Myristica fragrans (Jaiphal): A Significant Medicinal Herbal Plant

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ABSTRACT

The tradition of using herbal drugs and herbal remedies for treating human ailments is very old. From last few years, the demand of herbal remedies has been increased. Myristica fragrans Houtt, commonly known as nutmeg, is a very common spice, which is used around the world. It is described in almost every medicine system such as Ayurveda, Siddha, Unani and folk system. It has wide range of fixed oils and essential oils in it for example myristicin, safrole, myristic acid, trimyristicin, eugenol, elmicin and meso-dihydroguaiaretic acid. Myristica fragrans Houttis well considered medicinal plant for its extraordinary properties like aphrodisiac, hepatoprotective, antimicrobial, anti-diabetic, anti-oxidant, anti-cancer etc. The review aim is to provide data/information related to medicinal herbal plant called Myristica fragrans such as its phytomedicinal value in traditional medicine systems like Ayurveda and folk system, its therapeutic uses and associated toxicity.

Keywords- Jaiphal, Rasapanchak, Myristic acid, Campesterol, Aphrodisiac.

I. INTRODUCTION

Nature is served as primary source of numerous medicines for thousands of years [1,2]. Medicinal plants/herbs hold a great significant value than rest of the plants. Medicinal plants/herbs possess phytochemical constituents that are medically important and are used for developing new drugs [3,4]. Kingdom plantae is also entitled with “the treasure house of many important drugs”. The use of plants for health benefits and other purposes is a very common tradition, which has been in practice since ancient times [5]. In the old times plants were the only source of most of the medicinal preparations [6]. Medicinal products/products derived from the plants are often named as herbal drugs, botanical drugs, botanicals, phytomedicines, traditional medicines, herbal medicines, traditional Chinese medicines (TCMs), traditional herbal medicinal products, natural health products, or plant food supplements. These herbal drugs have several advantages over the synthetic drugs such as their easy availability, safety, low cost, efficiency, negligible side effects [7,8,9]. Most of the modern drugs in the present times have derived from plant sources. As per the data resources, in industrialized countries tropical plants are the direct or indirect sources where quarter of the medicines have been derived from [10,11,12]. The practice of using plants for the treatment of several human ailments is as old as origin of mankind [13,14]. As per the WHO reports on the use of medicinal plants, it has observed that 80% of the total population in developed countries of the world depends primarily on herbal medicines to maintain their overall health and fulfill their day to day requirements [15,16,17,18]. India is one of the countries, which are categorized under world biodiversity centers. India has a very rich history of utilizing medicinal plants. It is a home to more than 45000 various species of plant and this is the reason why India is called as the Botanical garden of the world [19,20]. Many traditional systems of medicine such as Ayurveda, Siddha, Unani Folk system and as well as allopathy use medicinal plants in diseases treating practices [21]. Ayurveda is the most ancient system of medicine known in India which uses almost 600 different medicinal herbs/plants and their parts such as leaves, roots, fruits and stem and their formulations in treating variety of diseases [22,23]. Almost 25% of the population in U.K. uses herbal drugs in their daily routine [24]. Since 4000 years, traditional medicines have been in practice in Africa. As per the sources, African population still relies upon herbal drugs [25,26,27]. In the compendium of Materia Medica (an ancient encyclopedia of traditional Chinese medicine), there is a description of more than 1,000 plant species [28]. In China plants are being in use for maintaining health in the form of dietary therapy for many years [29,30]. More than half of the drugs out of 104 global drugs, which are used for last 37 years, have been come from the plant sources [31]. Traditional medicines are serving as the main healthcare system among almost 27% of the South African population [32]. Herbal medicines play a vital role in the health maintenance of West African population [33]. 85% Swazi and Nigerian population depends upon traditional herbal drugs [34,35]. Herbal medicines are used in almost each and every corner of the world. One such valuable medicinal plant is Myristica fragrans Houtt (figure1). It is a well-known spice in the world, which is commonly called as Jaiphal and Javitri in India. It belongs to the Myristicaceae family. This medicinal plant produces two spices named as mace and nutmeg respectively. The seed kernel inside the fruit is termed as nutmeg whereas the
red lacy covering (aril) present on the kernel is called as mace. Dried kernel is the most important part of *Myristica fragrans* in terms of pharmacological activity [36,37]. The name nutmeg has come from Latin word nux muscata, which means “musky nut”. It is believed that Portuguese discovered nutmeg in 1512. Arabs introduced nutmeg to Europe in the middle ages through the Venetians. It was used as a remedy to plague by Italians whereas Indians and Egyptians used it to treat problems related to intestine and embalming. In 19th century, its effect on Central Nervous System was observed for the very first time. Nutmeg was in the list of the expensive spices of the world in the earlier times. It was known as the hot-food [38]. It is commonly used as spice, which is found in almost every kitchen to add flavor in many dishes especially in North India where it is used as an ingredient of garam masala. Its oil is used in jam, chutney and juices, soft drinks, tea and also mixed with milk and alcohol [39,40,41]. It is used in bakery and confectionary products, pudding, meats, sausages, sauces [42]. In traditional systems of medicine such as Ayurveda and folk system this plant is used in treating different variety of human ailments due to the presence of different kind of phytochemical constituents in it such as alkyl benzene derivatives (myristicin, elemicin, safrole etc.), terpenes, alpha-pinene, beta-pinene, myristic acid and triacylglycerols like trimyristin, phenolic compounds, flavonoids, tocopherol, ascorbic acid, essential oils and many more [43,44]. Its essential oil is useful against sprains, muscle pulls etc. [46]. The most common uses of *Myristica fragrans* is used as a carminative, anti-inflammatory, analgesic, diuretic, anti-pyretic, hypolipidemic, aphrodisiac, anti-ulcerogenic, anti-oxidant, hypnotic, hallucinogenic, antispasmodic, and as a stimulant agent. It enhances the digestion. It is used as remedy for nausea, stomachache, headache, vomiting, diarrhoea associated with cholera. It is helpful in treating the problems related to spleen, liver, and eyes. It significantly enhances the blood circulation, boosts up the brain functioning [47,48,49,50]. Vernacular names and Taxonomy of *M. fragrans* is given in table 1&2.

### Table 1: Vernacular Names of *Myristica fragrans* [51]

<table>
<thead>
<tr>
<th>Language</th>
<th>Name</th>
</tr>
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<tbody>
<tr>
<td>English</td>
<td>Nutmeg</td>
</tr>
<tr>
<td>Sanskrit</td>
<td>Jati-phalam, malathi-phalam</td>
</tr>
<tr>
<td>Hindi</td>
<td>Jaiphal, multi phal</td>
</tr>
<tr>
<td>Assamese</td>
<td>Jayphal, kanivish, jaiphal</td>
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<tr>
<td>Bengali</td>
<td>Jayphala, jaepatri, jaepatri</td>
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<tr>
<td>Burmese</td>
<td>Zadi-plu</td>
</tr>
<tr>
<td>Kannada</td>
<td>Jadikai, jaykar, jajakai</td>
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<tr>
<td>Kashmiri</td>
<td>Jafal, zafal</td>
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<tr>
<td>Malayalam</td>
<td>Jatika, bush.</td>
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<tr>
<td>Marathi</td>
<td>Jaiphal</td>
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<tr>
<td>Oriya</td>
<td>Jaipholo</td>
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<tr>
<td>Punjabi</td>
<td>Jaiphal</td>
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<tr>
<td>Tamil</td>
<td>Sathkhai, jathikkai, jadikkay, jadikai, jatikkai</td>
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<tr>
<td>Telugu</td>
<td>Jajikaya</td>
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<tr>
<td>Gujarati</td>
<td>Jaiphal, javantri</td>
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<tr>
<td>Urdu</td>
<td>Jauzbuwa, jaiphal</td>
</tr>
<tr>
<td>Arabic</td>
<td>Jowz buwwa, jouza atteeb, josat attib</td>
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<tr>
<td>Sindhi</td>
<td>Jafar, jadika</td>
</tr>
<tr>
<td>Chinese</td>
<td>Daau kau syuh, yuhk dauh kau</td>
</tr>
<tr>
<td>Dutch</td>
<td>Nootmuskaat, muskaatnoot</td>
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<tr>
<td>French</td>
<td>Muscadier, musque</td>
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<tr>
<td>German</td>
<td>Achter muscatnussbaum</td>
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<tr>
<td>Hebrew</td>
<td>Egos muskat, egoz musqat</td>
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<tr>
<td>Russian</td>
<td>Opex muskatnyj orekh.</td>
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<tr>
<td>Armenian</td>
<td>Meshgengouz, Mshkenkoyz, Mekenkouz</td>
</tr>
<tr>
<td>Greek</td>
<td>Moschokarido</td>
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<tr>
<td>Indonesian</td>
<td>Pala</td>
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<tr>
<td>Italian</td>
<td>Noce moscata</td>
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<tr>
<td>Portuguese</td>
<td>Nozmoscada</td>
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<td>Romanian</td>
<td>Nuçoară</td>
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<td>Turkish</td>
<td>Hindistancevizi</td>
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<tr>
<td>Uzbek</td>
<td>Musqat</td>
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<tr>
<td>Persian</td>
<td>Djuh hendi, jouz hendi, jozbaweh</td>
</tr>
<tr>
<td>Unani</td>
<td>Fuqlaj, moschokarido</td>
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<tr>
<td>German</td>
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<td>French</td>
<td>Muscadier, musque</td>
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<tr>
<td>Indonesian</td>
<td>Pala</td>
</tr>
<tr>
<td>Spanish</td>
<td>Moscada, nuez moscada</td>
</tr>
</tbody>
</table>

Figure 1: *Myristica fragrans*
II. MORPHOLOGY OF MYRISTICA FRAGRANS

Myristica fragrans is a unisexual, aromatic, evergreen plant, which reaches up to the height of 5–13 m and sometimes may reach up to 20 m. Bark is greyish to black in color. A sticky pink or red sap exudes out when bark get injured. Slender twigs are present towards the upper side of diameter 1-2 mm. Simple alternate leaves are present which are chartaceous in nature. 1 cm long petiole is present. Elliptical to lanceolate blade is present with acute base and margins are present all over the surface. Upper surface of the leaf is shiny which is of dark green in color whereas the lower surface of leaf is pale green in color. Axillary inflorescences are present in, in umbellate cymes. There is presence of 1–10 flowers in male cymes whereas in female cymes 1–3 flowers are present. Flowers are usually pale yellow in color having fragrance in them and sparse glabrescent is present with minute tomentum and there is presence of 3–lobed perianth. On a slender pedicel of thickness less than 1 mm, 5–7 mm long male flowers are present which have 8–12 stamens. Whereas female flowers are slightly longer than the male flowers. There is presence of 1-celled ovary in the female flowers, which is superior and sessile having single basal ovule in it. 5–8 cm long subglobose yellowish fleshy fruit is present with a long medial groove which is usually berry or drupe-like in shape. Fruit splits out into two halves on ripening with the presence of one seed. The seeds of M. fragrans are 2–3 cm long with broad ovoid structure. A laciniate red aril is present around the shiny dark brown seed. Seeds are usually hard and stony which are wrinkled in a longitudinal direction. On getting dried aril starts becoming horny and brittle and turns into yellowish-brown colour. There is a presence of small embryo and ruminate endosperm in the kernel where essential oils are stored [52].

III. GEOGRAPHICAL DISTRIBUTION OF MYRISTICA FRAGRANS

Myristica fragrans is a native medicinal herb of Moluccas and Banda Islands in the South Pacific. It is grown in tropical areas, mainly in Indonesia, Grenada in the West Indies and Sri Lanka. In India it is found primarily in South India particularly in certain pockets of Kerala, Tamil Nadu and Karnataka. Indonesia and Granada are the major producers of Myristica fragrans with the production rate 75% and 20% respectively. In Indonesia nutmeg primarily comes from North Sulawesi [53,54,55].

IV. PHYTOCHEMICAL CONSTITUENTS OF MYRISTICA FRAGRANS

Myristica fragrans is known for presence of different phytochemical constituents in it such as fixed oils, volatile oils, starch, cellulose, pentosans, resin, and mineral elements and many more [56,57,58].

Fixed oils

Lipids are the main fixed oils, which are present in Myristica fragrans for eg. myristic, petroselinic, and palmitic acids. Myristic acid constituent 74.9% of the total lipid content of nutmeg. Trymiristin is the major fixed oil of this plant. Nutmeg butter (expressed/extracted fixed oil) is composed of saturated fats (90%) with 10% unsaturated fats. Other compound of fixed oils are Monoterpene hydrocarbons, oxygenated monoterpenes, sesquiterpenes, alkenes, aromatic ethers, aromatic monoterpenes, organic acids [59,60,61,62,63].

Essential oils

As per the reports of experimental study conducted by Kapoor et al., by using cleveger and soxhlet apparatus, it was revealed that there is vast variety of essential oils present in this medicinal plant such as α-Thujene, α-Pinene, camphene, sabine, β-Pinene, myrcene, α-Phellandrene, 3-Carene, α-Terpinene, p-Cymene, limonene, β-Phellandrene, γ-Terpine, cis-Sabinene hydrate, terpinolene, trans-Sabinene hydrate, cis-p-Menth-2-en-1-ol, trans-p-Menth-2-en-1-ol, Terpinen-4-ol, p-Cymen-8-ol, α-Terpineol, cis-Piperitol, trans-Piperitol, citronellol, bornylacetate, safrole, α-Cubebe, terpenyl acetate, citronellyl acetate, α-Copaene, geranyl acetate, methyl eugenol, β-Caryophyllene, trans-α-Bergamotene, α-Humulene, myristicin, elemicin, docosane [64]. Maruzuki et al., extracted myristicin, elemicin, safrole, (iso) eugenol by using hydro-distillation method [65]. Sabine, myristicin, elemicin, α-pinene, β-pinene, limonene, terpinen-4-ol and myristic acid were reported by Morsy et al., by using 1:4 of material and absolute ethanol ratio at room temperature [66]. Myristicin, elemicin, safrole, eugenol and eugenol derivatives are categorized under phenylpropanoids.

Table 2: Taxonomy of Myristica fragrans

<table>
<thead>
<tr>
<th>Taxonomic Rank</th>
<th>Taxon</th>
</tr>
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<tbody>
<tr>
<td>Kingdom</td>
<td>Plantae</td>
</tr>
<tr>
<td>Subkingdom</td>
<td>Viridiplantae</td>
</tr>
<tr>
<td>Infra kingdom</td>
<td>Streptophyta</td>
</tr>
<tr>
<td>Division</td>
<td>Tracheophyta</td>
</tr>
<tr>
<td>Subdivision</td>
<td>Spermatophyta</td>
</tr>
<tr>
<td>Class</td>
<td>Magnoliopsida</td>
</tr>
<tr>
<td>Superorder</td>
<td>Magnoliaceae</td>
</tr>
<tr>
<td>Order</td>
<td>Magnoliaceae</td>
</tr>
<tr>
<td>Family</td>
<td>Myristicaceae</td>
</tr>
<tr>
<td>Genus</td>
<td>Myristica</td>
</tr>
<tr>
<td>Species</td>
<td>fragrans</td>
</tr>
<tr>
<td>Common name</td>
<td>Nutmeg</td>
</tr>
</tbody>
</table>
Ligands
The presence of ligands like 8-O-4′ neolignans, for example, ‘erythroΔ8-4,7-dihydroxy-3,3′,5′-trimethoxy-8-O-4′neolignan and Δ8′-4-hydroxy-3,3′,5′-trimethoxy-8-O-4′-neolignan, have been reported [67,68].

Sterols
As per the report of study conducted by Khatib et al., sitosterol is the predominant sterol found in M. fragrans. Other sterols which are present in this medicinal plant are campesterol, desmosterol, and lanosterol [69,70].

Others
It contains minerals like potassium, phosphorus, and magnesium, calcium, iron. M. fragrans contains fair amount of vitamins like riboflavin, thiamine, niacin. It also contains fibers, carbohydrates and starch, flavonoid like epicatechin, phenyl propanoid ethers [71, 72].

Properties and uses of Myristica fragrans [79,80]
Sansthanik karm-nahaya: Its topical applications include its use an anti-inflammatory and analgesic agent. It is beneficial for skin disorders, acts as an air freshener. It is used in treating cold and headache. It is used against join inflammation in lepa form. It is useful in removing the foul smell of wound.

Abhyantar- nadi sansthan: It is an analgesic and antiepileptic agent. It is used in treating insomnia, epilepsy and pain.

Paachan sansthan: It is used as an appetizer and anti-helminthic agent. It enhances digestion and increases the liver metabolism. It is used in the treatment of diarrhoea, dysentery, irritable bowel syndrome, constipation, lose motion, cholera. It reduces thirst.

Rakatwah sansthan: It is helpful in treating cardiac problems.

Swasan sansthan: It is used as an anti-mucolytic agent. It is helpful against cold, cough, asthma nd hickups.

Prajannan sansthan: It is an aphrodisiac. It is helpful in inducing menstruation and ovulation. It is used in treating erectile dysfunctioning, amenorrhea, dysmenorrhea.

Twacha: It is useful against various skin related disorders.

Satmikaran: It is used as an anti-pyretic.
Formulations: Due to its extra-ordinary therapeutic properties, *M. fragrans* is used in many herbal formulations [81].

Jatiphaladi churna: It is the most commonly used Ayurvedic polyherbal formulation in which *M. fragrans* is one of the main ingredients. It is used in treatment of diarrhoea, dysmenorrhea and cough, anorexia, nasal congestion, dyspnea, rhinitis. The description of Jatiphaladi choorna lepa is mentioned in Bhavapraksha [82,83].

Dashamularishta: It is a polyherbal formulation which is used by females after the childbirth to normalize the physiological processes. It is also helpful to get relief from fatigue and helpful in removing the dead cells from the body and stimulates the regeneration of cells. It is used as a sedative and tonic. *M. fragrans* is used in general class of herbs in this herbal formulation [84].

b. Folk View

*Myristica fragrans* is an important and most commonly used medicinal plant around the world. It is used in many folk cultures for its numerous therapeutic properties and food enhancing properties. It is used as a medicinal drug as well as cooking spice in many cuisines around the world. For instance, in Maluku Province of Indonesia and Central and East Java *M. fragrans* is used for the treatment of diarrhea, mouth sores, and insomnia [85]. Maluku people use *M. fragrans* oil to keep their body temperature warm [86]. The fruits of *M. fragrans* are used as anti-parasitic in Enugu State of Nigeria [87]. In Kaduna State, Nigeria, this medicinal plant is used as a spice [88]. In South Aceh, Indonesia *M. fragrans* fruit is used in cooking as a spice. [89] In China, people use nutmeg as a spice in hotpots [90]. Chinese people use seed powder in the treatment of dysentery [91]. In Tanane Province of Southwest Morocco, people use seed powder in the treatment of problems related to respiratory system, digestive system, skeleton, genital [92]. People in Republic of the Union of Myanmar, use seeds of *M. fragrans* for treating piles and leucorrhrea [93]. In Bhutan the seeds are used as anticephalagic and adaptogen. They are used to treat vertigo, dysphoria, insomnia, giddiness, headache and heart related problems [94]. In Aceh, people use this plant as a remedy for headache [95]. Batak people of North Sumatra, Indonesia use the fruits of *M. fragrans* plant as steam-bathing material. They also use this plant in the treatment of rheumatism, syphilis and tooth ache [96]. Fruits and seeds of *M. fragrans* are used in the preparation of oke sou which is an herbal drink used in Lako Akediri Village of North Moluccas Indonesia [97]. The Karonese people from North Sumatra, Indonesia use *M. fragrans* seeds against cancer, virility, child immunity [98]. Seeds are used for the treatment of neurological disorders in the Region of Middle Oum Rbia (Morocco) [99]. In Brazil, people use seeds in tea for soothing effect [100]. People in Bangladesh, use fruit powder of *M. fragrans* as a remedy for burning, general weakness, headache and insomnia [101]. In Chanpur and Andabaaaz villages in Bagerhat district, Bangladesh, kavirajes use seed and fruit of *M. fragrans* against paralysis, malaria, rheumatoid arthritis, leprosy and colic. They are also used as aphrodisiac agents [102]. Nigerian people use seed powder or decoction of the seeds against diarrhea, rheumatism and also use it as carminative, rubefacient. The seed powder is used in cooking to enhance the flavor and odor of the food [103]. In India it is used a sedative to treat various disorders related to nervous system [104]. In district Coimbatore, Tamil Nadu people use fruits of *M. fragrans* to heal mouth wounds and stomach wounds [105]. The tribal people of Kurumba, Tamil Nadu, use fruits in pickle form to cure problems related to digestion while the seeds are used along with the breast milk to provide immunity to the infants [106]. Traditional healers of Karimnagar district, Telangana, use *M. fragrans* leaves and fruits to treat nervous disorders [107]. In Deogarh district, Odisha, people use *M. fragrans* fruits in many home remedies [108]. The decoction of fruit is administered orally against dysentery in Chikmagalur district of Karnataka [109]. People use boiled seeds of *M. fragrans* along with with *P. nigrum, P. longum* and *O. tenuiflorum* to treat malaria in Karnataka [110]. In Paliyan tribes of Sirumalai Hills of Southern India, people use seeds along with milk to enhance their digestion [111]. In Rangamanti district, this medicinal plant is used against fever [112]. Some tribes of Gujarat use *M. fragrans* fruit against hemorrhoid [113]. In Rajasthan, the fruit of this plant is used in cooking as a spice and to enhance the flavor [114]. The Gaddi tribes of Kangra district of Himachal Pradesh use jaiphal along with ajwain seeds and choti elaichi to treat diarrhoea among infants [115]. In Assam, Jaiphal is used in treating dysmenorrhea [116]. Jaiphal is a very common home remedy for cough and cold [117].

c. Modern View:

In the modern times the herbal drugs are preferred more due to their several advantages over modern synthetic drugs made up of inorganic sources. Herbal drugs have negligible adverse impacts on the living systems also these are less expensive than synthetic drugs. But due to increasing market demand of these herbal drugs their quality is getting degraded due to factors like adulteration and contamination [118,119,120]. Unintentional adulteration of herbal drugs is induced by misidentification of species or sometimes by misidentification of plant parts. It is most probably happened due to the conflict in similarities of vernacular names as well as scientific names of various medicinal plants. And this practice is directly or indirectly associated with the degradation of herbal drugs [121]. For instance, *M. malabrica* (false nutmeg) is a most common adulterant which is used in true mace herbal drugs [122]. Intentional adulteration is the primary reason behind degradation of herbal drugs which is induced derive maximum profit. It is done by using either orthodox drugs or by the substitution of...
Inferior products or by adding foreign particles which are most commonly called as contaminants such as sand, metals, soil etc. [123,124,125]. Mercury, arsenic, and lead, cadmium, copper and thallium, pesticides, microbes and mycotoxins are the most commonly used contaminants in the herbal drugs [126,127,128,129,130,131,132]. Powders, capsules, extracts are the commonly available forms of herbal drugs in the market. Usually adulterants are added in the herbal drugs either before the processing phase or during the processing phase. Proper quality analysis and standardization protocols are need to be applied during these phases so that the health risk can be avoided [133,134,135]. Standardization ensures the quantity and quality of the herbal drugs [136]. The most preferred technique in today’s time is standard DNA barcode which significantly works on identification of species [137].

VI. THERAPEUTIC USES OF MYRISTICA FRAGRANS

Myristica fragrans Houtt. (nutmeg) is associated with wide range of biological properties which are useful in treating several diseases. Some of its therapeutic properties are discussed below.

Aphrodisiac

Ahmed et al., conducted a study on male rat models to evaluate the activity of Myristica fragrans Houtt. (nutmeg) on sexual behavior. It was observed that 50% ethanolic extract of the plant exhibited aphrodisiac activity [138].

Effect on memory

Parle et al., conducted a study on mouse models for evaluating the effect of Myristica fragrans seeds on the learning capacity and memory of the models used. The memory impairment was induced by scopolamine and diazepam. It was found that n-hexane extract significantly worked on learning capacity and memory [139].

Anti-stress

Anti-stress activity was examined by Dhingra et al., on mice models. Stress was induced in the models by using two methods that are the forced swim test (FST) and the tail suspension test (TST) method. It was observed that M. fragrans extract significantly reduced the immobility periods of mice in both the FST and the TST methods [140].

Anti-diarrhoeal

A study was conducted by Gupta et al., on ileal loops of rabbit and guinea pig. E. coli heat labile (LT) and heat stable (ST) enterotoxins were used in this experimental study. The result revealed that hexane-soluble fraction was associated with inhibition of secretory responses which were induced by E. coli heat labile (LT) and heat stable (ST) enterotoxins [141].

Antithrombotic

As per the data report of an in-vitro study carried out by Janssens et al., it was revealed that eugenol and iso-eugenol were associated with inhibition of platelet aggregation, this attributes to its antithrombotic activity [142].

Hepatoprotective

Zhao et al., conducted an experimental study to check the effects of AEN (alcohol extract of nutmeg, the seed of Myristica fragrans) on obesity and inflammation which are associated with Nonalcoholic fatty liver disease (NAFLD). They use mice models for the study. Models were fed with high-fat-diet. It was revealed from the study, alcohol extract of nutmeg significantly reduced the body weight and levels of inflammation, cholesterol and lipid accumulation, blood glucose which supports its use as an hepatoprotective agent [143]. Dkhil et al., also studied hepatoprotective activity of Myristica fragrans. The study was carried out on rat models. Models were administered with paracetamol (acetaminophen; N-acetyl-p-aminophenol (APAP) for the artificial induction of hepatotoxicity. Myristica fragrans Kernel extract showed some significant effect against APAP induced toxicity [144].

Anti-cancer

Prakash et al, studied the anti-cancerous behavior of Myristica fragrans in an in-vitro study on human cell lines Colon cell (Colon502713, Colo205), Liver (Hep-2), Lung (A-549), Ovary OVCAR-5 and Prostrate (PC-5) and central nervous system. Ethanolic extract of seed of Myristica fragrans (Houtt) was found to be effective against these cell lines. Ethanolic extract exhibited highest anti-cancerous activity against OVCAR-5. The results of this study demonstrated that Myristica fragrans is a potent anti-cancer agent [145].

Anti-oxidant

Dorman et al., conducted an in-vitro study to check the anti-oxidant potential of many medicinal herbs against synthetic anti-oxidants like BHA (butylated hydroxyanisole), BHT (butylated hydroxytoluene), alpha tocopherol and pyrogallol. It was found from the study that essential oil extracted from nutmeg is an effective anti-oxidant agent [146].

Anti-microbial

Orabi et al., conducted an experimental study in 1991 to check the anti-microbial potential of mace of M. fragrans against Staphylococcus aureus and Candida albicans. It was revealed that resorcinols malabaricon B [1] and malabaricon C [2] both showed significant anti-microbial potential against Staphylococcus aureus and Candida albicans [147]. As per the results of study conducted by Hattori et al., dehydro-di-isoeugenol and 5-methoxydehydrodiisogenol were found to be effective against Streptococcus mutans. They significantly helped in the inhibition of Streptococcus mutans growth [148].
Hypolipidemic effect

In-vivo study conducted on rabbit models by Ram et al., suggested that the oral administration of ethanolic extract of nutmeg at the dosage of 500 mg/kg at the regular interval of 60 days in artificially induced hypolipidemic rabbits significantly lowered the lipoprotein lipids levels which supports its use as an hypolipidemic agent [149]. Sharma et al., carried out an in-vivo study on hypercholesterolemic rabbit models which revealed that administration of seed extract of M. fragrans exhibited properties like reduction in serum cholesterol and LDL cholesterol by 69.1 and 76.3%. It also lowered down the ratio of cholesterol/phospholipid by 31.2% and it significantly elevated the ratio of decreased HDL [150].

Anti-diabetic

As per the study report of Han et al., macelignan extracted from M. fragrans is associated with anti-diabetic potential. It activates the peroxisome proliferator receptor (PPAR, α/β) which helps in improving the insulin sensitivity and lipid metabolic disorders [151].

Anti-convulsant

Wahab et al., studied anti-convulsant potential of M. fragrans in well-established animal seizure models. It was observed that nutmeg oil exhibits anti-convulsant properties. During the study nutmeg oil showed anti-convulsant activity against tonic seizures induced by pentylenetetrazole which supports its use as an anticonvulsant agent [152].

Table 4: Reported therapeutic uses of Myristica Fragrans

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Extract</th>
<th>Method</th>
<th>Property</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ethanollic extract</td>
<td>In-vivo study on rat models</td>
<td>Aphrodisiac</td>
<td>138</td>
</tr>
<tr>
<td>2.</td>
<td>n-hexane extract</td>
<td>In-vivo study on mice models</td>
<td>Effect on memory</td>
<td>139</td>
</tr>
<tr>
<td>3.</td>
<td>Hexane soluble fraction</td>
<td>In-vitro study</td>
<td>Anti-diarrhoeal</td>
<td>141</td>
</tr>
<tr>
<td>4.</td>
<td>eugenol and iso-eugenol</td>
<td>In-vitro study</td>
<td>Antithrombotic</td>
<td>142</td>
</tr>
<tr>
<td>5.</td>
<td>Alcoholic extract</td>
<td>In-vivo study on mice models</td>
<td>Hepatoprotective</td>
<td>143</td>
</tr>
<tr>
<td>6.</td>
<td>Ethanollic extract</td>
<td>In-vitro study</td>
<td>Anti-cancer</td>
<td>145</td>
</tr>
<tr>
<td>7.</td>
<td>Essential oil</td>
<td>In-vitro study</td>
<td>Anti-oxidant</td>
<td>146</td>
</tr>
<tr>
<td>8. b.</td>
<td>Dehydro-di-isoeugenol and 5-methoxydehydrodisogenol</td>
<td>In-vitro study</td>
<td>Anti-microbial</td>
<td>147, 148</td>
</tr>
<tr>
<td>9.</td>
<td>Ethanollic extract</td>
<td>In-vivo study on mice models</td>
<td>Hypolipidemic effect</td>
<td>149</td>
</tr>
<tr>
<td>10.</td>
<td>Macelignan</td>
<td>Clinical study</td>
<td>Anti-diabetic</td>
<td>151</td>
</tr>
<tr>
<td>11.</td>
<td>Nutmeg oil</td>
<td>In-vivo study</td>
<td>Anti-convulsant</td>
<td>152</td>
</tr>
</tbody>
</table>

Toxicity study

A case study on the toxicity of M. fragrans reported by Green et al., revealed that myristicin extracted from the volatile oil of plant has toxicity associated with it. It was observed that nutmeg at higher dose i.e. above 4 gm exhibits depressive actions on Central Nervous System [153].

VII. CONCLUSION

M. fragrans is a promising herb which is most commonly used in traditional systems of medicine for treating numerous human ailments. It is widely used for its extra-ordinary property of enhancing overall reproductive health. It possesses wide range of phytochemical constituents like myristic, petroselinic, and palmitic acids, α-Thujene, α-Pinene, camphene, sabine, β-Pinene, myrcene, α-Phellandrene, 3-Carene, α-Terpinene, p-Cymene, limonene, β-Phellandrene, γ-Terpinene etc. which exhibit significant biological properties such as hepatoprotectivity, anti-microbial, anti-stress, anti-diabetic etc. Apart from its therapeutic uses, it is well known spice used in almost all type of cooking. In Ayurveda it is used to treat insomnia, pain, epilepsy, vomiting, stress, IBS, cardiac disorders, erectile dysfunction etc. This medicinal plant with multiple therapeutic uses can be a promising and reliable source of new drugs in future.

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