# A systematic review on Nutmeg and its medical importance

Saranya Kandambath and Neeraj Choudhary *

Department of Food and Biotechnology,

Faculty of Education and Methodology, Jayoti Vidyapeeth Women's University, Jaipur

Corresponding author mail-neeraj.ch1988@gmail.com

## Abstract

Nutmeg and mace have a very important role in ayurvedic medicine and home remedies.It is a very important spice used as a flavouring agent as well as it is a good remedy for stomach and kidney disorders. Essential oils, triterpenes, and various types of phenolic compounds are helpful in treating various ailments. This review paper provides an overview of the medical importance of various chemical metabolites isolated from nutmeg kernel and mace. It includes the analysis of various extracts and compounds, as well as their role in various treatments.

**Key words**: Nut meg, *Myristica fragrans*, Myristic acid, medical importance of nutmeg

## Introduction

The spice nutmeg (Jatiphala), which is made from the seed of the Myristica fragrans tree, has a long history of use in medicine. It has received recognition for its multiple health benefits, including anti-inflammatory, anti-cancer, anti-bacterial, anti-diabetic, pain-relieving, liver-protecting, and more.( Kumari et al.,2021) Native to Indonesia, nutmeg is frequently used in American classic baked products as well as Asian, European, Middle Eastern, and African cuisines.Due to pharmacological activities nutmeg essential oils and extracts are used in development of new drugs.(Abourashed EA, Khan IA ,2010) .According to studies, nutmeg may provide health advantages like reduced pain and inflammation, better heart and brain health, improved digestion, and better sleep. The fibre in nutmeg can aid with bloating, cramps, and diarrhoea brought on by food allergies or intolerances. The carminative properties of the spice can also soothe an upset stomach and aid in the release of digestive enzymes that increase metabolism. Traditionally Indian spices, as part of the diet, have comprehensive effects on human health. (Sachan AK et al., 2018). The nutmeg extract can be used to the external treatment of skin infections, rheumatism and paralysis (Abourashed and Khan 2010).There are so many reports of traditional uses and activities of nutmeg and mace,its underlying mechanisms are still unclear.So there must be a proper pharmacological study to understand the medical importance of this super spice.

The world is currently dealing with the introduction and spread of new types of infectious diseases, which is a major issue and necessitates a sizable amount of time and effort to develop the treatments to treat them.The best way to lower the danger of these illnesses is to strengthen our immunity, which is a growing health problem. There is some evidence to suggest that by enhancing the immune response, numerous nutritional supplements made from different spices help lessen the risk or severity of a variety of microbial diseases. The harmful consequences caused by many infections can be lessened by using these spice

extracts.(Martins IJ,2018) Therefore, using natural substances may offer an alternative to traditional preventative and therapeutic support. In this article, we examine the medical importance of nutmeg.

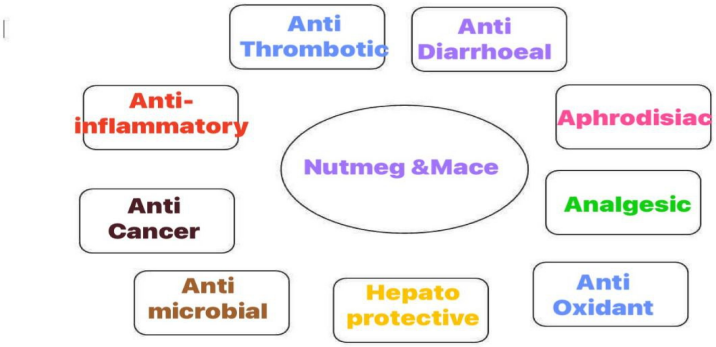


**Fig1: Medical importance of Nutmeg**

## Botanical description of plant

Mace and nutmeg are two separate spices that are produced from the nutmeg tree, *Myristica fragrans*. This evergreen shrub, which may reach a height of more than 20 meters (Periasamy et al., 2016), is planted in India, Ceylon, Malaysia, and Granada. The leaves are alternating, oblong, glabrous, acuminate, fragrant, dark green, and glossy above (Periasamy et al., 2016).According to Haldankar et al. (2007), flowers are typically dioecious but occasionally monoecious with varied sex expression, tiny, axillary, sub-umbellate racemes, complex, or infrequently forked. The peduncles and pedicels appear to be glabrous. The spherical fruit contains a fleshy pericarp, and its yellowish fruit skin divides into two longitudinal valves. When wet, the mace (aril) is a fleshy, reddish-purple aril that is folded, laciniate, and encases the nut; when dry, it becomes much hornier, yellowish-brown in colour, and extremely brittle The tree's fruit, known as a drupe or nutmeg apple, resembles an apricot or a peach in appearance. The nutmeg, which is a rocky endocarp or seed encircled by a scarlet, slightly squishy network or aril, is visible as the fruit matures and cracks open. While nutmeg is made by removing and drying the nut, mace is the name given to the dried aril alone. (Wallis, 1985).

## Bioactive molecules

The seed contains about 10% essential oil (Verghese J.2001, Maya KM et al.,2004), which is mostly composed of terpene hydrocarbons (a-pinenes, camphene, p-cymene, sabinene, b-phellandrene, g-terpinene, limonene, myrcene (60% to 90%), terpene derivatives (linalool, geraniol,terpineol - 5% to 15%) and phenylpropanes (myristicin, elemicin, safrole-2% to 20%). One of the factors contributing to the intoxicating effects of M. fragrans seed is the presence of myristicin and elemicin. ( Su L et al.,2005) Fats (30–40%) and essential oils (10%) are the two components present in nutmeg. GC-MS analysis is typically used to characterise essential oils (A.Y.Al-Maskri et al.,2011)(J.Widelski,et al.,2017) Phenylpropanoids include myristicin, elemicin, safrole, eugenol, and eugenol derivatives. (Kapoor IP et al.,2013)

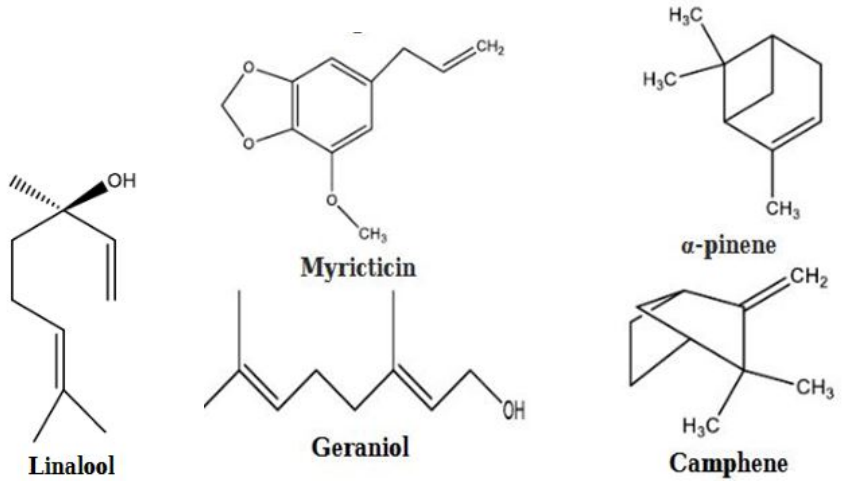


**Figure 2:** Important chemical molecule present in nutmeg oil

**Table 1** : Active phytocompounds present in Nutmeg in various studies

| Name of phytocompound | Method of isolation | Reference |
|---|---|---|
| essential oils(α-Thujene, α-Pinene, camphene, sabinene, β-Pinene, myrcene, α-Phellandrene, 3-Carene, α-Terpinene, p-Cymene, limonene, β-Phellandrene, γ-Terpinene, 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-Cubebene, terpenyl acetate, citronellyl acetate, α-Copaene, geranyl acetate, methyl eugenol, β-Caryophyllene, trans-α-Bergamotene, α-Humulene, myristicin, elemicin, docosane) | clevenger and soxhlet apparatus | Kapoor et al.(2013) |
| myristicin, elemicin, safrole, (Iso) eugenol | hydro-distillation method | Marzuki et al.,(2014) |
| Sabinene, myristicin, elemicin, α-pinene, β-pinene, limonene, terpinen-4-ol and myristic acid | absolute ethanol extraction method(1:4 of material) at room temperature | Morsy et al.,(2016) |

**Table 1:Bioactive molecules of nutmeg**

## Pharmacology

### Antimicrobial effects

The oils of mace and nutmeg and their individual components (trimyristin, myristic acid, myristin, mace lignan) have been assessed for *in vitro* activity, which has been shown against some oral microorganisms.(Yanti, Rukayadi Y,2008). The essential oils of spices have been reported to inhibit microorganism growth (Ashokkumar et al., 2020a, 2020b, 2021b) and are insoluble in water. *Helicobacter pylori* was found to be strongly inhibited by the crude extract of M. fragrans (aril or leaf), which had a minimum inhibitory concentration (MIC) of 12.5 mcg/mL for the aril extract and 50 mcg/mL for the leaf extract. As controls, MIC ranges of amoxicillin (0.0039 to 0.25 mcg/mL) and metronidazole (64 to 124 mcg/mL) were employed.( Bhamarapravati S et al.,2003)

Extract of *M.fragrans* has antibacterial efficacy against *Proteus vulgaris, Staphylococcus aureus,* and *Klebsiella pneumonia*,(Ibrahim et al. 2011) and ineffective against *Pseudomonas aeruginosa, Bacillus subtilis, and Salmonella typhirium*. *Aspergillus glaucus, Aspergillus niger, Collectotrichum gloeosporoides, Colletotrichummusae, Fusarium oxysporum, and Fusarium semitectum* are all inhibited by 0.1% nutmeg essential oil, according to the radial growth determination. When the *M. fragrans* concentration rose to 0.3%, this growth inhibition could have reached a maximum of 100% (Valente et al., 2011). In addition, mace and nutmeg have potent antibacterial properties against pathogens that affect plants and animals, such as Escherichia coli, Saccharomyces cerevisiae, and Helicobacter pyroli. (Dorman & Deans, 2000; Rani & Khullar, 2004; De et al., 1999)

### Antioxidant activities

Chemical assays such as DPPH (2,2-diphenyl-1-picrylhydrazyl), FRAP (ferric reducing/antioxidant power assay), suppression of lipid peroxidation, and bleaching of -carotene can be used to demonstrate the antioxidant activity of MFEO(*M. fragrans* Eessential oil) (Gupta, Bansal, Babu, & Maithil, 2013). With an EC50 dosage of 181.4 g/ml, the nutmeg essential oil demonstrated 88.7% suppression of linoleic acid oxidation (Piaru et al., 2012). According to Matulyte et al. (2020), the antioxidant activity of pure MFEO and MFEO with 1% magnesium aluminometasilicate was comparable at EO concentrations of 0.2-20%.

### Anti-inflammatory activities

Nutmeg's oil and anti-inflammatory properties have been noted by several authors (*M. Mueller* et al., 2010).(Das et al., 2020; Hiranrat & Hiranrat, 2019; Kholibrina & Aswandi, 2021; Nikolic et al., 2021; Özkan et al., 2018; Purkait, Bhattacharya, Bag, & Chattopadhyay, 2018; Thileepan, Thevanesam, & Kathirgamanathar, 2018; Valente, Jham, Jardim, Dhingra, & Ghiviriga, 2015). Nutmeg oil exhibits pharmacological actions that are comparable to those of non-steroidal anti-inflammatory medications (O.A.Olajide et al.,2000). But only petroleum ether extracts have been found to have anti-inflammatory action. The entire nutmeg extract stimulated the AMP-activated protein kinase enzyme, which is a possible therapeutic target for treating the metabolic syndrome, which includes type 2 diabetes and obesity. From this extract, seven active ingredients were identified,

including tetrahydrofuroguaiacin B, 2,5-bis-aryl-3,4-dimethyltetrahydrofuranlignans, fragransin C1, saucernetindiol, nectandrin B, verrucosin, galbacin, and nectandrin . The M. frangrance petroleum ether extract resembles non-steroidal anti-inflammatory medicines in terms of its characteristics.( Olajide et al.,2000)

## Other medicinal importance

Some of the main advantages of nutmeg essential oil include reducing mood swings and depression, removing toxins from the liver, enhancing cognition, treating respiratory issues, alleviating insomnia, promoting digestive and bone health, aiding in kidney stone dissolution, maintaining optimal brain health, reducing skin inflammation and irritation, and boosting digestive and bone health. (Dhaslin YF et al., 2019) The Myristicaceae plant family has been tested by the National Cancer Institute for efficacy against certain leukaemia strains. Apoptosis was raised and leukaemia and neuroblastoma cell growth was lowered in in vitro tests using methanol extract and myristicin. Of the studied extracts, 18.8% had antileukemia activity.(Cragg GM et al.,2006) (Lee BK et al.,2005), 20) A few of older studies show some activity on the enzymes responsible for the activation and detoxification of carcinogens. (Chirathaworn C et al.,2007)

**Table 2** : Recent studies of Nutmeg for medicinal importance on various extracts

| **Name of extract** | **Medicinal use** | **Reference** |
|---|---|---|
| Ethanolic extract | Aphrodisiac | Ahmad, S., Latif,(2005) |
| n-hexane extract | Effect on memory | Parle, M., et al.,(2004) |
| Hexane soluble fraction | Anti-diarrhoeal | Gupta, S. et al.,(1992) |
| eugenol and iso-eugenol | Antithrombotic | Janssens, J.et al.,(1990) |
| Alcoholic extract | Hepatoprotective | Zhao, W., Song, F et al.,(2020) |
| Ethanolic extract | Anti-cancer | Prakash E, et al.,(2013) |
| Essential oil | Anti-oxidant | Dorman, H. D(2000) |
| a)Malabaricon B [1] and malabaricon C | Anti-microbial | Orabi, K. Y.et al.,(1991) and Hattori M et al.,(1986) |
| b)Dehydro-di-isoeugenol 5-methoxydehydrodiisogenol | Anti-microbial | Orabi, K. Y.et al.,(1991) and Hattori M et al.,(1986) |
| Ethanolic extract | Hypolipidemic effect | Ram, A., et al.,(1996) |
| Macelignan | Anti-diabetic | Han, K. L. et al.,(2008) |
| Nutmeg oil | Anti convulsant | Wahab, A. et al.,(2009) |

## Conclusions

The current study emphasises the potential use of *Myristica fragrance* as an antibacterial, antifungal, hepatoprotective activity, anti-inflammatory and analgesic property, memory-enhancing activity, anticonvulsant activity, anti-diabetic properties, neuropharmacologic properties, hypolipidemic, and hypocholesterolemic property due to its valuable bioactive compounds, which may have potential for the development of drugs against pathogenic microorganisms. Since nutmeg contains a complex mixture of different compounds, it can occasionally be beneficial when used in moderation but can also be quite hazardous when used improperly or in large doses. The pharmacological actions of MFEOs and their active components in humans should be the focus of future research.Future studies should investigate the toxicity,and pharmacokinetics of nutmeg to identify the chemical elements causing its effects and broaden the use of M. fragrans in medicine. We think that the details offered or covered here will raise people's awareness of nutmeg and mace and be useful for further studies.

## References

Kumari, Isha & Kaurav, Hemlata & Chaudhary, Gitika. (2021). Myristica fragrans (Jaiphal): A Significant Medicinal Herbal Plant. International Journal for Research in Applied Sciences and Biotechnology. 8. 213-224. 10.31033/ijrasb.8.2.27.

Sachan AK, Kumar S, Kumari K, Singh D. Medicinal uses of spices used in our traditional culture: worldwide. J Med Plants Studies. 2018;6(3):116–22.

Abourashed EA, Khan IA (2010) Nutmeg. In: Khan IA, Abourashed EA (eds) Leung's encyclopedia of common natural ingredients used in food, drugs and cosmetics, 3rd edn. Wiley, Hoboken, pp 467–470

Martins IJ. Indian spices and biotherapeutics in health and chronic disease. Health. 2018;10(04):374.

Haldankar PM, Rangwala AD. Nutmeg-a boon spice for Konkan. Spice India. 2009; 22:4-9.

Haldankar, P.M., Khandekar, R.G., & Joshi, G.D. (2007). Effect of growth regulators on germination and seedling growth in nutmeg. *South Indian Horticulture*, 55, 315-319.

Periasamy, G., Karim, A., Gibrelibanos, M., Gebremedhin, G., & Gilani, A. H. (2016). Nutmeg (*Myristica fragrans* Houtt.) oils. In V. R. Preedy (Ed.), *Essential oils in food preservation, flavor and safety* (pp. 607–616). New York, NY: Academic Press.

Wallis, T. E. (1985). *Text book of pharmacognosy* (5th ed., p. 652). New Delhi, India: CBS Publishers and Distributors.

Verghese J. Nutmeg and Mace.IV. Essential oils of Myristica fragrans Houtt. And of Myristica argentea Warb. Spice India 2001; 14:7-11.

Maya KM, Zachariah TJ, Krishnamoorthy B. Chemical composition of essential oil of nutmeg (Myristica fragrans Houtt.) accessions. J. Spices Aromatic Crops 2004; 13: 135-139.

Olajide, Olumayokun & Makinde, J. & Awe, S.. (2000). Evaluation Of The Pharmacological Properties Of Nutmeg Oil In Rats And Mice. Pharmaceutical Biology - PHARM BIOL. 38. 385-390. 10.1076/phbi.38.5.385.5976.

Su L, Yin JJ, Charles D, Zhou K, Moore J, Yu L. Total phenolic contents, chelating capacities, and radical-scavenging properties of black peppercorn, nutmeg, rosehip, cinnamon and oregano leaf. *Food Chem*. 2005.

A.Y. Al-Maskri, M.A. Hanif, M.Y. Al-Maskari, A.S. Abraham, J.N. Al-sabahi, O. Al-Mantheri. (2011). Essential oil from Ocimum basilicum (Omani Basil): a desert crop. Natural product communications. 6(10): 1934578X1100601020.

J. Widelski, W. Kukula-Koch, Psychoactive Drugs. In Pharmacognosy, Elsevier: 2017; pp 363-374.

Kapoor IP, Singh B, Singh G, De Heluani CS, De Lampasona MP, Catalan CA. (2013). Chemical composition and antioxidant activity of essential oil and oleoresins of nutmeg (Myristica fragrans Houtt.) fruits. International journal of food properties,16(5),1059-70.

Marzuki, I., Joefrie, B., Aziz, S. A., Agusta, H., & Surahman, M. (2014). Physico-chemical characterization of Maluku nutmeg oil. International Journal of Science and Engineering, 7(1), 61-64.

Morsy, N. F. (2016). A comparative study of nutmeg (Myristica fragrans Houtt.) oleoresins obtained by conventional and green extraction techniques. Journal of food science and technology, 53(10), 3770-3777.

Yanti, Rukayadi Y, Kim KH, Hwang JK. In vitro anti-biofilm activity of macelignan isolated from *Myristica fragrans* Houtt. against oral primary colonizer bacteria. *Phytother Res*. 2008;22(3):308-312.17926328

Ashokkumar, K., Murugan, M., Dhanya, M. K., & Warkentin, T. D. (2020). Botany, traditional uses, phytochemistry and biological activities of cardamom [*Elettaria cardamomum* (L.) Maton]—A critical review. *Journal of Ethnopharmacology*, 246, 112244.

Ashokkumar, K., Murugan, M., Dhanya, M. K., & Warkentin, T. D. (2021). Phytochemistry and therapeutic potential of black pepper [*Piper nigrum* (L.)] essential oil and piperine: A review. *Clin Phytoscience*, 7(52). https://doi.org/10.1186/s40816-021-00292-2

Bhamarapravati S, Pendland SL, Mahady GB. Extracts of spice and food plants from Thai traditional medicine inhibit the growth of the human carcinogen *Helicobacter pylori*. *In Vivo*. 2003;17(6):541-544.14758718

Ibrahim MA, Cantrell CL, Jeliazkova EA, Astatkie T, Zheljazkov VD. Utilization of Nutmeg (*Myristica fragrans* Houtt.) Seed Hydrodistillation Time to Produce Essential Oil Fractions with Varied Compositions and Pharmacological Effects. Molecules. 2020 Jan 28;25(3):565. doi: 10.3390/molecules25030565. PMID: 32012955; PMCID: PMC7037852

Dorman HJ, Deans SG. (2000) Antimicrobial agents from plants: antibacterial activity of plant volatile oils. J Appl Microbiol; 88:30816

Rani P, Khullar N. (2004) Antimicrobial evaluation of some medicinal plants for their anti-enteric potential against multi-drug resistant Salmonella typhi. Phytother Res; 18:670-3

Gupta, A. D., Bansal, V. K., Babu, V., & Maithil, N. (2013). Chemistry, antioxidant and antimicrobial potential of nutmeg (*Myristica fragrans* Houtt). *Journal of Genetic Engineering & Biotechnology*, 11, 25–31

Matulyte, I., Jekabsone, A., Jankauskaite, L., Zavistanaviciute, P., Sakiene, V., Bartkiene, E., … Bernatoniene, J. (2020). The essential oil and hydrolats from *Myristica fragrans* seeds with magnesium aluminometasilicate as excipient: Antioxidant, antibacterial, and anti-inflammatory activity. *Food*, 9(1), 37. https://doi.org/10.3390/foods9010037

Piaru, S. P., Mahmud, R., Abdul Majid, A. M., & Mahmoud Nassar, Z. D. (2012). Antioxidant and antiangiogenic activities of the essential oils of *Myristica fragrans* and *Morinda citrifolia*. *Asian Pacific Journal of Tropical Medicine*, 5(4), 294–298. https://doi.org/10.1016/S1995-7645(12)60042-X

Das, S., Kumar Singh, V., Kumar Dwivedy, A., Kumar Chaudhari, A., Upadhyay, N., Singh, A., … Dubey, N. K. (2020). Assessment of chemically characterised Myristica fragrans essential oil against fungi contaminating stored scented rice and its mode of action as novel aflatoxin inhibitor. Natural Product Research, 34(11), 1611–1615. https://doi.org/10.1080/14786419.2018.1519826

Hiranrat, A., & Hiranrat, W. (2019). Myristigranol, a new diarylpropane derivative from the wood of Myristica fragrans. Natural Product Research, 33, 2958–2963.

Kholibrina, C. R., & Aswandi, A. (2021). The aromatherapy formulation of essential oils in reducing stress and blood pressure on human. IOP Conference Series: Earth and Environmental Science, 914, *012072*. https://doi.org/10.1088/1755-1315/914/1/012072

Nikolic, V., Nikolic, L., Dinic, A., Gajic, I., Urosevic, M., Stanojevic, L., … Danilovic, B. (2021). Chemical composition, antioxidant and antimicrobial activity of nutmeg (Myristica fragrans Houtt.) seed essential oil. Journal of Essential Oil-Bearing Plants, 24(2), 218–227. https://doi.org/10.1080/0972060X.2021.1907230

Özkan, O. E., Olgun, Ç., Güney, B., Gür, M., Güney, K., & Ateş, S. (2018). Chemical composition and antimicrobial activity of Myristica fragrans & Elettaria cardamomum essential oil. Kastamonu Uni., Orman Fakültesi Dergisi, 18(2), 225–229.

Purkait, S., Bhattacharya, A., Bag, A., & Chattopadhyay, R. R. (2018). Antibacterial and antioxidant potential of essential oils of five spices. Journal of Food Quality and Hazards Control, 5, 61–71.

Thileepan, T., Thevanesam, V., & Kathirgamanathar, S. S. (2018). Anticandidal activity of essential oils of Myristica fragrans and Syzygium aromaticum. Journal of Innovations in Pharmaceutical and Biological Sciences, 5(3), 35–38.

Valente, V. M. M., Jham, G. N., Jardim, C. M., Dhingra, O. D., & Ghiviriga, I. (2015). Major antifungals in nutmeg essential oil against aspergillus flavus, and A. ochraceus. Journal of Food Research, 4(1), 51–57.

O.A. Olajide, J.M. Makinde, S.O. Awe. (2000). Evaluation of the pharmacological properties of nutmeg oil in rats and mice. Pharmaceutical biology. 38(5): 385-390

Dhaslin YF, Issac R and Prabha ML. Antioxidant, antimicrobial, and health benefits of nutmeg. Drug Invention Today.2019; 12(1).

Cragg GM, Newman DJ, Yang SS. Natural product extracts of plant and marine origin having antileukemia potential. The NCI experience. *J Nat Prod*. 2006;69(3):488-498.16562862

Chirathaworn C, Kongcharoensuntorn W, Dechdoungchan T, et al. *Myristica fragrans* Houtt. methanolic extract induces apoptosis in a human leukemia cell line through SIRT1 mRNA downregulation. *J Med Assoc Thai*. 2007;90(11):2422-2428.18181330

Lee BK, Kim JH, Jung JW, et al. Myristicin-induced neurotoxicity in human neuroblastoma SK-N-SH cells. *Toxicol Lett*. 2005;157(1):49-56.15795093

Ahmad, S., Latif, A., Qasmi, I. A., & Amin, K. M. Y. (2005). An experimental study of sexual function improving effect of Myristica fragrans Houtt.(nutmeg). BMC Complementary and Alternative Medicine, 5(1), 1-7.

Parle, M., Dhingra, D., & Kulkarni, S. K. (2004). Improvement of mouse memory by Myristica fragrans seeds. Journal of medicinal food, 7(2), 157-161

Gupta, S., Yadava, J. N. S., Mehrotra, R., & Tandon, J. S. (1992). Anti-diarrhoea1 profile of an extract and some fractions from Myristica fragrans (Nut meg) on Escherichia coli enterotoxin-induced secretory response. International journal of pharmacognosy, 30(3), 179-183.

Janssens, J., Laekeman, G. M., Pieters, L. A., Totte, J., Herman, A. G., & Vlietinck, A. J. (1990). Nutmeg oil: identification and quantitation of its most active constituents as inhibitors of platelet aggregation. Journal of ethnopharmacology, 29(2), 179- 188.

Zhao, W., Song, F., Hu, D., Chen, H., Zhai, Q., Lu, W., ... & Wang, G. (2020). The protective effect of Myristica fragrans Houtt. Extracts against obesity and inflammation by regulating free fatty acids metabolism in nonalcoholic fatty liver disease. Nutrients, 12(9),

Prakash, E., & Gupta, D. K. (2013). Cytotoxic activity of ethanolic extract of Myristica fragrans (Houtt) against seven human cancer cell lines. Journal of Food and Nutrition Science, 1(1), 1-3.

Dorman, H. D., Surai, P., & Deans, S. G. (2000). In vitro antioxidant activity of a number of plant essential oils and phytoconstituents. Journal of Essential Oil Research, 12(2), 241-248.

Orabi, K. Y., Mossa, J. S., & El-Feraly, F. S. (1991). Isolation and characterization of two antimicrobial agents from mace (Myristica fragrans). Journal of natural products, 54(3), 856-859.

Hattori M, Hada S, Watahiki A, Ihara H, Shu YZ, Kakiuchi N, Mizuno T, Namba T. (1986). Studies on dental caries prevention by traditional medicines. X.: antibacterial action of phenolic components from mace against Streptococcus mutans. Chemical and pharmaceutical bulletin, 34(9), 3885-93. Ram, A., Lauria, P., Gupta, R., & Sharma, V. N. (1996). Hypolipidaemic effect of Myristica fragrans fruit extract in rabbits. Journal of ethnopharmacology, 55(1), 49-53.

Han, K. L., Choi, J. S., Lee, J. Y., Song, J., Joe, M. K., Jung, M. H., & Hwang, J. K. (2008). Therapeutic potential of peroxisome proliferators–activated receptor α/γ dual agonist with alleviation of endoplasmic reticulum stress for the treatment of diabetes. Diabetes, 57(3), 737-745.

Wahab, A., Haq, R. U., Ahmed, A., Khan, R. A., & Raza, M. (2009). Anticonvulsant activities of nutmeg oil of Myristica fragrans. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 23(2), 153-158