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Nutmeg: A review on uses and biological properties

Namra Naeem[1], Rafia Rehman[1], Ayesha Mushtaq[1]*, Jihene Ben Ghania[2]

[1]Department of Chemistry, University of Agriculture, Faisalabad-38040-Pakistan and [2]Department of Biology, Faculty of Sciences, University of Tunis. E.I Manar Tunis

Abstract

Myristica fragrans is an annual spice belonging to the family Myristicaceae. It has been cultivated throughout the world and used for food flavoring, essential oil applications and in traditional medicines. Mostly nutmeg contains terpenes and phenylpropenes. Chemical composition of these constituents varies due to different cultivation conditions. Nutmeg is considered as essential ingredient of numerous industrial applications ranging from food to cosmetics. Its pharmaceutical products are also important due to its antioxidant and antimicrobial properties. More uses and applications of nutmeg byproducts are continuously added. Nutmeg is used as a constituent in preparations of medicines such as for dysentery, flatulence, stomachache, nausea, vomiting, rheumatism, sciatica, malaria and early stages of leprosy. More research on maximizing yield, optimum preservation and oil extraction methods are needed.

Key words: nutmeg, *Myristica fragransis*, myricticin, antioxidant, anticancer

Full length article **Corresponding Author*, e-mail: ayesha_mushtaq123@yahoo.com

1. Botany

1.1. Introduction

Nutmeg (*Myristica fragrans*) is an evergreen tree belonging to family *Myristicaceae*, a family of flowering plants indigenous to Asia, Africa, Pacific islands, and America [1] and has been known by most taxonomists. It is occasionally called the nutmeg family, due to its well-known member, *Myristica fragrans*, the source of the spices nutmeg and mace. The genus *Myristica* consists of about 150 species spread in the western Pacific and Asia. Nutmeg cross pollinate because of inadequate flowers of both sexes on one tree. *Myristica fragrans* is known by different names in the world. In India specifically in Hindi, it called as Jaiphal, and in Indonesia, is called as Pala. It is known as Josat at-Tib in Arabic. In Urdu, it is called as jaifal. In French, it is called as muscade, and in Greek is known as moschokarido. In China, it is called as roudoukou.

The main profitable species of genus *Myristica* is *Myristica fragrans*. Besides *M. fragrans*, numerous other species of *Myristica are* grown all over the tropical regions including *M. malabarica* (Indian), *M. argentea*, and *M. fatua*. Although there appearance is similar to *M. fragrans*, however, they have less intense taste, aroma and fewer prices.

1.2. History

Nutmeg originated in Indonesia (Banda Islands), and was discovered by Portuguese (1512). The importance of the nutmeg seed was propagated by the Dutch. The name Nutmeg comes from Latin word *nux muscatus*, *meaning* "musky nut" [2].

1.3. *Demography/Location*

Although nutmeg grows in warm climatic and environmental conditions, but hot, humid climate without pronounced dry season are the key ecological requirements for its cultivation. Nutmeg is also very susceptible to frost damage. It grows well in areas with sandy loam, clay loam and red laterite soils. It is broadly cultivated in China, Indonesia, Taiwan, Malaysia, India, Grenada, South America and Sri Lanka.

Absolute figures for nutmeg production are difficult to obtained, but average world production of nutmeg is approximated between the ranges of 10,000 to 12,000 tons per year with annual world requirement approximated at 9,000 tons. Grenada and Indonesia govern production and transport of nutmeg by sharing 20% and 75% of world market respectively.

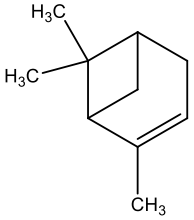
1.4. Botany, Morphology, Ecology

The areas about 1300 m above sea level are considered ideal for its development. *Myristica fragrans* tree is 25 feet high, having plenty of yellow juice and has a grayish-brown smooth bark. The branches scattered in whorls. The petioles are about 30 cm long. The leaves are alternate and glabrous. They are obtuse at base, elliptical, aromatic, acuminate, glossy and dark green above, paler underside and 4-6 inches long. The flowers are dioecious and small auxiliary racemes. Fruit is round drupe, pendulous

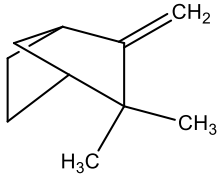
and composed of a succulent pericarp. The seed is fleshy, firm, whitish, transversed by red-brown veins, rich in oil. The tree has strong, delightful and peculiar smell and a strong sharp aromatic flavor. Nutmeg requires a warm and humid tropical climate. Annual daytime temperature requirements are within the range of 22 - 34°C is considered optimum for its growth, but it can also tolerate 12 - 38°C. Nutmeg requires well drained, fertile soil with high content of organic matter. It grows well in soils with pH 6.5-7.5. Its optimum growth has been observed 2000-3500 mm rainfall.

2. Chemistry

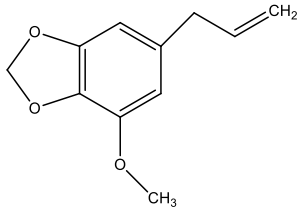
Nutmeg contains fats (30-40%) and essential oils (10%). Essential oil is generally characterized by GC-MS analysis [3-7]. The distinctive odor of nutmeg is due to presence of essential oil which contains terpenes (α-pinene, p-cymene, sabinene, camphene, myrcene and γ-terpinene) terpene derivatives (terpinol, geraniol, and linalool) and phenylpropanes (myricticin, safrole, and elmicin) [8]. Structures of important compounds found in nutmeg are mentioned in figure 1. Nutmeg shows hallucinogenic effect which is due to the presence of hallucinogenic phenyl-propanes. These phenylpropanes are hepatotoxins and are considered being harmful for frequent users.



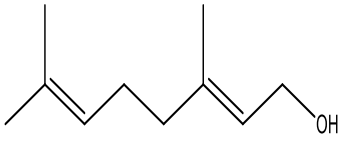
α-pinene



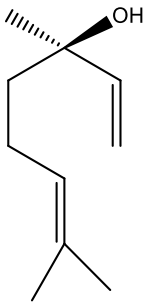
Camphene



Myricticin



Geraniol



Linalool

Figure 1. Structures of some important chemicals present in nutmeg oil

3. Value addition

Nutmeg is a major spice that earns farmers a fair income. They often discard its pericarp. But, it is no longer so. A variety of value-added products can be made from nutmeg especially in spicy and sweet dishes like custard, pies, spice cakes, cookies, soups, sauces, cheese, vegetables and egg dishes. Mace is usually used in dishes that are light in color for giving it bright orange, saffron like color. Several products from the pericarp of nutmeg are also made. Nutmeg can be a key ingredient in jam, pickle-, syrup and squash says that they can be produced by farmers at their homes with minimum investment. In fact these products, if properly made and promptly marketed, can earn the farmers a bigger fortune than they make from nutmeg and mace themselves. In general, nutmeg completely dried kernels can also use directly in the cooking even they are either milled or grated just before being added in the cooking (in last minutes). Nutmeg is also used in many cosmetic products like shampoos, soaps, shaving creams, perfumes etc. It is also used in making balms and syrups for medicinal purposes.

4. Uses

Nutmeg has many uses ranging from culinary to medicinal. Nutmeg has been used in cooking for millennia. It is used in soups as well as in meats and vegetables. It is easily blended with other spices like white pepper, cloves and ginger; further, all spice and cinnamon are optional ingredients. Nutmeg essential oil is also used in the manufacturing of camphor, plasticizers, bases, solvents, perfume and synthetic pine oil. Nutmeg contains many chemical compounds that are identified as anti-oxidant, health promoting properties and disease preventing. The spicy nuts have fixed oil in the form of trimyristin and also essential (volatile) oils which gives sweet fragrant flavor to nutmeg. These active compounds in nutmeg have numerous curative uses in traditional medicines as anti-depressant, anti-fungal, digestive, aphrodisiac, and carminative. Since ancient times, in Chinese and Indian traditional medicines nutmeg and its oil were being used for illnesses associated to the digestive and nervous systems. The compounds such as elemicin and myristicin in this spice have stimulant as well as brain soothing properties. In dentistry, for toothache eugenol has been used to relief the pain. To reduce

rheumatic pain and muscular pain of joints, oil is used for local massage. With honey freshly prepared decoction has been used to relief of gastritis, nausea, and indigestion disorders. Whole kernels usually preferred over powdered form because they have additional essential oils, which gives rich taste and freshness to recipes. Recently, research showed that mace lignin could be used as a skin whitening agent because it inhibits melanin biosynthesis effectively.

5. Pharmacological uses

5.1. Antioxidant activity

Nutmeg possesses antioxidant activity due to the presence of various compounds including β-caryophyllene and eugenol, having hydrogen atoms in the allylic or benzylic positions. Because of the comparatively simple abstraction of atomic hydrogen from these functional groups, these compounds have high antioxidant activity. The abstraction of atomic hydrogen is done by peroxy radicals that produced under oxidative stress. In another view, role of Eugenol in nutmeg favors the antioxidant property by promoting the activities of superoxide dismutase, catalase, glucose-6-phosphate dehydrogenase, glutathione peroxidase and glutamine transferase enzymes [2].

The compounds having catechol like structure as in caffic acid are considered to be good antioxidants as they easily donate electrons or phenolic hydrogen to the acceptors, such as lipid peroxyl groups or reactive oxygen species. Calliste *et al* (2010) stated that lignan derivatives are considered as a class of compounds that shows the antioxidant potential of nutmeg seeds [9]. After absorption of lignans and their glycosides into the body, they are metabolized to produce biologically active compounds having catechol structures that are responsible of high antioxidant property of nutmeg seeds.

5.2. Immuno-modulatory and radio-protective activities

The lignans present in fresh nutmeg and mace show radio modifying and immune modulatory properties, present in the aqueous extract of fresh nutmeg maceThese properties found in cell free systems and protected PUC18 plasmid against radiation that induced DNA damage. The mammalian splenocytes in response to polyclonal T cell mitogen concanavalin A (Con A) proliferate. This process is inhibited by these mace lignans which was due to G1 phase of cell cycle and augmentation of apoptosis as presented by increase in pre G1 cells. The increase in activation of induced cell death by mace lignans was depending on the dosage. Splenocytes are protected by mace lignans against radiations. These radiations induced by producing intracellular reactive oxygen species depending on the dose. Mace lignans was not cytotoxic for lymphocytes. On the other hand, in splenocytes the radiation-induced DNA damage is inhibited by decreasing DNA fragmentation [10].

5.3. Antimicrobial activity

The essential oil and different extracts of aromatic plants have shown strong antimicrobial activity against variety of fungi as well as bacteria [11]. Narasimhan *et al* (2006) demonstrated the antibacterial activity by preparing chloroform extract of nutmeg against both gram negative and gram positive bacteria. They found myristic acid and trimyristin are the main antibacterial compounds extracted from nutmeg seeds. Researchers isolated three lignans (meso-dihydroguaiaretic acid, nectandrin-B and erythro-austrobailignan-6) showing antifungal activity, from the methanolic extract of nutmeg seeds [12]. The development of wheat leaf rust and rice blast was suppressed by these three lignans. Some compounds like carvacrol, γ-cymene, α-pinene, β-pinene, and β-caryophyllene are reported to be antimicrobial present in essential oil of nutmeg seeds [13]. Some plant phenolics are also reported for antimicrobial activity. Antifungal and anti-inflammatory activities of plant essential oil are due to the presence of β-caryophyllene [14]. α-Pinene and β-pinene which are monoterpene hydrocarbons are also antimicrobial agents. They are considered to be involved in membrane disruption [15]. Carvacol is another significant compound for antimicrobial activity. Carvacol works in the same way as the other phenolic compounds, which work through membrane destruction, resulting in an increase in permeability of membrane to potassium ions and protons, proton-motive force disruption and intracellular ATP pool depletion. γ-Cymene (a precursor of carvacrol) could also be an important component. It has been demonstrated that γ-cymene works synergistically with carvacrol in membrane enlarging, which results weakening of the membrane while alone shows weak antibacterial activity [16]. It has been proposed that antimicrobial activity is due to the minor and major both compounds; while it is feasible that the major compound controlled by other minor compounds [17].

5.4. Anti-carcinogenic and hepatoprotective activity

Nutmeg shows resistance against carcinogenic elements. Hussain and Rao, (1991) reported that, in Swiss albino mice uterine cervix, 3-methylcholanthrene -induced carcinogenesis could be prohibited by mace oral administration [18]. Nutmeg also shows hepato-protective activity. This property observed in rats with damaged liver, by giving nutmeg in their diets. Kyriakis *et al* (1994) studied on the activities of hepatic carcinogen-metabolizing enzymes, like aryl hydrocarbon hydroxylase, cytochrome P-450, and acid soluble sulphhydryl and glutathione-S-transferase level in albino mice and checked the influence of essential oil from nutmeg [19]. They found that the essential oil hinders the activities of the host enzymes related with detoxication and activation of xenobiotic components, as well as mutagens and chemical carcinogens.

5.5. Anti-inflammatory activity

Several authors reported anti-inflammatory activity of nutmeg as well as its oil [20]. Similar to non-steroidal anti-inflammatory drugs, pharmacological activities also exhibited by nutmeg oil [21]. But anti-inflammatory activity is shown only by petroleum ether extracts. The total extract of nutmeg activated an enzyme that is AMP-activated

protein kinase enzyme (potential therapeutic target) for curing the metabolic syndrome including type-2 diabetes and obesitys. Seven compounds like tetrahydrofuroguaiacin B, 2,5-bis-aryl-3,4-dimethyltetrahydrofuranlignans, fragransin C_1, saucernetindiol, nectandrin B, verrucosin, galbacin and nectandrin A were isolated from this extract as an active constituents. Some of the isolated compounds produced strong AMPK stimulation in differentiated C_2C1_2 cells, at 5μM concentration. Nutmeg and its active components not only used to treat type-2 diabetes and obesity but also for the development of agents other metabolic disorders [22].

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