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THE NUTMEG – ITS BOTANY, AGRONOMY, PRODUCTION, COMPOSITION, AND USES*

JOSY JOSEPH

Central Plantation Crops Research Institute, Regional Station, Calicut 673 012, Kerala, India.

ABSTRACT

This literature review on nutmeg (*Myristica fragrans* Houtt.) covers its history, origin, distribution, taxonomy, phylogeny, botanical description, cultivation practices, breeding, sex inheritance, vegetative propagation, production statistics, trade, chemical composition, and uses.

Nutmeg and mace are two important spices of commerce obtained from *Myristica fragrans* Van Houtten, family Myristicaceae. Nutmeg is the dried shelled seed and mace the laciniate aril covering the shell of the seed. The 'Papua Nutmeg and Mace' is derived from *Myristica argentea* (Guenther, 1952), 'Bombay Nutmeg and Mace' from *M. malabarica* and 'Otoba Nutmeg' from *M. otoba* (Hutchinson, 1964). These are of inferior quality and commercially not important.

History

The nutmeg and mace of *M. fragrans* were carried by Arab traders from East Indies to Constantinople in the sixth century A.D. (Rosengarten, 1969). By the end of the twelfth century, both the spices were well known in Europe (Guenther, 1952; Rosengarten, 1969).

The Portuguese discovered in 1512 that nutmeg trees were indigenous to the island of Banda in the Moluccas and they dominated the trade in nutmeg and mace for almost a century since then. In 1602, they were driven out of the Moluccas by the Dutch, who then maintained a monopoly over the trade for many years. In 1770, the French introduced smuggled nutmeg plants into Mauritius. The British occupied the Moluccas from 1796 to 1802, and during this period, they introduced nutmeg cultivation first into Penang and later to Singapore, thus contributing to the collapse of the Dutch monopoly (Guenther, 1952; Rosengarten, 1973).

Origin and distribution

New Guinea and the surrounding islands are regarded as the centre of distribution of the genus *Myristica* (Sinclair, 1958). *M. fragrans* probably originated in the Molucca Islands in Indonesia (Guenther, 1952; Rosengarten, 1969; Parry, 1969; Flach and Cruickshank, 1969).

The major nutmeg growing regions are Indonesia and Grenada (W. Indies) (Guenther, 1952; Rosengarten, 1969; Anonymous, 1977). In Indonesia, they are grown in Moluccas, Minehassa (Northern Celebes),

*Contribution No. 17, CPCRI, Regional Station, Calicut.

Sanguish Islands, Benkulen (W. Sumatra), Achin (N. Sumatra), and Nias Island (Guenther, 1952; Rosengarten, 1969; UNCTAD, 1977). It is also grown in a small scale in Sri Lanka, Trinidad, China, India (UNCTAD, 1977), the Windward Islands, St. Thomas and St. Vincent, Tobago, Zanzibar, and Mauritius (Brown, 1959; Anonymous, 1973). Recently, it has been introduced into the Soloman Islands (Gollifer, 1973).

In India, it is grown in certain pockets of Kerala, Tamil Nadu, and Karnataka. The total area is estimated to be about 400 hectares (Nair et al, 1977).

Taxonomy and phylogeny

The family name Myristicaceae was proposed by Brown (1810). Warburg (1897) recognised 15 genera in this family which was accepted by Smith and Wodehouse (1937) and Sinclair (1958). Hutchinson (1964) recognised 16 genera representing about 380 species. The genus *Myristica* consists of about 120 species of which five have been described from India. These are *M. fragrans* Houtt., *M. malabarica* Lamk., *M. magnifica* Bedd., *M. beddomei* King Ann., and *M. contorta* Warb. (Gamble, 1915-1935; Santapau and Henry, 1973). Garratt (1933b), after reviewing the taxonomic position of Myristicaceae indicated that the main emphasis had been placed, at one time or other, on its relationship with Lauraceae, Anonaceae, Monimiaceae, Lardizabalaceae, and Menispermaceae. Based on the nature of the secondary xylem, Garratt (1933b) suggested that Myristicaceae was closely related with Lauraceae and observed that the tanniferous tubes present in the medullary rays provided a definite diagnostic feature for the family. The close relationship between these two families has been supported by Smith and Wodehouse (1938), Hutchinson (1948), and Eames (1961). Bessey (1915), Hallier (1912), and Uphof (1959) placed it in the Ranales. Wettstein (1935) concurred with this and indicated it to be closely related to the Anonaceae. Joshi (1946) also supported its close relationship to the Anonaceae.

Myristicaceae is generally considered to be a primitive family. By statistically studying the correlation of morphological characters, Sporne (1956, 1969) suggested that the family is primitive. This has been corraborated by Corner (1976) based on its distribution, habitat, and the presence of aromatic tissues, simple leaves, dioecy, scaleriform vessels in the wood, apetalous reduced flowers with trimerous perianth, sessile and connate anthers, monocolpate pollen, simplified gynoecium, elaborate seed with a massive vascular supply to the carpel wall, aril, testa, and tegmen.

Botanical description

It is a dioecious or occasionally monoecious evergreen aromatic tree usually 10-20 m in height (Shanmugavelu, and Rao, 1977) sometimes growing to a height of 60 m (Nair, et al. 1977). Bark is greyish black and longitudianally fissured in old trees; leaves are alternate, subglaucous beneath, accuminate, 7.5-12.5 cm long and 3.75-5.00 cm broad (Hooker, 1890). Garratt (1933) observed that the presence of tanniferous tubes in the medullary rays provided a diagnostic feature of its wood. Joshi (1946) described the inflorescence of *M. fragrans* as an axillary raceme; but I have observed that it is a branched raceme in the male plant and simple cyme in the female plant. Flowers are drooping. They are unisexual or occasionally bisexual (Flach, 1966). The flower is bracteate and bracteolate (Baillon, 1872; Gamble, 1915–1935. Hutchinson, 1964; Nair and Bahl, 1956). In *M. fragrans*, the perianth is 3-lobed and valvate, which is termed tepals by Wilson and Maculans (1967). In the male flower only, the perianth shows a narrowing at its base (Flach, 1966). Nectar is produced from a nectary at the base of the calyx tube (Cobly, 1963).

Joshi (1943, 1946), Sastri (1954), and Nair and Bahl (1956) described the perianth as receiving ten vascular traces and have postulated a pentamerous origin. Wilson and Maculans (1967), however, found only nine vascular traces in the perianth. The androecium in *M. fragrans* 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 very short to nonexistant style and bilobed stigma. The ovule is single (Joshi, 1943, 1946; Sastri, 1954; Nair and Bahl, 1956). The placentation in *Myristica* has been variously described as sub-basal (Baillon, 1872; Nair and Bahl, 1956), basal (Hooker, 1885; Warming and Potter, 1932), marginal (Saunders, 1937), almost basal (Gunderson, 1950), parietal and sometimes seemingly basal (Lawrence, 1951). Saunders (1937), Nair and Bahl (1956) and Nair and Pillai (1959) considered the carpel of *Myristica* bicarpellary. Sastri (1954, 1959) and Wilson and Maculans (1967) treated it as unicarpellary. The ovule is anatropous and has two integuments; the inner integument surrounds the micropyle (Corner, 1976). 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 (Rosengarten, 1969).

The seed anatomy has been worked out by Voigt (1888), Sastri (1953), Periaswamy (1961), Parry (1969), and Corner (1976). Sastri's account agrees with Corner's which is as follows: There is a massive vascular supply to the testa, tegmen and aril. The testa and tegmen are thick and multiplicative. Nucellus enlarges by cell growth without division, then it is absorbed and crushed. Endosperm is oily and starchy. Ruminations formed by outgrowths of the inner brown vascular layer of the tegmen, push the nucellar tissue into the endosperm except at the pointed micropylar end.

According to Sastri (1955), the aril arises from the outer integument, but Nair and Pillai (1959) considered that it was funicular in origin. Corner (1976) proposed that it was both exostomal and funicular.

Cultivation practice

Propagation is mostly by seeds, though vegetative propagation is also resorted to. For this, only seeds from mature fruits as indicated by the splitting of the pericarp are used. Flach (1966) found that seeds sown three days after harvest generally did not germinate. Shanmugavelu and Rao (1977) found that seeds stored in polythene bags or moss remained viable for 15 days.

The seeds are sown after removing the pericarp and the aril in either sand beds of 15 cm thickness and convenient length and breadth or directly in polythene bags containing the soil mixture (Kannan, 1971). In the former case, the seedlings are transferred to polythene bags containing a mixture of garden soil, cattle manure, and sand in the ratio of 2:1:1. The seeds can be sown flat or vertical with the micropylar end up. The roots go very deep. In Malaysia seeds are sometimes sown in situ (Shanmugavelu and Rao, 1977). In Kerala, some cultivators sow the nuts vertically exposing about one-third of the micropylar end. Sprouting starts in about four weeks and it goes on for about 22 weeks. Maximum germination occurs between 50 and 80 days (Kannan, 1971). Nair et al (1977) observed that germination took place in about 60-90 days. Flach, (1966) has proposed that higher the monthly yield of a tree the higher its percentage of germination, which varies from 35-70. Perrl (1938) found that germination percentage was higher in nuts of female trees growing nearer to male trees.

According to Rosengarten (1969), seedlings are transplanted to the field at six months. Shanmugavelu and Rao (1977) found that small seedlings less than 30 cm in height failed

to establish in India, though in Malaysia, the practice is to plant seedlings of 15 cm height. Others (Kannan, 1971; Nair, 1978) have observed better establishment by transplanting seedlings of 18-24 months' age. For transplanting, the pits are made of the size 60^3 cm, filled with 5-10 kg well rotten cattle manure and mixed with top soil (Kannan, 1971).

In India, planting is done during the South West Monsoon. The recommended spacing is about 9 m (Flach, 1966; Shanmugavelu and Rao, 1977). Seedlings are protected from hot sun by mulching the soil and providing shade (Ruinard, 1961; Flach, 1966; Aiyadurai, 1966; Kannan, 1971). Abraham (1958) suggested growing it in homestead gardens and in small compact groves in all moist and cool situations in orchards and plantations of coffee, tea, coconut, arecanut, rubber, pepper, and cardamom.

Nutmeg has a shallow spreading root system. This fact should be kept in mind whenever interplanting is planned. Surface digging of the soil should also be avoided (Flach, 1966).

Aiyadurai (1966) recommended regular application of 22.7 kg cattle manure to a mature tree every year. Kannan (1971) recommended the application of 40-50 kg of organic manure annually. Cruickshank (1973) suggested that young marcotted plants might be given 13:8:24 NPK manuring increasing from about 0.5 kg/tree after one year to 2.5 kg/tree at 10 years. The Kerala Agricultural University recommends cattle manure or compost at the rate of 15 kg/tree/annum. The dosage of inorganic fertilizers recommended for a plant is 20 g N, 18g P_2O_5, and 50g K_2O for the first year and double this quantity for the second year, gradually increasing it to 300 g N, 250 g P_2O_5 and 750g K_2O/year for a tree of 15 years or more (Anonymous, 1978). Joseph (1979) suggested the application of 50 kg of organic manure and 500:250:1000 g of N, P_2O_5 and K_2O/tree from the 6th year onwards. A soil cover of some leguminous plant like *Calapagonium* and pruning the trees to produce watershoots have been recommended by Flach (1966).

Mixed cropping of nutmeg in coconut gardens along with other crops has been found to do well in India (Nair, 1977).

Breeding

Hardly any work has been done in variety improvement. The main difficulties are the long juvenile phase, the difficulty in propagating it vegetatively, the dioecy, and the single ovule in a female flower (Flach and Cruickshank, 1969; Sriram, 1977).

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 fruit and nut (Flach and Cruicksharek, 1969: Shanmugavelu and Rao, 1977 and Sriram, 1977). Janse (1898) was the first to propose selection of seeds from healthy trees having bigger seeds and thicker mace. Purseglove (1968) stated that in addition to high yield, nutmegs should be large and uniform in size, round in shape, light brown in colour, low in terpene content and possesses a thick mace. A programme of controlled crosses between superior performers and various types of male trees has been used in Indonesia (Sriram, 1977).

Flach (1966) reported significant correlations between plant height and trunk diameter and between tree diameter and year of first flowering and number of fruits produced. He also worked out multiple regression equations which showed that from a statistical point of view, diameter and height were about equally useful for predicting yield, but from a practical point ofview, diameter would be preferrable.

The studies at Kallar and Burliar in India have shown that the pistillate and staminate flowers open between 6 and 7 PM and anther dehiscence occurs 12 hr ahead of the opening of flowers. The stigma was then

receptive and it retained its receptivity till 2.30 PM of the day after flower opening. Fruit set was improved by the proximity of male trees and the availability of both the staminate and pistillate flowers at the same time. The bigger the flower the greater was the fruit set. Trees in which the flowers were borne on longer pedicels recorded increased fruit set. Fruit set was 10-27% in plants with wider opening of the perianth, whereas it was only 1-9% in flowers with narrow opening (Anonymous, 1966).

Artificial pollination can be carried out by inserting an androecium into the female perianth or by means of some pollen on top of a pencil (Deinum, 1949). Flach (1966) has stated that many of the female flowers shed after flowering which was accelerated after artificial pollination. Mature pollen is monocoplate (Joshi. 1946a) and trinucleate (Flach 1966) indicating that pollen cannot be saved for later pollination.

Nutmeg is obligately cross-fertilized. Hence for ensuring efficient pollination Flach (1966) has recommended one male tree for every 10 female trees in a plantation. Pollination is usually effected by a moth (Deinum, 1949). Development of a fruit takes about 9-10 months (Anonymous, 1966; Flach, 1966). Perrl (1938) opined that *M. fragrans* might be able to produce seeds without pollination. Duncan and Ferguson (1967/68) after detailed studies of the embryo sac and events leading upto fruit formation, suggested that incompatibility mechanism might be operating in nutmeg to ensure cross fertilization. Cruickshank (1973) has cited some cursory observations to suggest that a stimulus of pollination might be necessary for getting fruit set.

In the female trees, Flach (1966) found a correlation of $r = +0.5$ between tree girth at 40 cm above the ground level and number of fruits.

Simmonds (1954) reported 42 as the chromosome number. But Flach (1966) after a detailed study of mitosis and meiosis reported the presence of 44 small isodiametric chromosomes.

Sex inheritance

Nichols and Pryde (1958) after reviewing the literature on sex inhertiance (Warburg, 1897; Janse, 1898; Dienum, 1949; Hermans, 1926) oncluded that female and male trees are produced in approximately equal numbers. According to Flach (1966) there are two different sexes, a female flowering sex and a male flowering sex. The latter is subdivided into four different groups, males, bisexual males, bisexuals and bisexual females.

Janse (1898) reported that male trees possessed smaller leaves and less horizontal branches, but as young trees showed these characters less clearly, it was not possible to determine the sex of young trees using this method. Flach (1966) did not agree with him. Prestoe (1884) stated that the leaves of female plants less than 30 cm tall were nearly elliptical with more or less straight veins, while the leaves of male plants were nearly obovate with their veins rounded to the more pronounced point of the leaf. The method was tested by planting and observation until fruiting of the trees and was found to be accurate in 8-9 out of 10 cases. Flach (1966) showed that the female trees had a significantly higher stem diameter during the prebearing stage, there was no significant difference between either sexes for plant height. He also hypothesized that nutmeg might possess a sex mechanism involving four pairs of chromosomes. According to this, the female sex is heterogametic with four of the supposed eight sex chromosomes showing facultative nucleolar properties which show up in meiosis when the nucleolus orientates these four chromosomes to one side. The different male flowering tree types would then have to be explained by partial failure of the mechanism of orientation.

Phadnis and Chowdhari (1971) reported colour differences in the leaf extracts of male and female nutmeg plants when treated with ammonium molybdate. Nayar, Rai and Vatsala (1977) postulated a method for distinguishing the sex by the shape of calcium oxalate crystals in the lower epidermal cells of leaves of plants of at least two years age. Male plants show a single large rhomboidal or prismatic crystal with rectangular or square flat faces. Female plants have a large cluster of small crystals.

Vegetative propagation

On account of the uncertainty in predicting the sex in nutmeg seedlings vegetative methods for propagating female plants have a distinct advantage. Several authors have dwelt upon it (Cheeseman and Spencer, 1936; Dienum 1949; Macmilan, 1954; Nicholas and Pryde, 1958; Nicholas and Cruickshank, 1964; Flach, 1966 and Cruickshank, 1973).

Postma (1935) obtained 30% success with budding on rootstocks of *M. succedana* in Indonesia. Such trees were healthy but somewhat stunted (Deinum, 1949). In New Guinea, budding was tried with *M. fragrans* and *M. argentea* as rootstocks, but they were not successful in the long run (Flach, 1966). In Kerala, India, limited success has been obtained by progressive cultivators with budding.

As early as in 1894, grafting experiments had been undertaken in the Botanical garden at Bogor, Indonesia (Deinum, 1932). In India, inarching or approach grafting was successfully done on root stocks of *M. fragrans*, *M. malabarica*, and *M. beddomei* (Sunderraj and Varadarajan, 1956). Those on *M. beddomei* and *M. malabarica* developed into low, spreading trees, whereas nutmeg seedlings generally develop into tall trees; the grafts came to flowering in 4-6 years of planting vs. 6-8 years by the seedlings. (Mem. Dept. Agric., Madras 1964). Rasalam (1978) claimed 100% success in approach grafting on seedlings of cultivated and wild species of nutmeg; when erect branches of female nutmeg trees were used as the scion, flowering commenced in the second year after grafting. Gopimani (1978) reported some success in slotted side grafting with male tree as the rootstock and defoliated branch of the female tree as scion. Kannan (1973) indicated that top working of male parents with shoots collected from female trees as scion material could be successfully done during the rainy months.

Kannan (1971) has reported the occurrence polyembryony in nutmeg. Raising of more than one seedling, usually 2, from a germinating seed by cutting longitudinally the root and shoot was reported by Flach(1966).

Production statistics

In Indonesia, nutmeg commences to fruit in the 8th or 9th year, but reaches their peak productivity only at about 25 years age; in the West Indies, it has been reported that the first bearing begins four years after planting, and commercial harvest is begun after 16 years (Guenther, 1952). In India (Courtalam and Burliar) the trees start flowering after about 12 years of planting (Anonymous, 1955). In recent times, Nair (1978) has observed that the tree start to bear from the 6th year, though the peak bearing period is reached after about 20 years only.

In the East Indies, the trees bear fruit almost round the year with the heaviest crops in May-June and August-September: in the West Indies also the trees produce fruit round the year but the harvest production is in August-September (Guenther, 1952). According to Cruickshank (1973) there are two distinct production peaks, in Grenada, January-April and September-October. The harvest calendar given by UNCTAD/GATT (Anonymous, 1977) shows April-June for Indonesia, February-April and August-September for west Indies, and February-March for Sri Lanka. In India,

though some crop is available throughout the year, the peak harvesting period is in June-August (Nair et al. 1977).

The fruit is ripe when the pericarp splits exposing the aril which covers the seed. In Indonesia, the fruits are pulled off the branches by hooked staffs, whereas in Grenada they are collected when they fall on the ground (Guenther, 1952). In Penang, Malaysia, the fruits are collected from the trees with the aid of bamboo sticks about 1 m long split several times close to one end and expanded to form a hollow cavity surrounded by a twopronged projection (Parry, 1969). Only the fruits harvested at exactly the right time, i.e., within one day after splitting, yield the best quality of nutmeg and mace (Flach, 1966).

After harvesting, the mace is pealed off the seed and dried in the sun or artificially (Hagreis, 1936). The seeds are dried on so-called smoklofts, under which a smouldering fire is maintained (Flach, 1966). The temperature at drying should not exceed 45°C, because at higher temperatures, the fat in the nutmeg begins to melt.

After 4-6 weeks the nutmegs are dry and they rattle in their shells. They are then removed and finally graded into the following qualities (Flach, 1966): (*i*) Sound and undamaged nutmegs: This is again divided into five grades in East India on the basis of the numbers per 500 gm (75-80 nutmegs, grade A; 80-90, grade B; 90-105, grade C; 105-125, grade D; and 125-160, grade E). (*ii*) Shrivelled nutmegs and (*iii*) Broken and wormy nutmegs.

The products should be kept dry to prevent insect and mould infestation. (Slooff, 1949). Insects are killed by fumigation by methylbromide in Indonesia (Cagliardi, 1949) and carbon disulphide in Grenada (Ruinard, 1961).

The freshly removed mace is flattened out by hand, spread on bamboo trays or mats and dried in the sun for 4-5 hours a day for a fortnight; during dry weather drying ma be accomplished in 2-3 days (Guenther, 1952). Great care must be taken to prevent the mace from becoming mouldy. When fresh, the mace possesses a brilliant red colour, which changes to orange on drying, and yellow after a few months. A perfect sample of mace should consist of entire double blades (not broken), flattened and of large size, horny in texture, not too brittle, and of good, clear, and bright colour (Ridley, 1912). The different grades of nutmeg and mace reported by Guenther (1952) are Banda Nutmeg and Mace (commercially the finest), Siauw Nutmeg and Mace Penang Nutmeg, and Java Estate Nutmeg and Mace.

In Grenada, the best plantations give an average production of 1500 fruits/tree and in the new and adequately spaced plantations, production reaches 700 kg of nutmeg and 140 kg of mace per ha/year. If the number of trees in these plantations is estimated at 100 female trees/ha, this would mean 7 kg nutmeg and 1.4 kg mace/tree (Flach, 1966).

The average production in Sri Lanka is approximately 4000 fruits/tree/Year; the maximum production is said to be 12,000 (Swing 1949). In India, a 10 year old tree may yield 500-800 fruits, at 20 years 2000-3000 fruits and a full grown tree 3000-10,000 fruits annually (Shanmugavelu and Rao, 1977). A yield of 1500-2000 is a good average and works out to 6-8 kg (Abraham, 1957). Nair (1978) reports that a good average tree yields about 1000 fruits/year, though yields may vary from few hundreds upto 10,000. Bisexual trees also yield fruits; but their number is considerably less compared to female trees (Flach, 1966).

The average weight of a shelled nutmeg is 3.9 g, shell 1.7 g, and mace 1.02 g with a ratio of 3.86: 1 for shelled nutmeg to mace (Flach, 1966).

Trade

During 1971-75, the international trade

of nutmeg and mace came to about 8,400 tons, valued at US $16.5 million, the proportion of nutmeg to mace was 8:1. USA the EEC countries, Japan, and East European countries are the chief importers (Anonymous, 1977).

Composition

According to Gopalan et al (1971) analysis of nutmeg gave the following values: moisture 14.3%; protein 7.5%; ether extract 36.4%; carbohydrates 28.5%; fibre 11.6%; mineral matter 1.7%; calcium 0.12%, phosphorus 0.24%; iron 4.6 mg/100 g. The principal constituents of nutmeg are a fixed oil (fat), volatile oil, and starch. The flavour and therapeutic action are due to the volatile oil whose content varies from 6-16% based on the origin and quality of nutmeg (Nair, et al. 1949; Guenther, 1952; Lewis et al. 1976). Wormy nutmegs give a much higher yield of volatile oil than do sound ones and commercial oil is derived from broken and wormy nutmegs (Guenther, 1952). Nutmeg oils obtained from different regions varied in composition and these differences affected the flavours (Baldry et al., 1976). Shulgin and Karlinger (1964) distilled nutmeg oil and got three fractions, a terpene fraction, a myristicin and elemicin fraction, and a heavy oil fraction (Sammy and Nawas, 1968). The major components of nutmeg oil are 10 monoterpene hydrocarbons, 6 monoterpene alcohols, one sequiterpene, and 5 aromatic ethers (Sammy and Nawas, 1968). Loss of volatile oil from ground nutmeg is relatively rapid (Clevenger, 1935, cited by Guenther, 1952).

Nutmeg contains 38-43% of ether extractable material which includes essential oils, a small amount of resin, and a substantial portion of unsaponifiable material, in addition to the glycerides (Echey and Miller, 1954). Commercial preparation of nutmeg butter is usually obtained by pressing of the ground and cooked or steamed kernels, rather than by extraction. The yield is 24-30%. It is a solid, yellowish red fat possessing a nutmeg odour. Nutmeg fat contains 8 fatty acids, myristic acid forming the largest component (Sammy and Nawas, 1968).

Nutmeg starch resembles legume starches in appearance. The grains are irregular in shape and vary in size from 5 μ to 50 μ (Thorpe, 1945-56).

The mace contains the following: moisture 15.9%; protein 6.5%; ether extract 24.4%; carbohydrates 47.8%; and phosphorus 0.10% iron 12.6 mg/100g) (Gopalan, Sastry, and Balasubramanyan, 1971). The oil closely resembles nutmeg oil in odour, flavour, and composition and trade makes no distinction between them (Guenther, 1952).

Mace yields a fat similar to that from nutmeg, but in a much smaller amount. A sample of Indian mace gave 26% of red coloured fat on extraction with carbon tetrachloride (Pishawikar and Pishawikar, 1953).

The leaves of *M. fragrans* have 0.41-0.62% of a light brown volatile oil with a pleasing spicy odour on water distillation (Khan and Krishnaswamy, 1954). Steam distillation of dried leaves in East Indies gave 1.56% of a colourless volatile oil (Guenther, 1952). Volatile oil can be extracted from the bark and flowers (Wealth of India, Vol. 6, 1962). Fresh pericarp from ripe fruit contains an acidic astringent juice with an aromatic flavour (Burkil, 1935).

Uses

Nutmeg is a stimulant, carminative, astringent, aphrodisiac, and hallucinogen; it is used in tonics and electuaries and forms a constituent of preparations prescribed for dysentry, stomach ache, flatulence, nausea, vomitting, malaria, rheumatism, sciatica, and early stages of leprosy. It is also used in inducing abortion. Mace is used for flavouring cigretts and chewing to mask foul breath (Nadkarni and Nadkarni, 1954; Chopra et all., 1958; Anonymous, 1962. 1968; Weil, 1965; Rosengarten, 1973; Lewis and Elvin-Lewis, 1977; Stanford et al. 1978). Oil of nutmeg or mace is employed for flavouring food products and liquers, soaps, tobacco dental creams and perfurmery products. It is also used in medicine (Guenther, 1952; Lewis and Elvin-Lewis, 1977). The volatile oil from the leaf has weedicidal properties. It may also be used for scenting soaps, dentrifices, chewing gums, and tobacco (Khan and Krishnaswamy, 1953). Nutmeg butter is used as a mild external stimulant in ointments, hair lotions, and plasters and is used in cases of rheumatism, paralysis, and sprains. It is also used in perfumes for imparting a spicy odour and in the manufacture of soaps and candles. Nutmeg butter is sometimes substituted by fats from other *Myristica* species (Wealth of India, Vol. 6, 1966). Alcoholic extracts of nutmeg show antibacterial activity against *Micrococcus pyrogenes* var. *aureus* (George et al. 1947). Aqueous decoctions are toxic to cockroaches, myristicin present in the kernal may be employed as an additive to pyrethrum to enhance the toxicity of the latter to houseflies (Jacobson, 1958).

The fleshy pericarp of the fruit, which is also some-what aromatic, is used for making pickles and gelly (Abraham, 1957). A mixture of nine spices including nutmeg and mace used in Lebanon bolonga formulation, enhanced fermentation of sausages (Zaika et al., 1978).

Recently the whole oil of nutmeg was found to increase the duration of sleep induced by ethanol in young chickens (Sherry et al. 1978). Oleoresin can be extracted from nutmeg (Adamson, 1971) and this is being increasingly used for various purposes in the USA (Stahl, 1973).

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