dried. Mace is the spice made from the reddish seed covering (aril) of the nutmeg seed. Its flavour is similar to that of nutmeg but more delicate; it is used to flavour baked goods, meat, fish, and vegetables, and in preserving and pickling. In the processing of mace, the crimson-colored aril is removed from the nutmeg seed that it envelops and is flattened out and dried for 10 to 14 days. Its color changes to pale yellow, orange, or tan. Whole dry mace consists of flat pieces—smooth, horn-like, and brittle—about 40 mm long. The nutmeg is unique among tree spices as it is the donor of the two distinct spices, nutmeg and mace. Nutmeg is the seed kernel inside the fruit and mace is the covering (aril) on the kernel. Both mace and nutmeg are used as condiment and medicine. It is native of Indonesia (Moluccas Islands). In India it is cultivated in Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, North East India and Andamans**.** The area, production and productivity in our country is very low and it is mainly due to the non adoption of improved crop management and post harvest handling technologies, decline in area under cultivation and incidence of pest and diseases. Nutmeg, tropical evergreen tree and the spice made of its seed. The tree is native to the Moluccas, or Spice Islands, of Indonesia and is principally cultivated .there and in the West Indies. The spice nutmeg has a distinctive pungent fragrance and a warm slightly sweet taste; it is used to flavour many kinds of baked goods, confections, puddings, potatoes, meats, sausages, sauces, vegetables, and such beverages as eggnog. The fleshy arils surrounding the nutmeg seed are the source of the spice mace. Historically, grated nutmeg was used as a sachet, and the Romans used it as incense. Around 1600 it became important as an expensive commercial spice in the Western world and was the subject of Dutch plots to keep prices high and of English and French counterplots to obtain fertile seeds for transplantation. The nutmegs sold whole were dipped in lime to prevent their sprouting. Nutmeg trees may reach a height of about 20 m. They yield fruit eight years after sowing, reach their prime in 25 years, and bear fruit for 60 years or longer. The fruit is a pendulous drupe, similar in appearance to an apricot. When fully mature it splits in two, exposing a crimson-coloured aril, the mace, surrounding a single shiny brown seed, the nutmeg. After collection the aril-enveloped nutmegs are conveyed to curing areas where the mace is removed, flattened out, and dried. The nutmegs are dried gradually in the sun and turned twice daily over a period of six to eight weeks. During this time the nutmeg shrinks away from its hard seed coat until the kernels rattle in their shells when shaken. The shell is then broken with a wooden truncheon and the nutmegs are picked out. Dried nutmegs are grayish brown ovals with furrowed surfaces.

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INTRODUCTION

Nutmeg belongs to the family Myristicaceae, genus *Myristica* and species *Myristica fragrans* (Wikipedia, 2024b). Indian Name of Spices is in Hindi : Jaiphal Bengali : Jaiphal Gujarati : Jaiphal Kannada : Jayikai Kashmiri : Zaaphal Malayalam : Jathikka Marathi : Jaiphal Oriya : Jaiphala Punjabi : Jaiphal Sanskrit : Jatiphala Tamil : Jathikai Telugu : Jajikai Urdu : Jaiphal (Indianspices, 2024). Other Name(s) are in Jaatipatree, Jaiphal, Jatiphal, Jatiphala, Jatiphalam, Muscade, Muscade et Macis, Muscadier, Muskatbaum, Muskatnuss, Myristica, Myristica fragrans, Myristica officinalis, Myristicae Semen, Noix de Muscade, Noix de Muscade et Macis, Nuez Moscada, Nuez Moscada y Macis,Nutmeg, Nux Moschata, Ron Dau Kou (RXLIST, 2025). Foreign name of spices are in Arabic : Jouza at-Teeb Chinese : Dou kou shu Dutch : Nootmuskaat French : Muscade German : Muskatnu Greek : Moschokarido Indonesia : Pala Italian : Noce moscata Spanish : Moscada (Indianspices, 2024). Nutmeg is the spice made by grinding the seed of the fragrant nutmeg tree into powder. The spice has a distinctive pungent fragrance and a warm, slightly sweet taste; it is used to flavor many kinds of baked goods, confections, puddings, potatoes, meats, sausages, sauces, and vegetables, and beverages such as eggnog. The seeds are dried gradually in the sun over a period of 15 to 30 weeks. During this time, the nutmeg shrinks away from its hard seed coat until the kernels rattle in their shells when shaken. The shell is then broken with a wooden club and the nutmegs are picked out. Dried nutmegs are greenish brown ovoids with furrowed surfaces. The nutmegs are roughly egg-shaped, about 20.5–30 mm long and 15–18 mm wide, weighing 5–10 g dried (Wikipedia, 2024a). Mace is the spice made from the reddish seed covering (aril) of the nutmeg seed. Its flavour is similar to that of nutmeg but more delicate; it is used to flavour baked goods, meat, fish, and vegetables, and in preserving and pickling. In the processing of mace, the crimson-colored aril is removed from the nutmeg seed that it envelops and is flattened out and dried for 10 to 14 days. Its color changes to pale yellow, orange, or tan. Whole dry mace consists of flat pieces—smooth, horn-like, and brittle—about 40 mm long (Wikipedia, 2024a).

Indonesia produced 60 %, Grenada 40 % of the 5600 tons of nutmeg (the dry shelled seeds) and 1400 tons of mace (the dry arillus) of the tropical rain forest tree (Flach, 1966). Restriction of male flowering trees to 10 % and spacing at 9 metres would rise yields per ha sharply above the usual 800 kg nutmeg and 160 kg mace, at 2000 fruits per female tree (Flach, 1966). In Grenada air-layering and approach-grafting, although expensive, were developed for practical use. In New Guinea the tree showed a 1:1 segregation into a female-only flowering sex, with strong correlation between production and stem girth, and a male-flowering sex, mostly bearing also female flowers and fruits (Flach, 1966). Investigations for a visible chromosomal sex mechanism showed 44 (2n) nearly isodiametric chromosomes (0.4-1.0μ) and 'non-localized' centromeres. Breakage of chromosomes by X-rays produced persisten fragments, proving nutmeg to be the first dicotyledon with diffuse centromeres (Flach, 1966). The hypothesis was developed that nutmeg had four pairs of sex chromosomes. The heterogametic female had four facultative nucleolar sex chromosomes, in meiosis orientated by the nucleolus. The variation in female flowering was explained by partial failure of orientation. If proved, the hypothesis offered opssibilities for sexing young seedlings and improvement by breeding (Flach, 1966). The nutmeg is unique among tree spices as it is the donor of the two distinct spices, nutmeg and mace (Thangaselvabai *et al.,* 2011). Nutmeg is the seed kernel inside the fruit and mace is the covering (aril) on the kernel (Thangaselvabai *et al*., 2011). Both mace and nutmeg are used as condiment and medicine (Thangaselvabai *et al.,* 2011). It is native of Indonesia (Moluccas Islands) (Thangaselvabai *et al.,* 2011). In India it is cultivated in Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, North East India and Andamans (Thangaselvabai *et al.,* 2011). The area, production and productivity in our country is very low and it is mainly due to the non adoption of improved crop management and post harvest handling technologies, decline in area under cultivation and incidence of pest and diseases (Thangaselvabai *et al.,* 2011).

It's not a nut. Nutmeg is the seed kernel inside a yellow fruit of the nutmeg tree, an evergreen native to the Molucca Islands (sometimes called the Spice Islands) of Indonesia. Whole nutmeg seeds are oval, brown and about an inch long, with a nutty aroma and taste—but they don't pose a risk to people with nut allergies (Oosterwyk, 2015). This beloved holiday spice can be dangerous. But only in fairly large amounts. It takes two tablespoons or more to produce symptoms of nutmeg poisoning, toxicologists say. Those symptoms may include acute nausea, dry mouth, dizziness and a slowdown of brain function to the point where victims experience blackouts. Higher doses can cause shock and hallucinations (Oosterwyk, 2015). That's due to the nutmeg's essential oil. Myristica, as the oil is called, contains myristicin, a narcotic that functions in the plant as a natural insecticide. Nutmeg also—as do its frequent recipe companions, cinnamon and clove—acts as an antibiotic (Oosterwyk, 2015). Nutmeg has other medicinal properties as well. Consumed in small doses, nutmeg can serve as a digestive aid in reducing flatulence and indigestion, and can also help treat nausea and diarrhea as well as lower blood pressure. Applied topically, it can offer pain relief and has been used for rheumatism, mouth sores and toothache (Oosterwyk, 2015). Nutmeg was more valuable than Manhattan. By the 16th century, nutmeg—coveted as a flavoring, hallucinogen, alleged aphrodisiac and deterrent to the plague—was being sold by European traders at a 6,000 percent markup (Oosterwyk, 2015). The Dutch soon wrested control of all the nutmeg-producing Moluccas except for a tiny island called Run, which was controlled by the British. At that time, Run seemed more valuable than Manhattan, then under Dutch control as New Amsterdam. In order to seal their nutmeg monopoly, the Dutch gave the British New Amsterdam in exchange for Run. It seemed like a good idea (Oosterwyk, 2015).

Nutmeg is native to a small cluster of islands in Indonesia, the Banda Islands (Periasamy *et al.,* 2016). It is the seed of a peach like fruit that grows from the tree *Myristica fragrans* (Periasamy *et al.,* 2016). Europeans discovered nutmeg in the middle ages and it became quite valuable for its culinary and folk remedy uses (Periasamy *et al.,* 2016). By the late nineteenth century, nutmeg was becoming widespread and its purported uses continued to evolve (Periasamy *et al.,* 2016). Reports in the medical literature began to appear of women ingesting large amounts of nutmeg to induce abortion. These ingestions are some of the first medical descriptions of the nutmeg toxicity (Periasamy *et al.,* 2016). Nutmeg is an important commodity. It is widely used in the food and

medical industries and is one of the oldest traded commodities in the world. It is used extensively in the form of essential oil, powdered, crushed, and whole in food, medicine, and cosmetics. Nutmeg has a characteristic pungent and pleasant fragrance, with a slightly warm and sweet taste. It is used to flavor many kinds of baked goods, breads, confections, puddings, dairy products, meats, sausages, saucers, vegetables, and beverages. It is also used as a component of candies, chewing gum, syrups, curry powder, teas, and soft drinks, or is mixed in milk and alcohol (Periasamy *et al.,* 2016). Dried whole, ground nutmeg- Flavoring in the food industry: meat and dairy products (sausages, soups, spice mixes, baked products, eggnog, ice cream etc.), both domestic and industrial use (Periasamy *et al.,* 2016). Nutmeg oil- Flavoring of processed foods and beverages (Periasamy *et al.,* 2016). Mace: dried, whole, ground- Domestic and industrial culinary uses as flavorings for sweet foods, cakes, doughnuts, dairy products, and cigarettes (Periasamy *et al.,* 2016). Mace oil- Flavorings in processed foods and baked products; extract used in perfumes, scented soaps, denture creams, and chewing gum (Periasamy *et al.,* 2016). Nutmeg is one of the most popular spices, known since olden days for its aromatic, aphrodisiac, and curative properties. Nutritionally, nutmeg is rich source of energy, carbohydrates, proteins, and dietary fiber. It is mainly rich in vitamins A, C, and E, but it also contains electrolytes (sodium and potassium), minerals (magnesium, calcium, copper, iron, zinc, manganese, and phosphorus), and phytonutrients including carotene-B and crypo-xanthin B (Periasamy *et al*., 2016).

Because of its aroma, nutmeg's essential oil has been used as a natural flavoring extract and as a perfume in the cosmetic industries. In particular, the oil has been used as a flavoring agent, replacing ground nutmeg in order to avoid leaving particles in foods and beverages. In addition to being nutritionally rich and having widespread use in flavorings, current research seems to focus on the potential use of nutmeg and its essential oil as food preservatives (Periasamy *et al.,* 2016). Owing to its demonstrated antimicrobial and antioxidant properties, nutmeg essential oil is considered to be a promising biopreservative (Periasamy *et al.,* 2016). Recently, the interest in essential oils (EOs) and their application in food preservation has been amplified because (1) it is desired to reduce the potential health risk and increasing negative consumer perception of synthetic preservatives; and (2) foodborne diseases are a growing public health problem worldwide, calling for more effective preservation strategies (Periasamy *et al*., 2016). EOs serve as preservatives through their antimicrobial and antioxidant mechanisms as many of them are effective in retarding microbial growth, food oxidation, and rancidity, making them promising natural preservatives to be used in food industry. Thus, it is highly desirable to employ natural preservatives with antioxidant and antimicrobial properties to avoid the side effects associated with the use of synthetic preservatives. Accordingly, nutmeg essential oil and its various oleoresin extracts displayed antimicrobial and antioxidant properties that make them a promising natural food preservative to replace the synthetic ones (Periasamy *et al*., 2016). Essential oils and various oleoresins (acetone, ethanol, methanol, butanol, and water extracts) extracted from nutmeg demonstrated antimicrobial activities against both Gram-positive and Gram-negative bacteria as well as against pathogenic fungi (Periasamy *et al.,* 2016). One of the modern ways to improve the hygienic safety of manufactured food products is to exploit the antimicrobial properties of natural plant extracts, allowing for a decrease of the use of chemical antimicrobial agents, which constitute a potential human health hazard. In this regard, the antimicrobial properties of EOs have been known for a long time and continue to be the subject of several studies that evaluate their microbial potential as alternatives to chemical agents in food industries (Periasamy *et al.,* 2016). Because antioxidants help prevent oxidation of foods, especially fats and oils, and protect cells from free-radical damage, food manufacturers use antioxidants as food additives to help guard against food degradation and enhance the health profile of functional foods (Periasamy *et al.,* 2016). Both natural (ascorbic acid and tocopherols) and synthetic (propylgallate, tertiary butylhydroquinone, butylated hydroxyanisole, butylated hydroxytoluene) antioxidants act as food preservatives. However, there are some arguments about the safety and adverse effects of the synthetic antioxidants when used as food additives. In fact, in recent years, researchers have focused on spicy and medicinal plants for extracting natural antioxidants, which play an important role in the food industry to combat food deterioration (Periasamy *et al.,* 2016). Despite the demonstrated potential of essential oils and their constituents in vitro, their use as preservatives in food has been limited because high concentrations are needed to achieve sufficient antimicrobial activity. In many food products, the hydrophobic essential oil constituents are impaired by interactions with food matrix components, such as fat, starch, and proteins (Periasamy *et al*., 2016).

Floral diversity in monoecious type nutmeg reveals three types of flowers namely; pistillate, staminate and hermaphrodite flowers. The structure of hermaphrodite flowers in nutmeg is reported for the first time (Aarthi *et al*., 2018). The flowers are borne on the leaf axil, flowering habit of the three types of flowers are seen in cymes as well as solitary in the same tree (Aarthi *et al.,* 2018). The gynoecium consists of single ovary with bifid stigma in the pistillate flowers and the androecium of staminate flowers has adnate 7-13 anthers (Aarthi *et al.,* 2018). Intra flower variability is evident in case of hermaphrodite flowers. In hermaphrodite flower the androecium ranges with 1-4 anthers, in the form of fused filament or free filament or both; some anthers are fused with the gynoecium (Aarthi *et al*., 2018). Besides remnants of the stamen in the developed fruits of hermaphrodite flowers, staminodes are also observed in the flowers (Aarthi *et a*l., 2018). Colour of all the three types of flowers are light creamy yellow, with thick gamosepalous perianth which bursts as bilobed, trilobed, tetralobed and pentalobed lobes during anthesis (Aarthi *et al.,* 2018). Analysis of variance of trees for flower types and floral attributes like flower type, number of anthers, length of anthers, length of filaments and length of ovary are found to be highly significant (Aarthi *et al.,* 2018). High coefficient of variation is recorded for hermaphrodite (183.84%) and pistillate (171.71%) flowers. The pollen viability of the hermaphrodite flowers are found less as compared to the staminate flowers. The percentage of pollen viability is 79.74 and 90.77 in hermaphrodite and male flower respectively (Aarthi *et al*., 2018). In the population studied, the occurrence of hermaphrodite flower in monoecious tree ranged from 0 - 10% (Aarthi *et al.,* 2018). Nutmeg is an important tree spice, yielding two spices, namely, the nutmeg (dried seed) and the mace (dried aril surrounding the seed). Nutmeg is hitherto considered to be predominantly dioecious in nature (Aarthi *et al.,* 2018). Of late this concept is undergoing a paradigm shift, as monoecious trees are being reported often across the country (Aarthi *et al.,* 2018).

Nutmeg is the seed of the evergreen tree. The inner seed is enveloped by a bright red aril known by spice traders as mace. If you stroll past a nutmeg tree on a sunny beach, you may spot the yellow, peach-like fruits drooping high in the branches. When the fruits are ripe, they split open revealing the crimson mace aril, signaling the spices are ready for harvest and curing (Rampe, 2019). The Spice House's premium nutmeg and mace come from the Caribbean island of Grenada, where it is still harvested by hand. Skilled workers delicately remove the crimson veil of mace from the nut, and dry it in the sun for up to two weeks (Rampe, 2019). As mace cures, its color often transitions from a bright red to a yellow-orange. The nutmegs are set on drying racks for up to two months before another layer of shell is removed and the precious nutmeg is finally exposed (Rampe, 2019). Freshly ground nutmeg has an intensely perfumed aroma that is sweet, nutty, spicy, and faintly reminiscent of mint or eucalyptus, similar to the profiles of cardamom or pine. Nutmeg is best when ground fresh from whole seeds, however The Spice House offers freshly ground nutmeg for your convenience as well (Rampe, 2019). Mace's flavor and aroma differ slightly from nutmeg as its profile tends to be sharper and less sweet. The essential oils of the two spices have different chemical compositions and noticeably different flavors even though they come from the same plant. This is similar to how an orange peel will taste and smell different than the flesh (Rampe, 2019). Nutmeg trees are native to the Banda Islands, tiny volcanic archipelago situated 250 miles east of Indonesia. For over a thousand years, these specks of land were the only source of nutmeg and mace in the world. The best nutmegs for cooking are about an inch long, but for most of written history nutmeg resembled a soccer ball that was kicked around by Arab, Portuguese, French, English, and Dutch spice traders (Rampe, 2019).

Nutmeg, is the ground spice or seed of some species of the genus *Myristica. Myristica fragrans* (true nutmeg or fragrant nutmeg), is a dark-leaved evergreen tree harvested for two spices extracted from its fruit: mace, from the seed covering, and nutmeg, from its seed (Jafari *et al.*, 2020). Nutmeg is indigenous to the Banda Islands in the Moluccas (or Spice Islands) of Indonesia (Jafari *et al.*, 2020). Penang Island in Malaysia is another region known for its cultivation (Jafari *et al*., 2020). Nutmeg produces 8–15% of EO which is thought to be potentially responsible for the effects related to nutmeg intoxication. Its EO has elemicin, myristicin, safrole, eugenol, and safrole (Jafari *et al*., 2020). The EOs of mace and nutmeg have a similar aroma and chemical composition with a wide spectrum of colour varieties (brilliant orange to pale yellow) (Jafari *et al*., 2020). The oils of mace and nutmeg and their distinct components have been examined for their antimicrobial activity *in vitro* against some oral microorganisms, such as *Porphyromonas gingivalis* and *S. mutans*. Such activity has been seen against other bacteria, including some strains of *Salmonella typhi*, *L. monocytogenes, E. coli*, *Bacillus subtilis,* and *S. aureus* (Jafari *et al*., 2020). Nutmeg has carminative, aromatic, narcotic, stimulant, astringent, aphrodisiac, anti-inflammatory, antioxidant, hypolipidemic, antidysenteric, anti-platelet aggregation, and antithrombotic activities. It is used as a remedy for dietary habits, rheumatism, vomiting in pregnancy, and stomach ache, as both a herb and a spice (Jafari *et al*., 2020). Nutmeg has a characteristic pungent and pleasant fragrance, with a slightly warm and sweet taste (Jafari *et al.,* 2020). Nutmeg is used to flavor many kinds of baked goods, breads, confections, puddings, dairy products, meats, sausages, sauces, vegetables, and beverages (Jafari *et al.*, 2020). Because of its aroma, nutmeg essential oil has been used as a natural flavoring extract and as a perfume in the cosmetic industry (Jafari *et al.,* 2020). Nutmeg is a highly valued spice, known since antiquity for its aromatic, aphrodisiac, and curative properties (Jafari *et al*., 2020). Owing to its demonstrated antimicrobial and antioxidant properties, nutmeg essential oil is considered to be a promising biopreservative (Jafari *et al.,* 2020). Nutmeg has high nutritional value and is rich in carbohydrates, proteins, dietary fiber, vitamins A, C, E, and minerals such as calcium, copper, iron, magnesium, manganese, zinc, and phosphorus (Jafari *et al.*, 2020). Nutmeg is known to have multiple medicinal uses and applications, including treatment of gastrointestinal conditions such as stomach ulcers, indigestion, liver disorders, emmenagogue, nervine, digestive, diuretic, diaphoretic, and food flavoring properties (Jafari et al., 2020). Nutmeg essential oils from different geographical origins differ widely in their composition and commonly contain phytochemicals such as limonene, sabinene, α-pinene, β-pinene, myristicin, sabinene, and safrol (Jafari *et al*., 2020).

Nutmeg (*Myristica fragrans* Houtt.), belonging to the family Myristicaceae, is a spice seed from the fruit of a tropical, dioecious evergreen tree called *M. fragrans* Houtt., which is native to the Moluccas, or Spice Islands, of Indonesia (Gordon, 2020a). Nutmeg has a distinctive, pungent fragrance and a warm, slightly sweet taste; it is used to flavor many kinds of baked goods, confections, puddings, meats, sausages, sauces, vegetables, and some beverages such as eggnog. Grated nutmeg has been used as a sachet; the Romans used it as incense (Gordon, 2020a). Nutmeg has been reported to have aphrodisiac, stomachic, carminative, tonic, nervous stimulant, aromatic, narcotic, astringent, hypolipidemic, antithrombotic, antifungal, antidysentric, and anti-inflammatory properties (Gordon, 2020a). It is said to be antihelminthic and is also used against skin diseases such as eczema and scabies (Gordon, 2020a). Phytochemical studies indicate that nutmeg contain a volatile oil, a fixed oil, proteins, fats, starch, and mucilage. The fixed oil contains myristin and myristic acid. Nutmeg yields 5–15% of volatile oil, which contain pine, sabincene, camphene, myristin, elemicin, isoelemicin, eugenol, isoeugenol, methoxyeugenol, safrole, diametric phenylpropanoids, lignas, and neolignas (Gordon, 2020a). Nutmeg is reported to be useful in paralysis and increases blood circulation. It is also demonstrated to have antioxidant properties and antidiarrheal properties (Gordon, 2020a). Nutmeg (*Myristica fragrans*) (Family: Myristicaceae) produces two separate spices, namely nutmeg and mace. Nutmeg is the dried kernel of the seed and mace is the dried aril surrounding it (Vikaspedia, 2020). Nutmeg is indigenous to Moluccas Islands (Indonesia). Over 50% of the worlds export of nutmeg and mace is from Indonesia (Vikaspedia, 2020). Grenada is the second largest exporter of nutmeg and mace in the world. In India, nutmeg is mainly cultivated in Thrissur, Ernakulam and Kottayam districts of Kerala and parts of Kanyakumari and Tirunelveli districts in Tamil Nadu (Vikaspedia, 2020).

The nutmeg of commerce is the kernal which is hard and brown, enclosed in a thin brittle shell. Surrounding this shell is aril which is scarlet in colour and furnishes the mace of commerce (KSSDB, 2021). Nutmeg also contains a volatile oil (6-16%), starch (14-25%), furfural (1.15%) and pectin (0.5-0.6%), mace contains a volatile oil (4-15%), amlodextrin (25%) (KSSDB, 2021). Mace is used as a culinary spice and largely as a flavouring agent. The husk is used for pickling when the fruit is at tender stage. Fresh husks of the ripe fruit can be used for making Jelly (KSSDB, 2021). Medicinally nutmegs act as a stimulant, astringent,

aphrodisiac and carminative. The essential oil has uses in medicine, toilet soap, dental pastes, for flavouring chewing gums, chewing tobacco and for flavouring baked goods, cakes, cookies, puddings and pickles. The aromatic oil has butter like consistency and orange in colour (KSSDB, 2021). Nutmeg is a spice derived from the genus *Myristica* plant native to both Africa and Eastern Indonesia (Rampe, 2022). *Myristica fragrans* (fragrant nutmeg) comes from the Indonesian Banda Islands, also known as the Spice Islands, and is among the earliest spices traded in history (Rampe, 2022). As the early spice trade developed along what we now call the Silk Road, nutmeg traveled from those small Indonesian Islands to become a beloved spice heavily used by cultures around the world (Rampe, 2022). According to *The Nutmeg Trail* by Eleanor Ford, "We can deduce that deliberate spice trade started around 2000 BC. From Austronesia to India traveled crops, including… spices like nutmeg, mace, and cloves. In return, India and Sri Lanka sent peppercorns [and] cinnamon" (Rampe, 2022). Nutmeg is not a nut but a seed of the *Myristica plant.* The fragrant nutmeg plant produces a golden-hued, apricot-like fruit. The kernel of that fruit is where nutmeg and mace, the outer skin of the nutmeg kernel called the aril, are sourced (Rampe, 2022). When the nutmeg kernel and arils are fresh, they have a glossy appearance from the oils in the nutmeg. Once they are dried into the spice, they lose their shiny exterior. It takes six to eight weeks of drying in order to prepare the nutmeg seed to be used as a spice (Rampe, 2022).

Myristica fragrans (Houtt.) is an evergreen tree native to the Maluku Islands, Indonesia. *M. fragrans* kernel is extensively used in Indian traditional medicines to treat various diseases (Ashokkumar *et al.,* 2022). Several studies attempt to compile and interpret the pharmacological potential of *Myristica fragrans* (Houtt.) aqueous and various chemical extracts (Ashokkumar *et al.,* 2022). Pharmacological potential of nutmeg essential oil has not been reviewed phytochemically and pharmacologically (Ashokkumar *et al.,* 2022). Nutmeg belongs to the Myristicaceae family (Ashokkumar *et al*., 2022). The plant is native to the Maluku Islands of Indonesia; however, it is extensively distributed to Grenada, India, Sri Lanka, Mauritius, South Africa, and the USA (Ashokkumar *et al.,* 2022). The nutmeg seed has outer, red arils called mace and an inner, brown kernel called nutmeg, both of which are used as a spice (Ashokkumar *et al*., 2022). In traditional medicine, different parts of the plant mentioned traditionally are used to cure various diseases. However, in Indian Ayurvedic medicine, nutmeg has been used to treat anxiety, nausea, diarrhea, cholera, stomach cramps, parasites, paralysis, and rheumatism and is also used as an aphrodisiac (Ashokkumar *et al*., 2022). Furthermore, in Pakistan traditional medicine, the nutmeg plant has been used to treat hypertension (Ashokkumar et al., 2022). The essential oil (EO) of *M. fragrans* is a colorless-to-light yellow liquid with a distinct spicy odor (Ashokkumar *et al*., 2022).

To make nutmeg for seasoning, the nutmeg seeds are dried gradually in the sun over a period of six to eight weeks. During this time, the nutmeg shrinks away from its hard seed coat. The spice is ready when the kernels rattle in their shells when shaken (Moncel, 2022). It is separated from the outer coat (the mace) and sold whole or ground up and packaged (Moncel, 2022). Nutmeg has a very interesting history, dating all the way back to the 1st century A.D. It was a treasured spice, considered high currency for trade, and was even the cause of war; the Dutch conquest the Banda Islands, which ended in a massacre, to monopolize the nutmeg trade. This resulted in the establishment of the Dutch East India Company, an amalgamation of several Dutch trading companies. Although both spices come from the same tree, nutmeg and mace do differ from each other. The mace, which is the outer coating of the nutmeg seed, is removed first and ground into a red-colored spice, while the nutmeg pit or seed can either be kept whole or ground up. Nutmeg has a milder taste compared to mace and is sweeter and more delicate; mace is a little spicier and can be described as a combination of pepper and cinnamon. Even though they grow as one, they are rarely used together in a recipe (Moncel, 2022). Nutmeg can be purchased as the whole seed or ground in a container. Grating the seed directly into a recipe will impart a fresher, cleaner taste than using store-bought ground nutmeg. Whole nutmeg is approximately the size of an apricot pit and will last a very long time while pre-ground nutmeg has a shorter shelf life (Moncel, 2022). Nutty and slightly sweet, nutmeg is an intense spice that has a strong and distinct aroma. For those who are more sensitive to heat, nutmeg might seem almost spicy (Moncel, 2022). Nutmeg has a long culinary history and can be part of both sweet and savory dishes. It can be used whole and grated directly into a recipe or measured or shaken from a canister of pre-ground nutmeg. To use whole nutmeg, you will need a microplane or nutmeg grater to shave off a small portion of the seed. When including nutmeg, make sure not to use a heavy hand, as this intense spice can easily overpower the flavors of a dish (Moncel, 2022). Nutmeg can be purchased in two forms: ground or whole. Ground nutmeg is easily found in the spice section of the grocery store. It has been milled into a rough powder form and, although convenient, tends to lose its flavor and aroma quickly. For this reason, ground nutmeg is generally sold in very small quantities. Whole nutmeg can be found in well-stocked supermarkets, gourmet shops, and online (Moncel, 2022). Store ground nutmeg in an air-tight container away from heat, light, and moisture. When stored properly, ground nutmeg will retain its freshness for approximately six months. Whole nutmeg will stay fresh indefinitely, but should always be stored away from heat and moisture. If you use nutmeg only occasionally, buying whole nutmeg is the best option because each time it is grated it will provide fresh, fragrant, and flavorful spice (Moncel, 2022).

To identify the center of origin and to infer recent evolutionary history of one of the most emblematic spice tree species nutmeg (*Myristica fragrans*; Myristicaceae). The species is thought to originate from the Banda islands (Southern Moluccas archipelago, Indonesia), but this has never been confirmed (Kusuma *et al.,* 2023). Characterized the genetic diversity of this species across the Moluccas archipelago using recently developed nuclear microsatellites markers and whole plastid genome sequences. We found two main intra-specific genetic clusters: one in South Moluccas (Banda and Ambon islands) and another in North Moluccas (Ternate, Tidore and Bacan islands) (Kusuma *et al.,* 2023). The latter cluster showed higher genetic diversity than the South Moluccas cluster. We then inferred the demographic history of nutmeg and evaluated different evolutionary scenarios using Approximate Bayesian Computation (ABC) analyses (Kusuma *et al.,* 2023). Populations from South Moluccas show patterns of a recent bottleneck, whereas North Molucca populations did not (Kusuma *et al.,* 2023). Moreover, South Moluccas populations are inferred as ancestral, with subsequent population migration to the North Moluccas during the late Pleistocene to early Holocene period (Kusuma *et al.,* 2023). Nutmeg is historically utilized to make desserts. Nutmeg fruit's seed has been widely used, notably in culinary, medicinal, and cosmetic sectors. Nutmeg is utilized as a flavor agent in a variety of baked products, confectionary,

meats, sausages, puddings, vegetables, and beverages. It is utilized as a component of curry powder, tea, and soft drinks, and it is added to milk and alcohol (Khanam *et al*., 2023). Nutmeg is a popular spice of many nations. Nutmeg is utilized in sweet recipes in Middle East and India. It is used as a flavor agent in potatoes, meats, eggs and even spinach in most European meals, as well as soups and sauces in the traditional medication used in Arabia, Israel, and Jewish community (Khanam *et al.,* 2023). It is utilized to regulate vomiting, bowel motions, as well as to treat TB, colds, and fevers, and to treat respiratory disorders in general. It has antihelminthic properties and used for the treatment of skin conditions including eczema and scabies. This utilized alternative medication in Unani medicine is to treat the sexual problems in males (Khanam *et a*l., 2023). Nutmeg is also primarily utilized to treat inflammatory disorders, joint, muscular discomfort, and liver illness. Nutmeg oil aids in the dissolution of kidney stone and the relief of kidney infections, and treatment of diarrhea, rheumatism, and cholera (Khanam *et al.,* 2023).

Myristica fragrans belongs to the family Myristicaceae and is a tropical evergreen tree (Okiki *et al*., 2023). It produces two spices, nutmeg and mace; the most important part of the plant in terms of its pharmacological activity and also in commerce is the dried kernel (seed), the nutmeg (Okiki *et al.,* 2023). The spice nutmeg has a distinctive fragrance and a slightly sweet taste. It is used globally, as a condiment to flavour baked foods, confections, sausages, sauces, meats, and in many other foods. This spice has been used extensively in traditional medicine in treating several ailments (Okiki *et al.,* 2023). Commercial antimicrobial drugs have been commonly employed for treatment of infectious diseases for many years. However, the indiscriminate use of these antibiotics has developed multiple resistances and side effects (Okiki *et al.,* 2023). Nutmeg is used as a constituent in preparations of medicines, such as for dysentery, flatulence, stomach-ache, nausea, vomiting, rheumatism, sciatica, malaria and early stages of leprosy. *M. fragrans* has been deductively approved to treat hypolipidemic and hypocholesterolaemia, antidepressant, aphrodisiac, antimicrobial, upper antioxidant, memory boosting, and hepatoprotective properties (Okiki *et al*., 2023). The essential oil of nutmeg and its fractions have been reported to contain pharmacological active compounds with aphrodisiac, hepatoprotective, antimicrobial, antidiabetic, antioxidant, anticancer properties (Okiki *et al.,* 2023).

Nutmeg is a perennial tree spices which is yielding twin spices; present days research thrust is to identify high yielding mother trees (Vikram *et al.,* 2024). But yield and quality both are equally important due to its wide spread medicinal as well as industrial usage (Vikram *et al*., 2024). The core collection of nutmeg genotypes form different locations of Kerala evaluated for biochemical composition (Vikram *et al.,* 2024). Seventeen morphologically distinct types of nutmeg were analysed through GC/MS method. The change in volatiles after storage (at 4°C) was also assessed after one year (Vikram *et al*., 2024). The range of variation was observed for kernel oil, mace oil, kernel oleoresin, mace oleoresin and fixed oil of kernel. Myristicin, elemecin and sabinene were principal volatile compounds (Vikram *et al*., 2024). The identification of distinct nutmeg chemotypes for specific volatile compounds which could be used in commercial cultivation/pharmaceutical application/ industrial use (Vikram *et al*., 2024). Study highlights the high and low hallucinogen (myristicine, elemicine and safrole) genotypes along with high sabinene types (Vikram *et al*., 2024). *Myristica fragrans* Houtt. is the only cultivated species of nutmeg which yields twin spices; nutmeg and mace, both having tremendous potential in the spice industry (Vikram *et al*., 2024). It is used for food, flavouring and as ingredient in many of the value added products due to the presence of a unique spectrum of flavour compounds (Vikram *et al*., 2024). Indonesia is the world leader in production and export of nutmeg and mace, followed by Graneda (Vikram *et al.,* 2024). As of now, the nutmeg is mainly cultivated in Southern India particularly in all the districts of Kerala and certain parts of Tamil Nadu and Karnataka (Vikram *et al.,* 2024). The present area under this crop in India is 24252 ha with an annual production of 15688 tonnes (Vikram *et al*., 2024). The volatile oil from this plant is extensively used in the pharmaceutical industry. The volatile oil is used externally for treating rheumatism and internally as a carminative. It is also used in soaps and in aroma therapy as postpartum medication (Vikram *et al.,* 2024). The hepatoprotective property of the essential oil is attributed to the presence of lignans, phenols and the phenyl-propanoids commonly found in Myristicaceae (Vikram *et al.,* 2024). The anti-inflammatory and antipyretic activities of the nutmeg have been scientifically proven (Vikram *et al*., 2024). Unlike other crops, where thrust is given on yield maximization of nutmeg, apart from yield, quality is equally important because of its wide spread medicinal as well as industrial usage (Vikram *et al.,* 2024). Comprehensive characterization of nutmeg for the contents of volatile oil, oleoresin and fixed oil and for constituents of volatile oil is very much limited (Vikram *et al.,* 2024).

Nutmeg a small holder's crop, with 3500 years of antiquity originated in the Moluccas, Indonesia, is now grown in about 12 countries including some secondary centres of domestication (Wikipedia, 2024). Centres of domestication overlap the centre of origin in nutmeg (Wikipedia, 2024). Out of about 175 species in the genus, only five are economically important (Wikipedia, 2024). Besides species diversity and cultivar diversity, ecosystem diversity is also a component of biodiversity of the genus (Wikipedia, 2024). The genus is represented by six species including four endemic species and subspecies each in India (Wikipedia, 2024). The history of the spice is mired in bloody wars, piracies, privateers, clandestine collection trips, wanton felling of the heirloom trees besides inadvertent specimen identity, inaccurate chronology and a treaty of land swap (Wikipedia, 2024). Though French and British colonial rulers took interest in popularising nutmeg in their colonies albeit for economic gains, the role of French was pivotal (Wikipedia, 2024). The package of practices of nutmeg (Colonial Horticulture) in the new French colonies were a complex process of creolizing the expertise borrowed from the native people of the Moluccas with the horticultural knowledge of the colonists, traders, settlers, slaves and other local residents (Wikipedia, 2024). Though nutmeg, a perennial tree of about 100 years of life span, has only about 300 years of domestication history in the country, the cultivar diversity is amazing as exemplified by the high frequency of farmer's varieties (Wikipedia, 2024). The nutmeg population of the country also exhibits good phenotypic plasticity as demonstrated by leaky dioecy (Wikipedia, 2024). While the transnational spread of nutmeg is a legacy of colonial rulers, the settlers mainly Christians, are credited with the intra state spread of nutmeg in Kerala, the major area of production in India (Wikipedia, 2024). Nutmeg popular for the twin spice it produces-nutmeg seed (kernel) and mace (aril covering the seed) - is an important spice found in the kitchens and bakeries across the world as well in the traditional pharmacopoeia (Wikipedia, 2024). Considered to be originated in the Moluccas (Spice Islands) in Indonesia, the tree is now an important small holder's plantation

crop in many countries (Wikipedia, 2024). Unlike in many other crop plants, the centres of domestication encompasses the centre of origin in nutmeg (Wikipedia, 2024). Including few secondary centres of domestication, the important nutmeg producing countries at present are Indonesia, India, Grenada, Sri Lanka, Malaysia, Mauritius, Zanzibar, Seychelles, Reunion Islands, Guatemala and Solomon Islands with Indonesia (34, 602 MT), India (15076 MT), Sri Lanka (5000 MT) and pre-hurricane Grenada (- 2000MT) leading in production (Wikipedia, 2024). The history of the transnational spread of nutmeg is beset with its own share of rivalry, clandestine voyages, sea piracy, biopiracy and cash transfers besides lack of cogency on the chronology (Americas) and mistaken identity of the target specimen (*Monodora myristica* Dun known as 'Tobago nutmeg' or 'Jamaica nutmeg' and Pichurim nut *Nectandra pichurim* (Kunth Mez) instead of true nutmeg) (Wikipedia, 2024).

The most important commercial species is the common, true or fragrant nutmeg, *M. fragrans* (Myristicaceae), native to the Moluccas (or Spice Islands) of Indonesia (Wikipedia, 2024a). It is also cultivated on Penang Island in Malaysia, in the Caribbean, especially in Grenada, and in Kerala, a state formerly known as Malabar in ancient writings as the hub of spice trading, in southern India (Wikipedia, 2024a). In the 17th-century work Hortus Botanicus Malabaricus, Hendrik van Rheede records that Indians learned the usage of nutmeg from the Indonesians through ancient trade routes (Wikipedia, 2024a). Nutmeg and mace are common spices that come from the same tree, Myristica fragrans. Nutmeg comes from the shelled, dried seed. Mace comes from the seed covering (Webmd, 2024). Nutmeg contains chemicals that might affect the central nervous system. Nutmeg might also kill bacteria and fungi (Webmd, 2024). People use nutmeg for cavities in children, diarrhea, and other conditions, but there is no good scientific evidence to support these uses (Webmd, 2024). Nutmeg is sometimes used recreationally in large doses to create a natural "high." Taking large doses may be unsafe and can lead to serious side effects (Webmd, 2024). *Myristica fragrans*, commonly known as the nutmeg tree, is an evergreen species indigenous to the Maluku Islands of Indonesia (Wikipedia, 2024b). This aromatic tree is economically significant as the primary source of two distinct spices: nutmeg, derived from its seed, and mace, obtained from the seed's aril (Wikipedia, 2024b). Valued for centuries in global spice trade, *M. fragrans* is now widely cultivated throughout tropical regions, including parts of Southeast Asia (Indonesia, Malaysia), South Asia (Kerala in India, Sri Lanka), East Asia (Guangdong, Taiwan, and Yunnan in China), the Caribbean (notably Grenada), and South America (Wikipedia, 2024b). Nutmeg is a major tree spice of Kerala. The wet tropical weather of the state is ideally suited to its growth (Joy, 2024). The tree is important for two spices derived from the fruit, nutmeg and mace. Both nutmeg and mace are currently among the most expensive spices, which are in high demand both domestically and internationally (Joy, 2024). Increasing the area and production of the crop will definitely serve as means of gaining the much valued foreign exchange earnings and also saving it by reducing imports (Joy, 2024). India today accounts for more than 11 per cent of the world output in nutmeg. Ninety six per cent of its total production comes from the state of Kerala (Joy, 2024). The area of nutmeg plantation in India in the year 2020-21 comes to 22512 hectares, which produces 14342 million tonnes with a yield of 637.08 per hectare (Joy, 2024). By exporting a quantity of 3280 million tonnes of nutmeg and mace, the country could bring in foreign exchange earnings worth US$ 24.82 million, in 2019 (Joy, 2024). They do not have to spend much on the tree. The changing lifestyles and food habits have also boosted the demand for nutmeg in the country (Joy, 2024).

Sangihe nutmeg (*Myristica fragrans* Houtt.) is one of the major sources of spices as it contains triterpene essential oils, aromatic compounds and various types of phenolic compounds that are potential medicines (Agustina *et al.,* 2024). Nutmeg has many uses ranging from culinary to medicinal, especially in food flavouring essential oil applications and traditional medicines (Agustina *et al.,* 2024). It can help lower blood pressure, soothe stomach aches and stop diarrhoea, as well as (at low doses) detoxify the body and stimulate the brain (Agustina *et al.,* 2024). Indonesia dominates the production and export of nutmeg globally. Considerably, nutmeg originated from Indonesia, especially from Maluku. Although it originated from Maluku, the largest production of nutmeg in Indonesia is on Sangihe Island presently. Sangihe Island is surrounded by oceans and is the oldest active subduction zone in the Indonesia–Philippines region where frequent tectonic earthquakes occur . This isolation causes geographic and reproductive isolation in Sangihe nutmeg (Agustina *et al.,* 2024). The variation in morphological and agronomic characteristics of nutmeg is high (Agustina *et al.,* 2024). Agronomic characters are morphological characteristics beneficial for pomologists, for example, fruit diameter index, seed diameter index, fruit weight, seed weight and mace weight. Additionally, the chemical composition of nutmeg might vary with environment, variety and geographical location (Agustina *et al.,* 2024). Diversity in plant genetic resources can provide an opportunity to develop improved and new cultivars of crops according to desired characteristics, such as farmer- (yield potential and large seeds) and breeder-preferred traits (resistance to pests and diseases and photosensitivity) (Agustina *et al.,* 2024).

Nutmeg is an evergreen tree belonging to the family Myristicaceae, a family of flowering plants indigenous to Asia, Africa, Pacific islands, and America (Bini Sundar *et al.,* 2024). It is a fragrant spice, globally cherished as a culinary ingredient (Bini Sundar *et al*., 2024). It originated in Indonesia's Moluccas, and it is propagated both sexually and asexually. However, grafting is preferred due to the uneven results in sexual reproduction (Bini Sundar *et al*., 2024). Nutmeg genetic diversity manifests through intricate character associations, unveiling relationships between agronomic traits like plant height, stem girth and fruit yield (Bini Sundar *et al.,* 2024). Genetic variation is the foundation for any breeding programme. It offers pre-breeding material to the breeder for selection (Bini Sundar *et al.,* 2024). In nutmeg, variability and inter-character associations for fruit weight, fruit number, seed weight, and mace weight have shown that selecting trees with an ideal fruit number and a reasonably excellent seed weight would be beneficial (Bini Sundar *et al.,* 2024). Identification of diverse parents to produce segregating offspring with the greatest genetic variability and the introgression of desirable genes from diverse germplasm into the existing genetic base are made possible by accurate assessment of genotypes for the proportion and patterns of genetic diversity and variability (Bini Sundar *et al*., 2024). Inheritance of most of the economic traits is complex in nutmeg and mainly involves fruit and tree characteristics. To understand the effect-cause relationships between yield and its constituent parts, it is useful to employ the path coefficient analysis (Bini

Sundar *et al*., 2024). Evaluation of existing variability in the nutmeg genotypes for important economic traits is necessary for successful crop improvement programmes (Bini Sundar *et al.,* 2024).

Most people identify nutmeg with the scent that fills the air in the winter. However, the nutmeg tree's natural habitat is very different from that of autumn in North America (Singh, 2024). It is a tropical evergreen that is indigenous to the South Pacific's warm Spice Islands (Singh, 2024). The tree is a striking feature in the environment with its dense, conical crown and glossy, scented, dark green leaves (Singh, 2024). Throughout the year, the tree occasionally displays flowers. They are little, barely noticeable, aromatic, pale yellow, and open at night (Singh, 2024). Nutmeg is also known as '*Myristica fragrans'* scientifically. It belongs to the Myristicaceae family (Singh, 2024). In India, people also call it 'Jaiphal'**.** This spice tree is commonly grown and can grow up to 10 meters tall and bears two spices. They are used in confectioners, food preparation, and the pharmaceutical markets (Singh, 2024). As we already know, nutmeg grows well in warm, humid tropical climates with well-distributed rainfall. Below are some of the Indian states where farmers are cultivating nutmeg (Singh, 2024). In India, Kerala (90% production), Tamil Nadu, Karnataka and Goa are the producing states (Singh, 2024). Until the 16th century, Europe's only source of nutmeg were the Arab traders, who attempted to protect their monopoly over the nutmeg trade by spinning tall tales about the spice's origin (Spence, 2024). In fact, nutmeg (and hence mace) is indigenous only to the tiny Banda Islands (also called the "Spice Islands"), an island group in the Maluku Islands—an Indonesian archipelago (Spence, 2024). The secrecy paid off for the Middle Eastern and Indian spice traders, who became very wealthy buying nutmeg from the Bandanese and selling it on to traders who would transport it from the shores of the Indian Ocean to the Mediterranean (Spence, 2024). Given that nutmeg, mace, and cloves all originated from the furthest reaches of the known world they were both more exotic and more valuable than other spices to Europeans than those spices that happened to be native to the Mediterranean or the Indian subcontinent (Spence, 2024). Along with cloves, nutmeg and its aril, mace, helped to put the Spice Islands (the Moluccas, part of the Indonesian archipelago) on the map of European sea powers (Spence, 2024). The Portuguese, and thereafter the Dutch, monopolized the trade in nutmeg until the 19th Century, when the tree was planted in the Caribbean and elsewhere (Spence, 2024). The Dutch built a fort on the largest of the Banda Islands. Over the first two decades of the seventeenth century, they exerted increasing control over the archipelago, pressuring the Bandanese into signing a treaty that enshrined a Dutch East Indies Company monopoly over the spice trade, and seizing one of two British-controlled nutmeg-producing islands (Spence, 2024). In 1621, the Dutch took control of the Spice Islands, massacring many of the native Bandanese population and enslaving those who were left on nutmeg plantations, alongside workers brought in from elsewhere in the Indonesian archipelago (Spence, 2024). This gave the Dutch a monopoly over nutmeg. To ensure that the trade remained profitable, the Dutch kept prices artificially high, on occasion deliberately burning warehouses of nutmeg in Amsterdam to reduce the amount of the spice that was in circulation in Europe (Spence, 2024). Dutch Indonesia subsequently fell under French control, before being invaded by the British, during the Napoleonic Wars of the early nineteenth century, when Holland became part of Napoleon's empire. A treaty returned the Spice Islands to the Dutch, but not before the British had transplanted seedlings of nutmeg trees to areas under their control, that included Singapore, Ceylon (Sri Lanka), Bencoolen (southwest Sumatra), and Penang (in Malaysia) (Spence, 2024). Subsequently, the spice then spread to Zanzibar, East Africa, and Grenada (Spence, 2024). The Dutch monopoly was broken for good. Ultimately, nutmeg was once a spice of geopolitical significance (Spence, 2024).

Nutmeg**,** tropical evergreen tree (family Myristicaceae) and the spice made of its seed (Britannica, 2025). The tree is native to the Moluccas, or Spice Islands, of Indonesia and is principally cultivated there and in the West Indies (Britannica, 2025). The spice nutmeg has a distinctive pungent fragrance and a warm slightly sweet taste; it is used to flavour many kinds of baked goods, confections, puddings, potatoes, meats, sausages, sauces, vegetables, and such beverages as eggnog (Britannica, 2025). The fleshy arils surrounding the nutmeg seed are the source of the spice mace (Britannica, 2025). Historically, grated nutmeg was used as a sachet, and the Romans used it as incense. Around 1600 it became important as an expensive commercial spice in the Western world and was the subject of Dutch plots to keep prices high and of English and French counterplots to obtain fertile seeds for transplantation. The nutmegs sold whole were dipped in lime to prevent their sprouting (Britannica, 2025). Nutmeg trees may reach a height of about 20 m. They yield fruit eight years after sowing, reach their prime in 25 years, and bear fruit for 60 years or longer (Britannica, 2025). The fruit is a pendulous drupe, similar in appearance to an apricot. When fully mature it splits in two, exposing a crimson-coloured aril, the mace, surrounding a single shiny brown seed, the nutmeg (Britannica, 2025). After collection the aril-enveloped nutmegs are conveyed to curing areas where the mace is removed, flattened out, and dried (Britannica, 2025). The nutmegs are dried gradually in the sun and turned twice daily over a period of six to eight weeks. During this time the nutmeg shrinks away from its hard seed coat until the kernels rattle in their shells when shaken. The shell is then broken with a wooden truncheon and the nutmegs are picked out. Dried nutmegs are grayish brown ovals with furrowed surfaces (Britannica, 2025). Nutmeg and mace contain 7 to 14 percent essential oil, the principal components of which are pinene, camphene, and dipentene (Britannica, 2025). Nutmeg on expression yields about 24 to 30 percent fixed oil called nutmeg butter, or oil of mace, the principal component of which is trimyristin. The oils are used as condiments and carminatives and to scent soaps and perfumes (Britannica, 2025). An ointment of nutmeg butter has been used as a counterirritant and in treatment of rheumatism. When consumed in large amounts, nutmeg has psychoactive effects and is reported to be a deliriant and hallucinogen. Nutmeg poisoning is rarely fatal but can cause convulsions, palpitations, and pain (Britannica, 2025).

ORIGIN AND DISTRBUTION

The plant is also grown in India, Sri Lanka, Malaysia, North-Eastern Australia, Taiwan and the Pacific, including the Solomon Islands, Fiji and Samoa as well as several islands in the Caribbean, with Grenada being the main producer in this region (Gordon, 2020). Nutmeg is a native of Moluccas Islands of Indonesia, East Indies or spice Islands. It is now grown in tropical countries of world, but cultivated on a large scale in the Malayan region. The British East India Company introduced this spice in India in 1800

AD. The countries producing nutmeg apart from Malaysia are Indonesia, Gsenada, Sri Lanka, India, Tanzania, Mauritius, Reunion, Trinidad and Tobago and China. The major importing country of nut meg and mace from India is Russia (KSSDB, 2021). Nutmeg tree is indigenous to Moluccas. The major nutmeg growing areas are Indonesia and Granada. It also grows on a smaller scale in Sri Lanka, India, China, Malaysia, Zanzibar, Mauritius and Solomon Island. Nutmeg thrives well in places with warm humid climate from sea level up to 600 mtrs MSL. It grows on a variety of soils from sandy to clayey loams and red laterite soils with good drainage. A well-distributed annual rainfall of 250 cm is ideal for the crop (Indianspices, 2024). The nutmegs, *Myristica*, are a genus of evergreen trees occurring in Africa, Asia, Pacific islands, and the Americas. New Guinea is considered as the centre of origin and distribution of *Myristica* genus (Wikipedia, 2024). Botanically known as *Myristica fragrans*, the nutmeg tree originates in Banda, the largest of the Molucca spice islands of Indonesia (Filippone, 2024).

TAXONOMY

It originated in the Moluccas Islands of Indonesia. The species occurring in India are *M. amygdalina* Wall., *M. andamanica* Hook, *M. attenuata* Wall., *M. dactyloides* Gaertn. (*M. laurifolia* Hook. f.), *M. beddomeii* King., *M. gibbosa* Hook., *M. glabra* Blume*, M.glaucescens* Hooker*., M. irya* Gaertn., *M. kingii* Hook., *M. longifolia* Wall. and *M. magnified* Bedd. Most of these are endemic to the Indo-Malayan region and the Western Ghat forests. The mace and seeds of *M. dactyloides* are used in tribal and indigenous medicine (Peter and Nlnnal Babu, 2006). *Myristica fragrans* was given a binomial name by the Dutch botanist Maartyn Houttuyn in 1774. It had earlier been described by Georg Eberhard Rumphius, among others. The specific epithet *fragrans* means "fragrant" (Wikipedia, 2024b). There are over 150 species of Myristica and are distributed in Asia and the western Pacific (Filippone, 2024).

BOTANICAL DESCRIPTION

Nutmeg is a dioecious or occasionally monoecious evergreen aromatic tree, usually 10-20 m in height with spreading branches which carry oblong-ovate leaves, acute at apex and base, 5-15 cm long and 2-7 cm wide, of feathery structure, dark green and lustrous. The shoot growth in nutmeg is cyclical, a period of growth followed by quiescence. Six flushes were observed in a year. All the flushes were not seen in all the shoots, which resulted in continuous growth. Two growth peaks were observed, in May-June and September. The inflorescence of *M. fragrans* is an axillary raceme. It is branched, in male plant and simple cyme in female plant. Flowers are drooping, creamy yellow and fragrant. Though nutmeg is usually dioecious, five different types of trees *viz*., pure male, pure female and bisexual male, bisexual female and hermaphrodite were identified. The flower is bracteate and bracteolate. The perianth is receiving ten vascular traces and has postulated a pentamerous origin. The androecium consists of a solid column or androphore to which is attached 14-22 bilocular anthers. The single pistil is more or less flask shaped with a short to non-existant style and bilobed stigma. The ovule is single. The fruit is pyriform and yellow in colour. The pericarp is fleshy when the fruit matures; it splits into two, exposing the scarlet-coloured net like aril covering the dark brown seed. In seed, there is a massive vascular supply to the testa, tegmen and aril. Endosperm is oily and starchy. Flowering pattern of male and female trees differ. In female trees, flowering continued to seven months, whereas in male trees, flowering was observed throughtout the year. Highest flowering in both the cases was in July followed by October. The female flowers took 154 days for complete development. Male flowers took only about half the period taken by the female flowers to develop. Anther dehiscence occurred about 24 hours prior to anthesis. The stigmatic receptivity lasted for six days after anthesis; the highest is during the first three days. The chief agent of pollination is wind. The percentage of set varied among the trees and for different aspects. Highest fruit set is in trees on western and eastern aspects. The fruits attained maturity in 206 to 237 days after fruit set. The developing fruits followed a sigmoid growth pattern (Thangaselvabai *et al.,* 2011).

The nutmeg is one of the more important spices that has found application in a wide range of culinary, food and beverage applications and also in the medicinal products industry. The plant is grown for two spices which are derived from the fruit: nutmeg which comes from the seed and mace which is the derived from the seed covering. The seed is also a source of nutmeg essential oil and nutmeg butter, both of which have found applications in the food industry as well as personal care and the medicinal products industry. What is generally known as nutmeg is the whole dried kernel of the seed or the powder derived from the ground dried kernel of “fragrant nutmeg”. While the whole fruit is known as “nutmeg”, the pericarp (the fruit covering) is used mainly in the countries where the fruit is grown for culinary purposes, while the kernels (“the nutmeg”) and the mace are mainly processed and packed for export. Once the fruit is mature, the fruit is harvested, the pericarp removed and the mace which covers the seed is also removed. The seed is then dried, shrinking the nutmeg kernel within the seed until they rattle when shaken. The shell is then cracked to harvest the kernel, this being done a variety of ways, including in the traditional way in Indonesia with a club. The nutmeg kernel and the mace can then be packaged for retail sale packaged in bulk or distributed for local use. Both nutmeg and mace have distinctive fragrances and unique flavors, making them the spice of choice in traditional recipes in their home countries and regions, as well as in cuisines around the world. Nutmeg trees are tall spreading diecious evergreen trees which were endemic to the islands of the Moluccas and New Guinea in Indonesia and grew traditionally in the rainforest regions (Gordon, 2020).

Nutmeg is a handsome, spreading evergreen tree with dense foliageTrees are 10-20 m. high sometimes reaches a height of 20 m or more, branches are spreading with dark gray bark; Nutmeg trees are dioecious in nature (male and female flowers occur in different trees). Monoecious condition is also reported to occur in aged trees at Burliar, in which case double and triple nuts are produced and the yield from such trees is low. The quality of the spice is also poor. The female and male trees can easily be identified by a trained eye in that male trees have erect branches and the leaves are generally smaller in size and conspicuously less leafy than female trees. The shape of the tree also is not regular. The calcium oxalate content of the leaves is also taken as a criteria for identification of sex in nutmeg (KSSDB, 2021).

Myristica fragrans is an evergreen tree, grown up to 20–25 ft high with greyish brown soft bark and spreading branches. The plant is grown well in warm, humid climate, with an elevation of 1,000 m above sea level with 150–250 cm rainfall. The leaves are aromatic, dark green, glossy above, alternate, oblong, glabrous, and acuminate. Flowers are usually dioecious, occasionally monoecious with variable sex expression, small axillary, sub-umbellate racemes, compound, or sometimes forked. The pedicels and peduncles have a glabrous appearance. The fruit has a fleshy pericarp and is spherical; the fruit skin is yellowish and splits into two longitudinal valves. The mace (aril) is a fleshy scarlet aril that is laciniate, folded, and envelops the nut when wet; when dry, it is considerably hornier, yellowish-brown in color, and highly brittle. The nut is oval or broadly ovate, with a hard, rough, dark-brown, glossy shell that is pale and smooth on the inside and is approximately half a line thick. When young, the seed/kernel is oval, pale brown, and soft, but it quickly shrivels and has irregular, vertical lines or furrows on its surface and rich in oil. The tree bears fruit all year, but the best time to harvest is between April and November (Ashokkumar *et al*., 2022). *Myristica fragrans* is an evergreen tree, usually 5–15 m tall, but occasionally reaching 20 m or even 30 m on Tidore. The alternately arranged leaves are dark green, 5–15 cm long by 2–7 cm wide with petioles about 1 cm long. The species is dioecious, *i.e*. "male" or staminate flowers and "female" or carpellate flowers are borne on different plants, although occasional individuals produce both kinds of flower. The flowers are bell-shaped, pale yellow and somewhat waxy and fleshy. Staminate flowers are arranged in groups of one to ten, each 5–7 mm long; carpellate flowers are in smaller groups, one to three, and somewhat longer, up to 10 mm long. Carpellate trees produce smooth yellow ovoid or pear-shaped fruits, 6–9 cm long with a diameter of 3.5–5 cm. The fruit has a fleshy husk. When ripe the husk splits into two halves along a ridge running the length of the fruit. Inside is a purple-brown shiny seed, 2–3 cm long by about 2 cm across, with a red or crimson covering (an aril). The seed is the source of nutmeg; the aril the source of mace (Wikipedia, 2024b).

Botanically, nutmeg is an evergreen tree with 10-12 metres height. Its branches spread with shiny leaves which are oblong to oval in shape and have dark grey bark. The flowers appear in cymes, and each cyme has several branches on which a number of flowers bloom that hang down. These flowers are small, pale yellow, bell shaped and is slightly aromatic. The fruits are fleshy, globose in shape, and are light brown in colour. Inside the fruit is the single glossy brown seed with a brittle shell over which is the beautiful, brilliant, scarlet and net like membrane aril known as mace, which is fragile and aromatic. Nutmeg trees are dioecious in nature, that is, male and female flowers occur in different trees. It is noticed that in female trees, in certain years, five per cent male flowers are also seen. Similarly, on a male tree, about five per cent of female flowers are observed occasionally. The exact reason for the different expression of sex is not known, and it may be perhaps due to the climatic variation and shade effects. The gender of the trees can easily be identified by an expert farmer, as the male trees have erect branches and the leaves are generally smaller in size. They are also conspicuously less leafy than the female trees. The shape of the tree is irregular. The bark is greyish black and slightly fissured longitudinally in the older trees; the twigs are glabrous, slender and greyish brown. The nutmeg, mace, their oleoresins and essential oils are used in food and beverage industries examined. The powder form of the spice is used in the food processing industry, its oleoresins are used in the preparation of confectioneries to flavour milk dishes and punches. Mace is an inevitable item in many of the savoury dishes either as a whole or in ground form and also used to flavour milkbased sauces and processed meats like sausages. It is also observed that the use of essential oils in aromatherapy is gaining importance (Joy, 2024).

Nutmeg & Mace are two distinctly different spices produced from a fruit of an evergreen tree usually 9-12 m high. Mace is the dried reticulated 'aril' of the fruit and nutmeg is the dried seed kernel of the fruit. The trees are normally unisexual, bearing either male or female flowers. The male flowers are born in clusters, whereas female flowers are often solitary. Fruit is a fleshy drupe, spherical in shape, pale yellow in colour with a longitudinal groove in the centre. When the fruit mature it burst open along the groove exposing the bright attractive mace, covering the hard black, shiny shell of the seed called nutmeg (Indianspices, 2024). Nutmeg, is a tropical evergreen tree in the family Myristicaceae grown for its seeds which are used as spices. The nutmeg tree has natural conical shape with a grey-brown trunk and dark green glossy leaves. The branches of the tree spread in whorls and the leaves are oval or lanceolate in shape. Leaves are arranged alternately on the branches and are 5–15 cm in length, smooth and lighter in color on the underside. The tree produces a clusters of numerous male flowers whereas the female flowers are produced solitary or in a maximum cluster of 3. The flowers are pale yellow and fragrant. The fruit of the nutmeg tree is a rounded fleshy berry which splits into two halves when it ripens. The seed inside is shiny dark brown and oval in shape. The seed coat is covered by lacy red aril which is attached at the base of the seed. Nutmeg trees can reach a height of 20 m and may live for upwards of 80 years. Nutmeg may also be referred to as mace and it is not known in a wild state. It likely originated from the Moluccan Islands, particularly the volcanic island of Banda (Plantvillage, 2024).

Botanical description is given in Fig. 1.

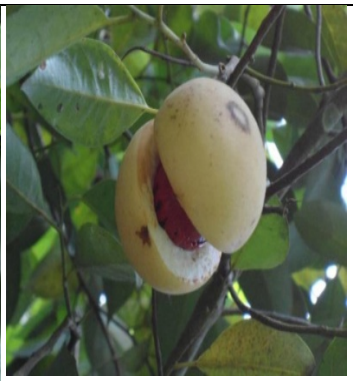
Seedlings

Nutmeg tree

Fallon fruits

Continue ….





Nutmeg flowers	Nutmeg fruits	Nutmeg fruit showing the pericarp and the Mace.

Fig. 1. Botanical decription

Pollination: Nutmeg tree produces two separate spices, namely, nutmeg (kernel of the seed) and mace (aril covering the seed) (Peter and Nirmal Babu, 2006). The issue of pollination and fruit set in the nutmeg is still not fully clarified. Many local farmers believe that male trees should be in the fields as a source of pollen, while others are of the opinion that these are not obligatory. It has also been suggested locally by many that the local wasp "mibone" plays a role in pollination. The flowers are known to be fragrant and to produce nectar (FAO, 2024).

GENETICS AND CYTOGENETICS

The plant has been reported to have four chromosome numbers such as $2n = 38$, $2n = 41$, $2n = 42$, and $2n = 44$. However, chromosome number $2n = 44$ is predominant at the nutmeg seedling stage (Ashokkumar *et al*., 2022).

GENETIC DIVERSITY

A high amount of variability has been reported in growth rate, productivity, size and shape of the leaf, flower size and shape and size of the fruit and seed. Variability and inter character association for fruit number, fruit weight, seed plus mace weight, seed weight and mace weight were also studied indicated high variances for fruit number per tree which had a significant negative correlation with mace weight; seed weight also had a very high positive significant association with mace weight. Selection will be effective in nutmeg if trees are selected with optimum fruit number and moderately good seed weight (Thangaselvabai *et al.,* 2011). Random Amplified Polymorphic DNA (RAPD) analysis was performed to assess the genetic diversity among the 19 superior accessions of nutmeg collected from different geographic locations and maintained in the germplasm collections of Regional Agricultural Research Station, Kumarakom, Kerala. This included one released variety IISR Viswasree. Out of 28 RAPD primers tested, 20 were amplified. Out of the 109 loci amplified, 82 were polymorphic with an average polymorphism rate of 72.74 per cent. The number of bands for each primer ranged from 2 to 8. The markers which produced maximum number of polymorphic bands were BB-18 and PO-5. PIC value of the markers ranging from 0.09 (OPA 11) to 0.48 (W-15) with an average of 0.31. The marker index (MI) varied between 0.09 and 2.08 with an average of 1.25. Jaccard's similarity co-efficient of the genotypes ranged between 0.34-0.93. Dendrogram constructed based on UPGMA analysis grouped the 19 selected genotypes into two major clusters. The knowledge on genetic diversity of nutmeg can be used for further breeding programmes for getting higher nut and mace yield (Krishnan *et al*.., 2017).

Nutmeg, a predominantly dioecious tree, has a domestication history of less than 300 years in India by all probability. But the degree of varietal/cultivar diversity observed in a perennial crop like nutmeg, propagated mainly vegetatively, within in a span of about 300 years of domestication is very amazing. Selection, either germplasm or true seedling progeny selection, has lead to a host of varieties (Wikipedia, 2024). Variants like yellow mace nutmeg and seed sterile mutant are also located and propagated from the primary genepool of the crop. Recently, evolution of nutmeg towards monoecy (leaky dioecy) is also reported. Morphological diversity of nutmeg mother trees and true seedling progenies is recorded from Indonesia too (Wikipedia, 2024). A panel of 25 nutmeg genotypes were evaluated at the Horticulture Research Station, Pechiparai, Kanyakumari district from 2019 to 2022 for the pattern of genetic divergence and relationship among them based on seven morphological traits by cluster and path analysis. Notable difference was observed for yield characteristics of genotypes, in which the genotype MF-4 was observed to record high plant height, stem girth, leaf length and fruit production. Genetic variability analysis revealed that traits such as stem girth, number of fruits and mace yield/tree were found to possess high genotypic coefficient of variation along with high heritability and genetic advance as percent of mean which implied that these traits had higher variability among the studied genotypes. The 25 genotypes were grouped in to four clusters based on cluster analysis. Path analysis revealed that traits such as number of fruits, single fruit weight and plant height had a favourable direct impact on the mace yield. These traits might be used as selection indicators in future breeding programmes (Bini Sundar *et al.,* 2024). A panel of 25 nutmeg genotypes were evaluated at the Horticulture Research Station, Pechiparai, Kanyakumari district from 2019 to 2022 for the pattern of genetic divergence and relationship among them based on seven morphological traits by cluster and path analysis. Notable difference was

observed for yield characteristics of genotypes, in which the genotype MF-4 was observed to record high plant height, stem girth, leaf length and fruit production. Genetic variability analysis revealed that traits such as stem girth, number of fruits and mace yield/tree were found to possess high genotypic coefficient of variation along with high heritability and genetic advance as percent

Seed sterile nutmeg

Yellow mace nutmeg

Fig. 2. Variability in nutmeg

of mean which implied that these traits had higher variability among the studied genotypes. The 25 genotypes were grouped in to four clusters based on cluster analysis. Path analysis revealed that traits such as number of fruits, single fruit weight and plant height had a favourable direct impact on the mace yield. These traits might be used as selection indicators in future breeding programmes (Bini Sundar *et al.,* 2024).

Fig. 2 gives the genetic diversity of nutmeg.

BREEDING

Genetic Resources

The IISR,· Calicut, maintains 484 accessions of *M. fragrans* and related species. The genetic base of nutmeg germplasm in India is rather narrow as these are derived from a very few trees, originally introduced to India. But being a sexually propagated dioecious plant, some variability exists in these populations, especially for characters such as fruit size and shape, mace, seed volume and chemical composition. They also show quantitative variations for major quality components (Peter and Nlnnal Babu, 2006). The genus Myristica consists of about 300 species of which fifteen have been described from India. They are *M. fragrans, M. malabarica, M. magnifica, M. beddomei, M. contorta, M. longifolia, M amygdalina, M. andamanica, M. attenuata M. gibbosa M. glabra M. glaucescens M. irya, M. kingie* and *M. prainii.* Germplasm of nutmeg is being conserved at the Indian Institute of

Spices Research, and the present holding is about 482 accessions. The Horticultural Research Station Pechiparai, TNAU and KKVP, Dapoli have a collection of 22 and 87 accessions respectively (Thangaselvabai *et al.,* 2011).

Crop improvement: Crop improvement is very difficult in nutmeg and it is mainly because of the dioecy, long juvenile period, the difficulty in propagation and the single ovule in the female flower. The breeding objective is to develop early and heavy bearing hermaphrodite types with high content of volatile oil. At present the crop improvement programme is limited to selection of mother plants based on their regular and heavy bearing nature. Selection of elite types involving biotechnological options and clonal multiplication of selected mother trees through epicotyl grafting/in vitro propagation techniques, avoiding a juvenile phase may result in a breakthrough in productivity (Thangaselvabai *et a*l., 2011).

Varieties

Two high yielding varieties namely Konkan Sugandha and IISR Viswasree were released for cultivation (Peter and Nlnnal Babu, 2006). Three cultivars were developed at Konkan Krishi Vidyapeeth (BSSKV). They are, Konkan Sugandha, Konkan Swad and Konkan Shrimathi. Konkan Sugandha is the only hermaphrodite variety released. It yields 2.63 kg dry seeds (526 seeds) per tree at the age of 15 years. The seed size is 5 g. and the average mace weight is 1.2g. Konkan Swad is a selection from the seedling population raised from the Ratnagiri collections. Average yield is 761fruits/tree. Konkan Shrimathi yields 9kg nutmeg and 2kg mace/plant. The nut size is 14.0g and mace thickness is 2.10g (Thangaselvabai *et al*., 2011).

IISRVishwasree is a high yielding nutmeg selection from IISR, Kozhikode. It yields about 3122 kg nuts/ha (dry) and 480 kg mace (dry)/ha. This variety possesses 7.1 per cent oil in seed and mace, 13.0 per cent oleoresin in mace and 2.5 per cent oleoresin in seed. Butter content in seed is 30.9 per cent (Thangaselvabai *et al*., 2011).

The fruits of East Indian nutmeg are ovoid, approximately 2.25 to 2.75 cm long, 1.75 to 2.25 cm in diameter, and longitudinally wrinkled. The colour is greyish brown, with furrows network of dark brown-veins, in which the volatile oil is found. 'Konkan Sugandha' is an improved variety of nutmeg released from Konkan Krishi Vidya Peeth, Depoli in Maharastra (ICAR, 2013).
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Another high yielding nutmeg line 'A 9/4', a clonal selection has been released as IISR Vishwashree with an average yield of 1000 fruits/tree at eighth year @ 360 per hectare with an average yield of 3122 kg dry nut and 480 kg mace per hectare. This line possesses 7.3 per cent oil in nut and mace, 13 per cent oleoresin in mace and 2.5 per cent oleoresin in nut. This variety also contains 30.9 per cent butter in nut (ICAR, 2013).

Pedigree: Seedling selection from the seedlings raised from an elite mother tree from Burliar, Nilgiris, Tamil Nadu
Areas of Adoption: All nutmeg growing areas of Kerala

Crop Duration: 6 years for first harvest
Yield: 480 kg mace/ha at 8" year 3122 kg nuts/ha
Potential yield: 4800 kg mace/ha at 25" year 31220 kg nuts/ha
Colour of ripe fruit: Yellow
Colour of aril: Dark red
Colour of seed: Brownish black
Shape of fruit: Elongate/oblong
Size of nut: Bold
Mace: Entire, thick and dark red
Fresh weight of fruit: 75-100 g
Fresh weight of seed:13-16 g
Mean yield/graft at 10th year after planting: 2000 fruits
Dry nut yield/graft at 10th year after planting: 21 kg
Nut yield /ha @ 360 graft: 7560 kg
Mace yield/graft at 10th year after planting: 4.2 kg
Mace yield /ha@360 grafts: 1512 kg (ICAR, 2013).

'Punnathanam Jathy' is an extra-large nutmeg variety developed in 1994 through selection from a local variety and further multiplied by budding. The variety gives nutmegs of extra-large size (4.5 cm long & 3 cm wide). A full bearing Punnathanam Jathy tree gives an average of 3000 fruits/tree/year and the weight of 50 dry fruits is 1kg & weight of 250 dry maces is 1 kg. It has upright growing habit. The variety has already been diffused to Idukki, Ernakulum, Kottayam and Trivandram districts of Kerala with over 500 saplings being sold. Varkey has a small nursery of Punnathanam Jathy started about three years ago. The saplings developed from the kernels include both male and female ones. It is his special skill which enables him to select the female samplings, which he sells, by visual selection (Thomman, 2015). Mathew collected nutmeg buds of different local unknown varieties from the Angamaly forest area. In 2003, he noticed the peculiarity of one plant with fruits in bunches, a higher number of fruits per tree and intense aroma in mace. Later he propagated it through budding and grafting and replaced the old plantation. In budding, he got good results and homogeneity of the desired characters. Now he owns 175 fifteen – seventeen years old trees of the variety at his farm. The trees bear fruits in bunches of three per stalk with higher yield (in a 17-years old plant, dry nut 35kg, dry mace 10kg). The high-quality mace contains superior essential oil per cent (24-25%) and medicinal properties. The variety was found to be superior in terms of higher mace oil content (24.3%), non-volatile extract (33.1%), Beta-pinene (12.69%) and

myristicin (25.95%) as compared to the check varieties. The variety is being cultivated in 2.5 acres in Idukki district where over 350 grafted plants have been transplanted (Mathew, 2019). The variety cultivated is mainly the 'Banda' nutmeg, *Myristica fragrans* Houtt., although in Indonesia, there is some cultivation of other varieties, including the 'Papuan' nutmeg *Myristica argentea* Warb. In Grenada, the second largest producer, the 'Banda' variety is the one that has almost exclusively been grown there for many years although in recent years, some Malayan plants have been imported and introduced to improve yields and shorten time to harvest (Gordon, 2020). Indian Institute of Spices Research (IISR) has released a high yielding variety IISR 'Viswashree' which yields about 1000 fruits at the eight year of planting. An average yield of approximately 3122 kg dry nut (with shell) and 480 kg dry mace per hectare could be obtained with a population of 360 plants/ha. The dry recovery of nut and mace of IISR Viswashree is 70 and 35%, respectively. The nut has 7.1% essential oil, 9.8% oleoresin and 30.9% butter, while the mace has 7.1% essential oil and 13.8% oleoresin (Vikaspedia, 2020).

IISR Vishwashree, Konkan Sugandha, Konkan Swad, and Konkan Shrimanthi; farmer participatory variety IISR Keralashree and about a dozen of farmer's varieties such as *Kadukanmackel, Nova, Kallingal, Punnanthanam, Kochukudi, Kinattukara, Kallivayal,* Ceylon, Ceylon-1, *Naveswari*, *Pullan*, *Souwriyamakkal, Nirappel* (Wikipedia, 2024).

Uses

Nutmeg (*M. fragrans*) is traditionally used in the preparation of sweets. The seed part of nutmeg fruit has many applications, particularly in the culinary, pharmaceutical, and cosmetic industries. The characteristic pleasant fragrance and slightly warm taste of nutmeg is used to flavor many kinds of baked goods, confections, puddings, meats, sausages, saucers, vegetables, beverages; and as component of curry powder, teas, and soft drinks; or is added to milk and alcohol. Many countries use nutmeg as a spice. In India and in the Middle East, nutmeg is used in sweet dishes. Europeans use it in most dishes to flavor potatoes, eggs, meats, and even spinach, along soups and sauces. Nutmeg is used as a drug of traditional medicine by Arabs of Israel and Jewish communities, especially Yemennities; there, it is also used as spice and as an important ingredient in "love potions." It is used to manage vomiting and to control the movements of the bowels; to treat tuberculosis, colds, and fever; and in general for respiratory problems. It is reported to have antihelminthic effects and is also used to alleviate skin diseases such as eczema and scabies. In the Unani system of medicine, it is used as alternative medicine in the management of male sexual disorders (Periasamy *et al.,* 2016). Moreover, nutmeg is traditionally used for inflammatory conditions and to treat joint and muscle pain, as well as liver disease. Nutmeg oil is helpful to dissolve kidney stones and alleviate infections of the kidney, as well as for the treatment of diarrhea, rheumatism, and cholera. In addition, it is reported that nutmeg and nutmeg oil have been used for illnesses related to the nervous and digestive systems, such as psychosis, stomach cramps, nausea, vomiting, flatulence, and anxiety, in addition to its use as an aphrodisiac and abortifacient. Nutmeg is used in both Western and Chinese herbal medicine, as a muscle relaxant, to eliminate gas from the digestive system, to sedate the body, to alleviate digestion problems, and to reduce abdominal pain. In Indochina, powdered seeds in boiled rice are used as a remedy against dysentery, anorexia, colic, and treat malarial debility. In Indonesia, the mace part of nutmeg is reported to have been used for reducing pain and to treat rheumatism (Periasamy *et al.,* 2016). As with most spices, nutmeg should be stored in a cool, dry place away from light. A whole nutmeg can keep for years or even decades, but should be used immediately once it is ground. Pre-ground nutmeg will stay flavorful up to nine months when stored properly. A classic microplane grater is one of the best ways to grind nutmeg at home, and this tool can also be used to grate cinnamon sticks, citrus zest, and hard cheeses. When grating your own fresh nutmeg, use half of the recommended amount called for in a recipe. In the United States, nutmeg is commonly used for sweet pastries and cocktails (Rampe, 2019).

The fruit covering (pericarp) is used to make jams and jellies in countries in the Far East and in the Caribbean where the fruit is grown. In Indonesia, it is sliced and made into sweets known as *manisan* (a fragrant fruit candy) or desert known as *maisan pala* while in Penang, Malaysia a similarly sliced, dried and sugar-coated product is used as a topping on Penand *ais kacang*. The fresh pericarp (rind) is also made into juices in Indonesia, Malaysia, the Caribbean, and India, among other countries, being used directly as harvested or boiled, with sugar added, depending on the type of beverage that is being made. It is also used for chutney and pickles in India (Gordon, 2020). Ground mutmeg's distinctive flavor, taste and olfactory stimulation makes it ideal to flavor a wide range of products. These include confectionary, meats and meat products, including sausages, sauces, spice blends, beverages, including egg nog, cakes and other baked goods, among other foods. While having similar sensory properties to ground nutmeg, mace has a more delicate flavor and is often used for the unique coloring that is provides to dishes. In European cuisine, mace is used in rice pudding and, along with nutmeg, in meat and potato dishes and meat products, baked items, soups and sauces. The Italians use nutmeg in tortellini, meat-filled dumplings, meatloaf and pumpkin pie while the Dutch add it to vegetables, mulled wine and, of course, egg nog. The traditional Scottish meat dish, haggis, benefits from the use of both nutmeg and mace while Caribbean people incorporate grated nutmeg into egg nog, cakes and baked goods and a range of alcoholic beverages, particularly those made with rum. In the East, Indians use nutmeg in meat preparations and other savory dishes, desserts, in *garam masala* in Kerala, Mughlai and other regional cuisines while soups such as *soto*, *oxtail soup*, *basko* and *sup kambing* and the meat dishes *bistik lidah*, *bistik* and *rolade* are among the dishes made with nutmeg in Indonesian cuisine (Gordon, 2020).

In the United States, nutmeg is popularly used as a baking spice in cooler months. It's used heavily in fall desserts, in pumpkin spice blends, and it's what gives eggnog its distinct flavor. Nutmeg is more widely used in Black diaspora cooking because of its history in African and Caribbean cuisine. Beyond the United States and its use in desserts, nutmeg is used in savory cooking as well. It is an essential part of spice blends like garam masala and quatre épices. Nutmeg is subtly layered into the mother sauce, bechamel, and can also be found in Jamaican jerk seasoning spice. On the island of Penang in Malaysia, the astringent fruit is sweetened and used in juice. "Nutmeg goes beyond the holiday season for me," says Samantha Fore, chef and owner of Tuk Tuk Sri Lankan Bites in Lexington, Kentucky. "I know it's super common in pies and eggnog and whatnot, but I like to use its warmth

in jaggery custards or even with savory dishes. I'll use a touch for a butternut squash soup or a pumpkin curry, but I think a little used as a finisher — finely grated over hearty meat dishes and sauces — adds a whole new dimension to what you are cooking." Nutmeg is not just used as a culinary spice. In Ayurvedic and Iranian medicinal practices, it is administered as an astringent, digestive aid, and to help with insomnia. *Monodora myristica* is also known as Ehuru, Calabash, or African nutmeg and was once considered to be a substitute for Indonesian nutmeg. During the trade of enslaved people, this variation was introduced to the Caribbean and is sometimes known as Jamaican nutmeg. Instead of an apricot-shaped fruit, the Calabash plant is shaped like an upside-down orchid and because of its beauty is often used as an ornamental plant. Try this Ehuru and Wildflower Honey Butter recipe if you are seeking to try Calabash nutmeg at home. Both variations of nutmeg are best used and most fragrant when freshly grated on a Microplane from the seed. Ground nutmeg can be used as well but it does not pack the flavor punch that freshly grated nutmeg does. Try grating it on top of whipped cream, brew it into your morning coffee, or add it to a batch of Rice Krispie treats (Rampe, 2022).

Mace is the aril that webs around the Indonesian nutmeg seed. The flavor profile is more delicate and floral than the nutmeg. The dried leaves can be added to stews, curries, and soups. Ford recommends adding the dried arils to a dish early in the cooking process, and then adding ground mace later "to keep it sweet and fragrant" (Rampe, 2022).

Both nutmeg and mace are used as condiment particularly in sweet foods. The spice in the ground form is mainly used in the food processing industry especially as a standard seasoning in many Dutch dishes. Nutmeg oleoresin is used in the preparation of meat products, soups, sauces, baked foods, confectionaries, puddings, seasoning of meat and vegetable etc. The fleshy outer cover of the fruit is crystallized or pickled or made into jellies. Mace is used in savoury dishes. It is used as a drug in Eastern countries because of its stimulant, carminative, astringent and aphrodisiac properties. Excessive doses have a narcotic effect. Nutmeg oil is used in cosmetics and toiletries (Indianspices, 2024). Nutmeg and mace have similar sensory qualities, with nutmeg having a slightly sweeter and mace a more delicate flavour. Mace is often preferred in light dishes for the bright orange, saffron-like hue it imparts. Nutmeg is used for flavouring many dishes. Whole nutmeg can also be ground at home using a grater specifically designed for nutmeg or a multi-purpose grating tool. In Indonesian cuisine, nutmeg is used in dishes such as spicy soups including variants of *soto*, *konro*, oxtail soup, *sup iga* (ribs soup), *bakso*, and *sup kambing*. It is also used in gravy for meat dishes, such as *semur*, beef stew, ribs with tomato, and European derived dishes such as *bistik* (beef steak), *rolade* (minced meat roll), and *bistik lidah* (beef tongue steak). In Indian cuisine, nutmeg is used in many sweet, as well as savoury, dishes. In Kerala Malabar region, grated nutmeg is used in meat preparations and also sparingly added to desserts for the flavour. It may also be used in small quantities in *garam masala*. In traditional European cuisine, nutmeg and mace are used especially in potato and spinach dishes and in processed meat products; they are also used in soups, sauces, and baked goods. It is also commonly used in rice pudding. In Dutch cuisine, nutmeg is added to vegetables such as Brussels sprouts, cauliflower, and string beans. Nutmeg is a traditional ingredient in mulled cider, mulled wine, junket and eggnog. In Scotland, mace and nutmeg are usually both ingredients in haggis. In Italian cuisine, nutmeg is used as part of the stuffing for many regional meat-filled dumplings like tortellini, as well as for the traditional meatloaf. Nutmeg is a common spice for pumpkin pie and in recipes for other winter squashes, such as baked acorn squash. In the Caribbean, nutmeg is often used in drinks, such as the Bushwacker, Painkiller, and Barbados rum punch. Typically, it is a sprinkle on top of the drink (Wikipedia, 2024a).

Nutmeg is one of two spices that come from the *Myristica fragrans* tree. Nutmeg is the tree's seed and has a warm, nutty flavor. Mace is the dried membrane surrounding the nutmeg seed and has a less intense, sweeter, more peppery flavor. Nutmeg is a spice that comes from a tropical evergreen tree native to Indonesia. It's been used as a spice since the Middle Ages and is a key ingredient in popular recipes like pumpkin pie, eggnog, and beef stew. In addition to its culinary uses, nutmeg has medicinal properties. It has been used as a complementary treatment for digestive and respiratory conditions. Nutmeg has been a culinary spice for hundreds of years and is an important ingredient in several cuisines. For example, nutmeg is a component of jerk seasoning and the North African spice blend "ras el hanout." It's also used in sweet and savory dishes and sauces such as béchamel, one of French cuisine's mother sauces. You can find nutmeg in curries, stews, meat dishes, and baked goods like pumpkin pie. It's also popular in cocktails, ciders, and sweetened coffee beverages. Nutmeg comes in ground form and as whole seeds. Freshly ground or grated nutmeg has a much more intense flavor than pre-ground nutmeg, as whole nutmeg seeds retain their flavor better than ground nutmeg. Pre-ground nutmeg is more convenient for baking or recipes requiring large amounts of spice, while freshly ground or grated nutmeg is commonly used to add a kick of flavor to cocktails and finished dishes (Jillian Kubalav, 2024). *Myristica fragrans* can be used as an accent tree. Ground nutmeg and mace are used in cooking. Seeds from the plant are used to make essential oils while other parts such as arils, bark, flowers and leaves are used for fragrance in soaps and perfumes (Wikipedia, 2024b). The seed of the nutmeg berry (nutmeg) and the aril (mace) are dried and used whole or ground as culinary spices (Plantvillage, 2024).

Nutrition Value

Studies in recent research report showed that Western Ghats of South India grown nutmeg leaf oil (3.2% v/w) was found to have sabinene (17.2%), eugenol (16.6%), myristicin (9.1%), caryophyllene (8.8%), α-pinene (5.4%), β-pinene (6.4%), limonene (5.0%), β-myrcene (4.7%), copaene (3.2%), germacrene D (3.0%), and 3-Carene (2.7%), while mace oil (8.1% v/w) had sabinene (38.4%), α-pinene (8.2%), β-pinene (7.6%), limonene (7.1%), myristicin (5.9%), 3-carene (5.1%), 4-carene (4.2%), safrole (3.9%), β-phellandrene (3.6%), and terpinen-4-ol (3.0%) as the major constituents. Furthermore, the Western Ghats (South India) grown nutmeg kernel (without rind/shell) are predominantly comprised of sabinene, α-pinene, β-pinene, limonene, and β-myrcene . However, these predominant chemical components were greater than those found in Pakistan grown nutmeg kernel oil. The higher concentration of oil components could be due to changes in soil type, location, season, and cultivars. However, mace oil was rich

in γ-terpinene, safrole, terpinen-4-ol, α-pinene, sabinene, and myristicin. Interestingly, the other nutmeg seed essential oil from Andaman & Nicobar Islands, India, extracted by hydrodistillation method, contained higher myristicin, sabinene, α-thujene, α-pinene, 4-terpineol, limonene, γ-terpinene, and elemicin. In a recent study, the Western Ghats (South India) grown nutmeg seed (with rind/shell) oil was predominantly composed of sabinene (27.7%) and it was found to have a two-fold lower concentration of sabinene (52.8%) in Grenada grown nutmeg seed EO (Ashokkumar *et al.,* 2022). The chemical constituents of various parts of MFEO are affected by several factors. However, different therapeutic applications such as antioxidant, antimicrobial, anticancer, and other miscellaneous activities are reported for MFEO and its active constituents in various literature. Potential biological and pharmacological activities of *M. fragrans* essential oil are Antioxidant activities, Antimicrobial activity, Antiinflammatory and analgesic activity, Insecticidal and nematicide activities and Miscellaneous activities (Ashokkumar *et al.,* 2022).

Health Benefits

Nutmeg has been reported to be an effective antifungal agent and also to have cytotoxic properties against specific cell lines of cancer cells, with the essential oil extract and myristicin being involved in mediating these effects. Nutmeg has also been shown to be effective in reducing the populations of some types of pathogenic *E. coli*. These include enterohaemorrhagic *E. coli O157* and enteroptahogenic *E. coli O111*, with β-pinene identified as a major active ingredient. Nutmeg was however found not to be effective against other *E. coli*, notably enteroinvasive *E. coli O29* and *O124* and enterotoxigenic *E. coli O6* and *O148*. Nutmegs have also been found to have analgesic properties. Despite these potentially beneficial properties, there have been various studies that have reported toxicity associated with nutmeg consumption. Nutmeg has been associated with various toxic (tachycardia, nausea, vomiting and agitation) and psychoactive effects if abused. The latter include hallucinations, delusions and feelings of euphoria typically associated with the use of some narcotic drugs, with myristicin, a major component of nutmeg being identified as the major active ingredient. The effects have been found to vary, depending on the quantum of the myristicin consumed in the seed, powder or extracted oil. It has been reported that overconsumption of nutmegs has resulted in at least two fatalities, although one of these included the consumption of a toxic dose of flunitrazepam, making it difficult to attribute the fatality to nutmeg consumption. Consequently, the association between nutmeg consumption and potential fatality is inconclusive, even when taken as part of a cocktail of psychoactive agents and narcotic drugs. This observation is supported by studies, some involving extensive case reviews that have shown that even at elevated levels of consumption, life-threatening situations have not been observed (Gordon, 2020).

Nutmeg is a rich source of various nutrients that our body needs, such as iron, zinc, phosphorous, copper, manganese, vitamin C, vitamin E, vitamin A, and magnesium. This spice has various health benefits. Works as a stimulant for the brain and reduces stress levels. Good for your heart health. Aids in managing kidney problems. Good for the digestion system. It has anticancer properties. It can relieve abdomen, joint, and muscular pain. Treats insomnia (Singh, 2024). The nutmeg seed and its essential oil have long been used medicinally as well as a recreational drug, given the seed's putatively hallucinogenic properties. The essential oil of nutmeg, meanwhile, is also used in the cosmetics industry (Spence, 2024). Although there aren't many studies on how nutmeg affects human health, it's known to contain compounds that support overall well-being. These include phenolic compounds and plant pigments, which have antioxidant and anti-inflammatory effects, helping to reduce inflammation and protect your body from cell damage. May Reduce Inflammation. May Lower Blood Sugar and Cholesterol (Jillian Kubalav, 2024).

CULTIVATION

Propagation

Nutmeg trees are propagated both sexually (from seeds) and from grafts. They typically take between seven to nine years after planting before they begin to bear and may take up to twenty years before they reach full maturity and full productivity in terms of yield per tree. Among the issues that affect the agronomy of nutmeg is the inability to determine the sex of the tree before it flowers, resulting in propagation yields which are often 50% male (the non-productive sex) when planted from seeds. This had resulted in grafting being the preferred means of propagation as it is much more efficient and can be used to ensure that the tree at flowering is the female which will produce the nutmeg fruit (Gordon, 2020). An important problem in nutmeg cultivation is the segregation of seedlings into male and female plants resulting in about 50% unproductive male trees. Though there has been several claims that sex could be determined at seedling stage on the basis of leaf form and venation, colour of young sprouts, vigour of seedlings and shape of calcium oxalate crystals on leaf epidermis, none of them is sufficiently reliable. The only alternative is to adopt vegetative propagation either by top-working male plants or using budded or grafted plants. Nutmeg is commercially propagated through grafts. For raising root stocks, naturally split healthy fruits are harvested during June- July. The seeds are extracted from the pericarp and sown immediately in sand beds of convenient length, 1 to 1.5 m width and 15 cm height. Regular watering is necessary for good germination. Germination may commence from about the 30th day and last up to 90 days after sowing. About 20 days old sprouts are transplanted to polythene bags containing a mixture of soil, sand and cow dung (3:3:1). The selected rootstock at the first leaf stage should have a thick stem (diameter of 0.5 cm or more) with sufficient length so as to enable to give a cut of 3 cm length. Scions with 2-3 leaves, collected from high yielding trees can be used for grafting. The stock and scion should approximately have the same diameter. A 'V' shaped cut is made in the stock and a tapered scion is fitted care-fully into the cut. Bandaging at the grafted region may be done with polythene strips. They are then planted in polythene bags of 25 cm x 15 cm size containing potting mixture. The scion is covered with a polythene bag and kept in a cool shaded place protected from direct sunlight. After 1 month, the bags can be opened and those grafts showing sprouting of scions may be transplanted into polythene bags, containing a mixture of soil, sand and cow dung (3:3:1) and kept in shade for development. The polythene bandage covering the grafted portion can be removed after 3 months. During grafting, precautions should be taken to

prevent wilting of scions and to complete the grafting as soon as possible. The grafts can be planted in the field after 12 months (Vikaspedia, 2020).

Nutmeg is generally propagated through seed. Well-matured seeds are collected for propagation. The fleshy pericarps of the seeds are removed and then the seeds are dried for a day before sowing. However, no difference was notified in the germination among various sizes of seeds except in the case of very small and immature seeds, which did not germinate satisfactorily. Seeds are sown immediately three days after extraction. Seeds are usually propagated at a spacing of about 30 cm apart and 2.5-5.0 cm deep. Freshly harvested seeds are used for sowing. Seed beds are prepared in shade where irrigation facilities exist .The seeds are placed in Sandy nursery beds at distances of 25-30 cm and 2.5 to 5 cm deep. It takes about 2-3 months for germination. The seeds may be sown in baskets, polythene bags or other containers. Six month old seedlings are transferred to polythene bags .When the seedlings attain an age of one and half to two years and height of 60 - 90 cm, they are used for planting. Vegetative propagation is considered the ideal method of nutmeg propagation to achieve desired female trees with early bearing and it should also be possible to select and propagate high yielding clones (Joy, 2024).

Cuttings: Nutmegs can be propagated from semi hardwood or hardwood with a length of 30-37 cm and about 8 mm diameter at the base. The root growth can be encouraged by quick dipping of the cutting. The second dip after 8 weeks further promotes a branched root system. Root induction takes approximately four months, but well branched root system are formed in three months. However, this method never became an established commercial method of propagation (Joy, 2024).

Air layering: Nowadays, this method is used in Grenada for the propagation of nutmeg. Healthy branches of about 1.5 cm in diameter and 90-100 cm in length are selected for air layering. A section is made by removing or splitting the bark in the middle of the stem about 80 to 90 from the tip (Joy, 2024).

Approach grafting: Grafting may be made on seedlings of other species of the genus Myristica. In approach grafting, seedlings of about 45 cm height and pencil thickness in the collar region are approach grafted to scion of similar thickness. The graft takes about four months to unite, after which the scion is detached below the union and placed for hardening (Joy, 2024).

Epicotyl grafting: Grafting is the system of connecting together of portions of two plants (scion and root stock) that will endure their growth after union as one plant. This forms the basis of asexual method of plant propagation with great advantages in breeding programmes for developing superior genotype. Epicotyl grafting is the same as grafting in terms of methodology, and is a simple, cheap and quick method of propagation (Joy, 2024).

Softwood grafting: Softwood grafting is possible in nutmeg. It was revealed that May was the best season for softwood grafting. The medium matured to fully matured scion sticks of 4 to 6 months old were preferred for softwood grafting. Retention of one terminal leaf on the scion sticks recorded 75 per cent success. The success in softwood grafting differs according to the scion variety. The variation among genotypes for sprouting, survival and growth parameters was statistically significant (Joy, 2024).

Nutmeg trees are dioecious plants (individual plants are either male or female), which are propagated sexually from seeds and asexually from cuttings or grafting. Sexual propagation yields 50% male seedlings, which are unproductive. Because no reliable method has been found for determining plant sex before flowering in the sixth to eighth year, and sexual reproduction bears inconsistent yields, grafting is the preferred method of propagation. Epicotyl grafting (a variation of cleft grafting using seedlings), approach grafting, and patch budding have proved successful, with epicotyl grafting being the most widely adopted standard. Air layering is an alternative though not preferred method because of its low (35–40%) success rate. The first harvest of nutmeg trees takes place 7–9 years after planting, and the trees reach full production after 20 years (Wikipedia, 2024a).

Cultivation

Nutmeg thrives well in warm humid conditions in locations with an annual rainfall of 150 cm and more. It grows well up to about 1300 m above mean sea level. Areas with clay loam, sandy loam and red laterite soils are ideal for its growth. Both dry climate and water logged conditions are not suitable for nutmeg cultivation. As nutmeg is cross-pollinated, considerable variations are observed in the crop. The plants differ not only for all aspects of growth and vigour, but also for sex expression, size and shape of fruit and quantity and quality of mace. A good tree yields about 2000 fruits annually on an average, but the yield may vary from a few hundreds to about 10,000 fruits. Planting in the main field is done at the beginning of the rainy season. Pits of 0.75 m x 0.75 m x 0.75 m size are dug at a spacing of 9 m x 9 m and filled with organic manure and soil about 15 days earlier to planting (Vikaspedia, 2020). For planting plagiotropic grafts, a spacing of 5 m x 5 m has to be adopted. A male graft has to be planted for every 20 female grafts in the field. The plants should be shaded to protect them from sun scorch during early stages. Permanent shade trees are to be planted when the site is on hilly slopes and when nutmeg is grown as a monocrop. Nutmeg can best be grown as an intercrop in coconut gardens that are more than 15 years old where shade conditions are ideal. Coconut gardens along river beds and adjoining areas are best suited for nutmeg cultivation. Irrigation is essential during summer months. Manures are applied in shallow trenches or pits dug around the plants. The Kerala Agriculture Department recommends 20 g N (40g urea), 18 g P_2O_5 (110g superphosphate) and 50 g K_2O (80 g muriate of potash) during the initial year and progressively increasing the dose to 500 g N (1090 g urea), 250 g P_2O_5 (1560 g superphosphate) and 1000 g K_2O (1670 g muriate of potash) per year in subsequent years for a fully grown tree of 15 years or more. FYM is to be applied @ 25 kg for 7-8 years old trees and 50 kg for grown up tree of 15 years (Vikaspedia, 2020). Nutmeg thrives well in warm humid conditions in locations with an annual rainfall of 150 cm to 250 cm and temperature of 25-35^{O}C. It grows well from sea level upto an elevation of 1300 m. Partial shade appears to be beneficial in

early growth stages 1300 m. For cultivation of nutmeg, river banks and hill valleys with clay loam, sandy loam and red laterite soils rich in humus are ideal for its growth. Both dry climate and water logged conditions are not good for nutmeg. It can grow well even in comparatively poor types of soils provided the soil is not sandy and not too wet or dry. A certain amount of iron in the soil is said to be beneficial to nutmeg trees. Nutmeg can be propagated by seeds as well as vegetatively by patch budding and epicotyl grafting. The percentage of success in the vegetative methods of propagation is between 38-80%. The bio-technological method of *in vitro* synthesis of mace has been standardised. For raising seedlings, only well matured large seeds of uniform size, shape, light brown colour with thick mace and low terpene content are collected. The seeds are dehusked and dried for a day before sowing. One kilogram contains about 200 small seeds or 90 big sized seeds. The average number of small, medium and big seeds is 125 in a kilogram. Seeds are collected from regular bearing and high yielding trees, yielding more than 10,000 fruits per tree per year and having 30 g wet weight per fruit, 1 g wet weight of mace per fruit and 10 g wet weight of nuts per fruit. Seeds (7-9 g in weight) are sown three days after extraction. The seeds begin to germinate in four to six weeks. The sprouted seeds at 2-leaf stage and having 15-20 cm height are transferred to polythene bags or when the seedlings are six months old, they are potted and allowed to remain in the pots for about a 12 to 18 months prior to planting in the main field. For raising the seedlings healthy fruits harvested during June-July are used. The seeds soon loose viability and should be sown immediately. Regular care regarding watering in necessary for good germination. The seedling progeny will give about 50 per cent of each sex, which is very difficult to distinguish until the trees flower 4-6 years after planting (KSSDB, 2021). Although, nutmeg can be vegetatively propagated by patch budding and epicotyl grafting, the later has been reported more easy and successful. For epicotyl grafting the selected root stock should have thick stem (diameter of 0.4 cm or more) with sufficient length to give a cut of 3 cm long. The scions with 2-3 leaves, collected from the high yielding trees can be used for the grafting purpose. The stock and scion should have approximately the same diameter. A `v' shaped cut is to be made in the stock and tapered scion is fitted carefully into the cut. The root stocks used for grafting or budding are *M.beddomei* and *M.malabarica*. Tying may be done with 300 gauge polythene strips. The completed grafts are to be planted in long polythene bags, containing coir dust as medium upto half of their length. After planting in bags the grafts are to be covered with polyethylene bags to prevent drying of scion and should be kept in a cool shaded place protected from direct sunlight. After one month, the bags can be opened and those grafts showing sprouting of scions may be transplanted in bags, containing a mixture of soil, sand and cowdung in the ratio of 1:1:1 and kept in shade. The polythene bandage covering the grafted portion can be removed after three months of transplanting. During grafting, precautions should be taken to prevent wilting of scions and to complete the grafting as soon as possible after detachment of shoots. Since the exudates from cuts pose a problem by covering the cut surfaces in the grafting process hindering union, the root stocks are to be prepared earlier than the scion, so that by the time the scion is ready, exudation in the root stock, might have ceased. Orthotropic shoots or straight growing shoots are used to get normal shaped nutmeg tree. If the lateral branches are used a shrubby spreading plant will result which is difficult to convert to a normal nutmeg tree (KSSDB, 2021).

The planting is done at the beginning of rainy season. A spacing of 8 m x 8 m or 9 m x 9 m is required for nutmeg plantations. Pits of about 0.75 m to 0.90 m cube are dug and filled with organic manure and soil about 15 days earlier to planting. The plants should be shaded by planting banana or glyricidia to protect them from sun scarch in the early stages. Permanent shade trees are to be planted when the site is on hilly slopes and nutmeg is grown as a monocrop. Nutmeg can be grown also as mixed crop in the old coconut and arecanut gardens where light shade conditions are suitable. One nutmeg can be planted at the centre of 4 coconut plants while in arecanut nutmeg can be planted at every third row so that within the square formed by 4 nutmeg plants, there are 9 arecanut seedlings. Farm yard manure is applied at 10 kg per pit and gradually increased to 50 kg per plant for 15 years old tree. The fertilizer doses vary with the age. In the first year after planting a dose of 20 g N, 18 g P_2O_5 and 50 g K_2O is given per plant. The dosage for the second year is 40 g; 36 g; 100 g and after five years it is 100 g; 90 g; 25 g and after fifteen year a dose of 500 g; 250 g; 1000 g of N: P_2O_5 and K_2O, respectively are applied. The manure may be applied in shallow trenches dug sufficiently away from the base of the tree. The manures and fertilizers are applied twice a year-one in May-June and the other in September-October, depending upon the moisture availability/rainfall (KSSDB, 2021). Regular weeding and irrigation are required for good growth, early bearing and higher yield. Irrigation in summer months is a must in dry areas. For 4-years old plants, 20 lit. of water per plant thrice a week are given and the quantity increased at the stages of growth. Gramaxone can be used for chemical weed control. In lighter soils the plant basins are mulched with heavy mulches of organic matter. Nutmeg is a dioecious plant and sex of the trees is known only after the trees flower *i.e.* about six or seven years after planting. Since the pistillate trees bear profusely it is necessary to have a maximum number of them interplanted with a few male trees for pollination (KSSDB, 2021).

Planting in the main field is done at the beginning of the rainy season. Pits of 0.75 m x 0.75 mx 0.75 mares dug at a spacing of 9 m x 9m for seedlings and 5m x 5m for bush/ lateral grafts and filled with organic manure and soil 15 days before planting. If male trees are not available, one male graft has to be planted for every 10 female grafts. Alternately, one male branch can be grafted to each female graft to provide enough pollen. The plants should be shaded to keep them from sunlight during early stages in summertime. In the hilly slope area, when the tree is planted as a monocrop, it requires shade trees to control the sunlight. Nutmeg can best be grown as an intercrop in coconut garden more than 15 years old where shade conditions are ideal, especially along river buds and adjoining areas (Joy, 2024). After planting, periodical irrigations are given at least for 3-4 years in the beginning, and thereafter, the trees are to be manured every year. Compost (15 kg) and 100 g each of ammonium sulphate, super phosphate and muriate of potash are given, in two split doses--the first with the onset of southwest monsoon along with the compost or cattle manure and the second during weeding. For eight years old bearing trees, 50 kg of compost, one kilogram each of ammonium sulphate, superphosphate and muriate of potash are applied and half of the dose for young and non-bearing trees. Manures are applied at the circular basins of 40 cm width and not more than 30 cm depth. It is necessary that Manures should be covered with soil and basins should not be kept open during rainy season, as plants cannot withstand waterlogged conditions. Basins of the trees can be mulched with dry leaves during summer to conserve moisture. Digging the ground has to be avoided, as the lateral roots spread near the surface (Joy, 2024). Nutmeg requires a warm and humid climate and adequate shade for its proper growth and

development. Previously, it was cultivated by sexual propagation. However, because of long bearing age, wide variability in fruit characters and yield, the vegetative propagation methods like epicotyl and softwood grafting are developed. The grafts prepared by using vertical branches results in bushy growth. It is an excellent mixed crop in coconut plantation. Fruit rot and shot holes are the major diseases, in this precious crop. Nutmeg yield varies between few fruits to few thousand fruits (Joy, 2024). Friable, well drained clay to red soils is suitable. This crop can be grown up to an elevation of 1000 m with 150 - 250 cm of rainfall, humid tropical climate. Seeds /grafts/ budded plants. Seed Propagation**:** Seeds are collected from regular bearing and high yielding trees (more than 10,000 fruits per tree per year) and having 30 g weight/fruit, 1 g wet mace /fruit and 10 g wet weight of nuts / fruit. Seeds are harvested during June - July. Sown immediately after extraction in beds at a spacing of 30 cm and 2.5 - 5.0 cm deep. Germination commences from 40 days and extends up to 90 days after sowing. Transplanted to poly bags (35 cm x 15 cm) one year old seedlings are transplanted to bigger poly bags (35 cm x 20 cm). Seedlings transplanted to main field from 18 - 24 months. Vegetative propagation: Grafting (approach method) or budding (Patch method) is recommended to perpetuate high yielding nutmeg types. Best season is from October to January. Use only orthotropic shoots as scion materials (Agritech, 2024). Plant 12 - 18 months old seedlings in pits of 60 cm x 60 cm x 60 cm size and filled up with equal parts of forest soil and cattle manure. Adopt spacing of 8 m x 8 m either way. Season of planting is June – December. Apply FYM 15 kg, N 20 g, P 20 g, K 60 g per tree during first year and FYM 50 kg, N 300 g, P 300 g, K 960 g for adult trees in two splits June - July, September - October. Apply 50 g in each of *Azospirillum* and *Phosphobacterium* one month after manuring. Irrigation is given once in 5 - 7 days during summer months. Keep the area around the plant weed free. Regulation of shade is important. It requires medium shade especially during the initial stages of growth. Fast growing shade trees or Banana are planted in between them a few months prior to planting and can be thinned out later. It can be grown as mixed crop with Arecanut and Coconut. In Arecanut plantations, Nutmeg can be planted after every third row of Arecanut (Agritech, 2024).

Harvesting

The female nutmeg tree starts fruiting from the sixth year, though the peak period is reached after 20 years. The fruits are ready for harvest in about 9 months after flowering. The peak harvesting season is during June-August. The fruits are ripe and ready for harvesting when the pericarp splits open. Alter harvest the outer fleshy portion is removed, and the mace is manually separated from the nut. The nut and mace are then dried separately in the sun. The scarlet coloured mace gradually becomes yellowish brown and brittle when drying is completed. The fleshy pericarp can be used for making pickles, jams and jellies (Vikaspedia, 2020). The female nutmeg tree starts fruiting from the sixth year. But, the peak harvesting period is reached after 15 or 20 years and continue for 40 years or more. The fruits are ready for harvest in about 6-9 months after flowering. Flowering and harvesting continue throughout the year. But, June-August or December – May is the peak period. The fruits are ripe and ready for harvest when the pericarp splits open. Harvesting is done by a bill hook. The fruits are split open, the outer fleshy portion is removed, and the mace is manually separated from the nut. Then, the nut and mace are dried separately in sun on a drying yard. The mace should be dried for 10-15 days and the nuts for 4-8 weeks till the kernel rattles within the shell. The scarlet coloured mace gradually becomes yellowish brown and brittle when the drying is completed. The fresh pericarp can be used for making pickles, jams and jellies (KSSDB, 2021). The bearing starts from six to seven years after planting. The mature fruits when they start splitting are harvested. The aril commonly known 'mace' and 'seed' are separated and dried (Agritech, 2024). Fruits : 1000 - 2000/tree; Dried nuts: 5 - 7 kg/tree; Dried mace : 0.5 - 0.7 kg/tree (Agritech, 2024).

Yield: Fruiting commences from fifth or sixth year but may take even eight or nine years. Optimum productivity is attained in about 15 years. Fruits are reported to ripe in 6-9 months after flowering. In India, fruits that split on the tree exposing crimson coloured aril are harvested. In Konkan region, the peak harvesting period is confined from June to October, whereas in Kerala it is June-July. The average yield of a good tree in full bearing is reported to be 3000 fruits between 15th and 30th year of growth. Average weight of a single fruit is 60g of which the seed weighs 6-7g, mace 3-4 g and the rest pericarp. Ratio of mace to nutmeg is 1:8. Fruits are collected from the tree by hand or with hooked sticks or allowed to fall naturally on the ground and are gathered every day (Thangaselvabai et al., 2011). A tree of 15 years and above will yield about 1000 - 2000 or more fruits and large trees which are over 30 years of age may yield about 3000-10000 fruits per year. The yield per hectare may vary from 1000-1500 kg of nutmegs and 200-500 kg of mace per annum. Mace to nutmeg ratio is about 3:20 on weight basis. Generally if the fruit weight is 60 g, 6-7 g nutmeg and 3-4 g mace could be recovered. The rest will be pericarp. For every 100 kg nutmeg, a tree produces only 4 kg of mace (KSSDB, 2021).

Production

utmeg the two in one spice is valued for its flavouring and medicinal properties. It is native of Moluccas Island and in India it is cultivated throughout Kerala, parts of TamilNadu, Karnataka, Goa, Assam and Andaman and Nicobar Islands. India produces about 11,424 tonnes of spice in an area of 15, 131 ha. Imports 1325 tonnes of nutmeg and 265 tonnes of mace. Under Indian conditions the production potential is very low *i.e*., 800 kg nutmeg and 125 kg mace/ha and the present production is not sufficient to meet the domestic requirement (Thangaselvabai *et al*., 2011). Inadequacy of genuine and disease free planting materials of improved varieties/ genetically superior stock plants and non adoption of improved production technologies are the causes for the low productivity and quality. India depends on foreign countries notably Indonesia and Srilanka for supply of nutmeg. Hence, to attain self sufficiency and to arrest the drain on foreign exchange the area and production has to be increased through planting quality planting materials and adoption of improved production technologies (Thangaselvabai *et al*., 2011). The annual world production is approximately 8000 tonnes of nutmeg and 1000 tonnes of mace, eighty five per cent of which is produced in Indonesia and Grenada followed by Sri Lanka. Relatively small quantities are exported from India. In India nutmeg is presently grown in Ernakulam, Cannanore, Kottayam, Thrissur, Idukki, Allepy, Mylapuram, Thiruvanathapuram, Palghat and Calicut districts of Kerala (3,502 ha), Dakshina Karnataka (110 ha) and also Andaman and Nicobar Islands. Total Indian production of

nutmeg and mace is 5537 and 5919 tonnes per year, respectively. In India nutmeg is also grown near couratallam of Tirunelveli district and round about the Burliar zone of the eastern slopes of the Nilgiris, Anjarakandi near Coonoor of Tamil Nadu and Karnataka. Arakuvalley in Andhra Pradesh and Wynad is Kerala are well suited for its cultivation (KSSDB, 2021). In 2019, global production of nutmeg was 142,000 tonnes, led by Indonesia, Guatemala, and India, having 38,000 to 43,000 tonnes each and a combined 85% of the world total (Wikipedia, 2024a).

Products

The pericarp (fruit covering) is used to make jam, or is finely sliced, cooked with sugar, and crystallised to make a fragrant candy. Sliced nutmeg fruit flesh is made as *manisan* (sweets), either wet, which is seasoned in sugary syrup liquid, or dry coated with sugar, a dessert called *manisan pala* in Indonesia. In Penang cuisine, dried, shredded nutmeg rind with sugar coating is used as toppings on the uniquely Penang *ais kacang*. The flesh of the nutmeg fruit is also blended, in the fresh state, into a type of smoothie (white in colour and having a fresh, 'green', tangy taste); or boiled, resulting in a brown liquid, much sweeter in taste, which is used in the preparation of iced drinks. In Kerala Malabar region of India, it is used for juice, pickles and chutney (Wikipedia, 2024a).

The essential oil obtained by steam distillation of ground nutmeg is used in the perfumery and pharmaceutical industries. The volatile fraction contains dozens of terpenes and phenylpropanoids, including D-pinene, limonene, D-borneol, L-terpineol, geraniol, safrole, and myristicin. In its pure form, myristicin is a toxin, and consumption of excessive amounts of nutmeg can result in myristicin poisoning. The oil is colorless or light yellow, and smells and tastes of nutmeg. It is used as a natural food flavoring in baked goods, syrups, beverages, and sweets. It is used to replace ground nutmeg, as it leaves no particles in the food. The essential oil is also used in the manufacturing of toothpaste and cough syrups (Wikipedia, 2024a).

Essential oil is extracted from the seed, mace, leaves and also the bark by stem distillation. For oil-distillation, the economically viable and accepted materials are the rejections from spice trade. The oil yield ranges from 6 to 16% in nutmeg, 4 to 15% in mace, 0.14% in bark and 0.4 to 0.6% in leaves. Nutmeg contains 25-40% fat which also can be recovered using solvents or by mechanical pressing. It is highly aromatic. Major constituent is trymyristicin. Oleoresin is extracted with solvents. It may have butter also. About 7-16 per cent nutmeg oil is found in it. Aromatic ethers, myristicin and elemicin are present in oil and oleoresin (KSSDB, 2021). Nutmeg butter is obtained from the nut by expression. It is semisolid, reddish-brown in colour, and has the taste and smell of nutmeg itself. About 75% (by weight) of nutmeg butter is trimyristin, which can be turned into myristic acid, a 14-carbon fatty acid, which can be used as a replacement for cocoa butter, can be mixed with other fats like cottonseed oil or palm oil, and has applications as an industrial lubricant (Wikipedia, 2024a).

Products developed using nutmeg is given in Fig. 3.

Nutmeg sweets

Ground Nutmeg

Curry

Nutmeg jam

Nutmeg oil

Nutmeg chutney

Fig. 3: Products

Mechanical drying

Freshly harvested mace can be blanched in water at 75°C for 2 min to retain the scarlet colour. This is followed by hot air drying at 55^0- 65^0 C which takes 3-4 hours for drying to a moisture level of 8—10%. However nut can be dried in 14-16 hours using hot air technique (Vikaspedia, 2020).

Grading

The dried nutmegs are graded by hand according to weight, shape and colour. After grading the nutmegs are fumigated with methyl bromide to protect them from storage pest. The following classification have been made in nutmeg trade: 1) Whole and sound nutmeg: This is used in spice trade as (a) large (b) medium and (c) small. 2) Sound shrivels: These are employed for grading but are usually too expensive for oil distillation. 3) Rejections: Considerably low-priced, this grade cab be used for distillation of oil. 4) Broken and warmy: This grade is also suitable for oil distillation (KSSDB, 2021). Banda Mace is considered to be the finest. It has a bright orange colour and fine aroma. Jave Estate Mace is golden yellow, interspersed with brilliant crimson streaks. Siauw Mace is of lighter colour than Banda mace and contains less volatile oil. West Indian Mace, often regarded as the fourth grade of East Indian mace, is derived from *argentiea*. It contains less volatile oil of undesirable turpentine like aroma. It is unsuitable for distillation pruposes. Maces are considered by the trade all the world over as of superior quality. Mace is available in the market as 'whole', 'broken' or 'ground' (KSSDB, 2021).

Value added products

The value added products are nutmeg oil, mace oil, nutmeg oleoresin, mace oleoresin, myristicin, nutmeg butter, volatile oil of bark and flowers (KSSDB, 2021).

Adulternats

Nutmegs are sometimes adulterated with 'false' nutmegs (*M.malabarica*) or 'Bombay nutmegs' which are odourless and tasteless. The oil is sometimes adulterated by addition of turpentine oil or pinene. Mace is also sometimes adulterated with 'Wild Mace' (*M.malabarica*) of inferior quality (KSSDB, 2021).

Risks of Nutmeg

Nutmeg is safe when consumed in small amounts. However, some people eat large amounts of nutmeg and use it as a recreational drug. This practice can lead to dangerous side effects. When taken in doses exceeding 5 grams, nutmeg can cause hallucinations and mood changes. These psychoactive effects are due to compounds found in nutmeg, including myristicin and safrole. High doses of nutmeg can also cause serious symptoms such as hypertension (high blood pressure), fast heart rate, vomiting, delusions, auditory and visual hallucinations, and severe agitation. There have been multiple reports of nutmeg toxicity, most of which are due to purposeful ingestion by people using nutmeg for its psychoactive properties. There have also been two reported deaths due to nutmeg intoxication.8 These cases were related to eating large doses of nutmeg. Consuming small amounts of nutmeg typically used in foods and drinks is generally considered safe (Jillian Kubalav, 2024).

Tips for Consuming Nutmeg

Nutmeg makes a delicious addition to sweet and savory dishes. If you're using whole nutmeg, use a microplane or grater to zest fresh nutmeg onto your favorite dishes. Freshly grated nutmeg is typically more powerful than pre-ground nutmeg and can easily overpower a dish when used in larger amounts. Here are a few ways to incorporate nutmeg into your diet: 1) Add a dash of nutmeg to hot chocolate, lattes, eggnog, and cider for a warm and nutty flavour. 2) Use nutmeg in meat and chicken dishes to add depth to your recipes. 3) Grate fresh nutmeg on finished dishes like mashed potatoes, french toast, pasta, soups, oatmeal, and fruit salad. 4) Combine nutmeg with other spices, such as cinnamon and cloves, in baked goods like pies, cakes, and muffins. 5) Make a béchamel sauce with butter, flour, milk, and freshly grated nutmeg (Jillian Kubalav, 2024).

Side Effects

When taken by mouth: Nutmeg is commonly consumed in foods. But nutmeg is possibly unsafe when used in in doses of 120 mg or more daily. Long-term use of large doses has been linked to hallucinations and other serious mental side effects (Webmd, 2024). When applied to the skin: There isn't enough reliable information available to know if nutmeg is safe or what the side effects might be (Webmd, 2024). Special Precautions (Webmd, 2024). When taken by mouth: Nutmeg is commonly consumed in foods. But nutmeg is possibly unsafe when used in in doses of 120 mg or more daily. Long-term use of large doses has been linked to hallucinations and other serious mental side effects. When applied to the skin: There isn't enough reliable information available to know if nutmeg is safe or what the side effects might be. Pregnancy: Nutmeg is commonly used as a flavoring in foods. But it is possibly unsafe when taken by mouth in larger doses when pregnant. It might cause miscarriages or birth defects. Stay on the safe side and stick to food amounts. Breast-feeding: Nutmeg is commonly used as a flavoring in foods. There isn't enough reliable information to know if nutmeg is safe to use in larger doses when breast-feeding. Stay on the safe side and stick with food amounts.

Psychoactivity and toxicity: Although used as a folk treatment for some ailments, nutmeg has no proven medicinal value (Wikipedia, 2024a).

Effects: Ingested in small amounts as a spice, nutmeg produces no noticeable physiological or neurological response, but in large doses, both raw nutmeg freshly ground from kernels and nutmeg oil have psychoactive effects. Such effects appear to derive from anticholinergic-like hallucinogenic mechanisms attributed to myristicin and elemicin. Myristicin—a monoamine oxidase inhibitor and psychoactive substance—can cause convulsions, palpitations, nausea, eventual dehydration, and generalized body pain when consumed in large amounts. Nutmeg may interact with anxiolytic drugs, produce allergic reactions, cause contact dermatitis, and evoke acute episodes of psychosis. Varying considerably from person to person, nutmeg intoxication may occur with side effects, such as delirium, anxiety, confusion, headaches, nausea, dizziness, dry mouth, eye irritation, and amnesia. Intoxication takes several hours to reach maximum effect, and may last for several days. Incidents of fatal poisoning from nutmeg and myristicin individually are uncommon.

Nutmeg poisonings occur by accidental consumption in children and by intentional recreational use. It is used recreationally with the intention of achieving a low-cost high resembling psychedelics, particularly by adolescents, drug users, college students, and prisoners. Relatively large doses of nutmeg are required to produce effects; a majority of reported nutmeg intoxication cases appear to result from recreational use. Playwright and poet William Shakespeare was alleged to use nutmeg for hallucinogenic purposes as nutmeg extract along with cannabis were found in analysis of fragments of his pipe (Wikipedia, 2024a). Nutmeg was once considered an abortifacient, but may be safe during pregnancy if used only in flavoring amounts. If consumed in large amounts, nutmeg could cause premature labor and miscarriage. Nutmeg may also interact with pain relievers such as pethidine, so avoiding it during pregnancy is recommended (Wikipedia, 2024a). The scent of nutmeg may attract pets, but it can be poisonous if consumed in excess (Wikipedia, 2024a).

Processing

After harvest, the pericarp/outer fleshy rind is removed and the mace, which envelops the shell, is peeled off. The “blades of mace” as the peelings are called are flattened by hand or between boards and are spread out to dry in the sun. In good dry weather, the drying operation is accomplished in two or three days. Sun drying leads to a certain amount of colour fading. To prevent such bleaching artificial drying is often resorted to. Exceptional care must be taken to prevent mace getting mouldy. A perfect sample of mace should consists of entire double blades, not broken, flattened and of large size, horny in texture and not too brittle and of a good, clear and bright colour. Nut is left in the shell and dried in the sun or in drying ovens. Drying is complete when the seed rattles. In Kerala the harvesting season coincides with the monsoon season. So sun drying often becomes impossible. Freshly harvested mace can be blanched in water at 75oC for 2min to retain the scarlet colour. This is followed by hot air drying at 55-65oC which takes about 3-4hrs for drying to a moisture level of 8-10%. Nutmeg loses about 25 per cent of their weight by drying. Shell is then cracked with wooden hammers or mechanically in specially designed machines and discarded or used as fuel and the nutmeg removed and dried. The aromatic ethers which are the chief components that determine the flavor and drug action in nutmeg oil was maximum one month prior to the fruit splitting stage. In mace oil it was found to be high two months prior to the fruit splitting stage. So if nutmeg and mace oils are intended for medicinal purpose, then it may be worthwhile to harvest fruits at the sixth month for extracting kernel oil and at the fifth month for extracting mace oil (Thangaselvabai *et al*., 2011).

Processing of nutmeg is given in Fig. 4.

		
Fruit with mace and nut	**Mace covering the outer shell of the nutmeg seed**	**Mace covering the outer shell of the nutmeg seed**
		
Seed and Mace	**Mace**	**Mace**

Continue ….

		
Washing of Mace	**Washing of Mace and Nuts**	**Washed Nuts**
		
Washed Mace	**Washed Mace**	**Nutmeg shells and kernels (the Nut)**
		
Nutmeg and shell removed	**Nutmeg shell removed**	**Bagging of nutmeg**

Fig. 4: Procesing of Nuts and Mace

Pests and Diseases (KSSDB, 2021)

Scale insects (*Parasaisettia nigra, Pseudaulacospis cockerelli*): Scale insects have been found to occasionally infect tender leaves and shoots generally in the nursery. Spraying of 0.05 per cent Monocrotophos or Quinalphos will control the pest infestation. Die back (*Diplodia natalensis):* Drying up of mature and immature branches from the tip downwards is noticed in the affected plants. The infected branches should be cut and cut ends pasted with Bordeaux Mixture. Spraying trees with 1 per cent Bordeaux mixture is also recommended. Fruit rot (*Colletotrichum gloeosporoides* and *Botrydeplodia theobromae*): Immature fruit rot and shedding are noticed in some trees without any apparent singns of infection. In case of fruit rot, the infection starts from the pedicel as dark lesions. They gradually spread to the fruit causing brownish discoloration of the fruit resulting in rotting. In advanced stages, the mace also rots emitting a foul smell. Bordeaux mixture (1%) or Diafottan or Blue copper or Dithane M-45 at 0.5% concentration is to be sprayed when the fruits are half mature to control this disease. Leaf blight caused by *Botrydiplodiea theobromae,* shot hole by *Colletotrichum gloeosporiodes*, leaf spot by *Alternaria citri*, algal leaf spot by *Cephaleuros* Sp. Sooty mould caused by *Phragmocapinus betle* and thread blight (*Marasmius pulcherima, Marasmius equicrinus)* are the other common diseases of nutmeg, which can be controlled by spraying 1% Bordeaux mixture repeatedly (KSSDB, 2021). *Loranthus* sp is a serious plant parasite affecting the growth of the nutmeg plant. This can be controlled by mechanical removal of the plant parasite. Remove severely affected branches. Twigs of nutmeg trees may also be removed along with the plant parasite and paint with Bordeaux paste (Agritech, 2024). Die back: The disease is characterized by drying up of mature and immature branches from the tip downwards. *Diplodia sp.* and a few other fungi have been isolated from such trees. The infected branches should be cut and removed and the cut end pasted with Bordeaux mixture 1% (Vikaspedia, 2020). Thread blight: Two types of blights are noticed in nutmeg. The first is a white thread blight wherein fine white hyphae aggregate to form fungal threads that traverse along the stem underneath the leaves in a fan shaped or irregular manner causing blight in the affected portions. The dried up leaves with mycelium form a major source of inoculum for the spread of the disease. The disease is caused by *Marasmius pulcherima*. The second type of blight is called horse hair blight. Fine black silky threads of the fungus form an irregular, loose network on the stems and leaves. These strands cause blight of leaves and stems. However, these threads hold up the detached, dried leaves on the tree, giving the appearance of a birds nest, when viewed from a distance. This disease is caused by *Marasmius equicrinus*. Both the diseases are severe under heavy shade. These diseases can be man- aged by adopting phytosanitation and shade regulation. In severely affected gardens, Bordeaux mixture 1% spraying may be undertaken in addition to cultural practices (Vikaspedia, 2020).

Fruit rot: Immature fruit split, fruit rot and fruit drop are serious in a majority of nutmeg gardens in Kerala. Immature fruit splitting and shed- ding are noticed in some trees without any apparent infection. In the case of fruit rot, the infection starts from the pedicel as dark lesions and gradually spreads to the fruit, causing brown discolouration of the rind resulting in rotting. In advanced stages, the mace also rots emitting a foul smell. *Phytophthora* sp. and *Diplodia natalensis* have been isolated from affected fruits. How- ever, the reasons for fruit rot could be both pathological and physiological. Bordeaux mixture 1% may be sprayed when the fruits are half mature to reduce the incidence of the disease (Vikaspedia, 2020). Shot hole: The disease is caused by *Colletotrichum gloeosporioides*. Necrotic spots develop on the lamina which are encircled by a chlorotic halo. In advanced stages the necrotic spots become brittle and fall off resulting in shot holes. A prophylactic spray with Bordeaux mixture 1% is effective against the disease (Vikaspedia, 2020). Black scale: The black scale (*Saissetia nigra*) infests tender stems and leaves especially in the nursery and sometimes young plants in the field. The scales are clustered together and are black, oval and dome shaped. They feed on plant sap and severe infestations cause the shoots to will and dry (Vikaspedia, 2020). White scale: The white scale (*Pseudaulacaspis cockerelli*) is greyish white, flat and shaped like a fish scale and occurs clustered together on the lower surface of leaves especially in nursery seedlings. The pest infestation results in yellow streaks and spots on affected leaves and in severe infestations the leaves will and dry (Vikaspedia, 2020). Shield scale: The shield scale (*Protopulvinaria mangiferae*) is creamy brown and oval and occurs on tender leaves and stems especially in nursery seedlings. The pest infestation results in wilting of leaves and shoots. The scale insects mentioned above and other species that may also occur sporadically on nutmeg can be controlled by spraying dirnethoate 0.05% (Vikaspedia, 2020).

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