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Exploring the Potential and Opportunities of Nutmeg Pericarp in Functional Foods

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Abstract

Nutmeg (*Myristica fragrans* Houtt) is a native plant of Banda Island known as the Spice Islands. Nutmeg fruit consists of the pericarp or rind, the seed kernel inside (nutmeg), and the nutmeg is a red lacy (aril) covering the kernel (mace). Nutmeg pericarp contributing 80-85% of the total weight of the nutmeg fruit but its use is still not getting enough attention and a lot of it is wasted as agricultural waste which can pollute the environment. This is because the economic value is considered to be lower than the seeds and mace of nutmeg. This article aims to the potential and opportunity benefits of nutmeg meat waste (pericarp) for human health and its application in functional foods. The method used in this paper is a literature review. The results show that, the pericarp has been reported to contain bioactive compounds similar to those of nutmeg and mace oil which have pharmacological values. Phytochemical compounds are beneficial to human health as anti-inflammatory, anti-diabetes, anti-microbial agents, antioxidants, anti-depressants and anti-cancer agents. Based on the composition, the pericarp is potentially used as a functional food to increase added value and reduce environmental pollution. In addition, the abundance of materials, relatively low prices, and the importance of healthy food for the health of the human provide opportunities for the development of functional foods based on bioactive compounds.

Keywords: Nutmeg, Phytochemical compounds, Therapeutic value, Functional foods

Introduction

Nutmeg (*Myristica fragrans*. Houtt) is native to Indonesian. The seeds and aril are commonly called nutmeg and mace respectively, are the primary products of *M. fragrans* known as spices. Products from nutmeg are known nationally and internationally from colonial times as ingredients for the spice, cosmetic industry, food industry, and medical industry. The

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largest exporting country of nutmeg and mace in the world is Indonesia, which is about 60% of the world's nutmeg needs and in 2020 Indonesia is the biggest nutmeg producer in the world. The total export volume of Indonesian nutmeg in the form of dry seeds and mace is 11,505,972 kg with a total export value of US $ 50,138,286. Prices for nutmeg oil and mace oil are relatively stable compared to other types of essential oil. Essential oil of nutmeg and mace from Indonesia are good quality and their exports dominate world nutmeg oil. Countries that import this product are the United States and the European Union.

Meanwhile, the utilization of nutmeg flesh (pericarp/rind) is still limited and a lot of it is wasted as agricultural waste, which is around 30-40% after the seeds and mace are taken. Nutmeg pericarp is the largest part of about 80-85% of the total weight of nutmeg fruit, but it still gets less attention because its economic value is considered lower than nutmeg and mace. They are generally taken by splitting the nutmeg directly in the nutmeg field and leaving the flesh strewn under the tree. The nutmeg and mace are generally taken by splitting the nutmeg fruit directly in the nutmeg field and leaving the flesh strewn under the tree. This nutmeg flesh/pericarp is very perishable so that it can pollute the environment and can even become a source of disease for nutmeg plants such as fruit rot. The economic value of nutmeg flesh/pericarp can be increased by diversifying its processing by producing derivative products that have socio-economic value and are highly competitive and reduce environmental pollution problems.

Nutmeg pericarp contains essential oils with hydrocarbon monoterpene components such as alpha pinene, beta pinene, D-limonene, alpha terpinene, acid monoterpenes and aromatic ethers such as myristicin and safrole. In addition, nutmeg pericarp also contains pectin in the form of a brownish latex which has gel-forming properties. Nutmeg pericarp also contains phytochemical compounds such as flavonoids, alkaloids, terpenoids and tannins.

Phytochemical compounds that are known to have physiological functions are carotenoids, phytosterols, saponins, glycosinolates, polyphenols, protease inhibitors, monoterpenes, phytoestrogens, sulfides, and phytic acid. According to Craig, a diet using large amounts of spices as a food flavouring can provide various active phytochemical components that are useful for maintaining health and protecting the body from chronic disease. These ingredients can be served in various forms, including health drinks, instant drinks, juices, syrups, candy, pickles, sweets, lunkhead, jams and jellies.

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Nutmeg pericarp has great potential to be explored in functional food development because of the abundance of ingredients and relatively low prices and along with the increasing public awareness of the importance of maintaining health. In addition, nutmeg contains phytochemical compounds which refer to nutraceuticals that have a very important role for health, including their function in preventing degenerative diseases. This paper examines the potential and health benefits of nutmeg as a functional food.

Phytochemical composition of Myristica fragrans fruit:

The Nutmeg fruit is commonly known as *Myristica fragrans*, consists of the pericarp, the aril and the seed. They are commonly referred to as nutmeg and mace respectively. It is a type of plant with closed seeds. Seeds are covered by a fruit wall (pericarp) which consists of three (3) layers, namely exocarp, mesocarp and endocarp, but not all fruits consist of these 3 layers, some only consist of 2 layers, namely exocarp, and endocarp. Exocarp is the outermost part of the fruit. Mesocarp is the part of the fruit that lies beneath the exocarp layer. The endocarp is the part of the fruit adjacent to the seed coat. Parts of the nutmeg fruit are showed in Figure 1.

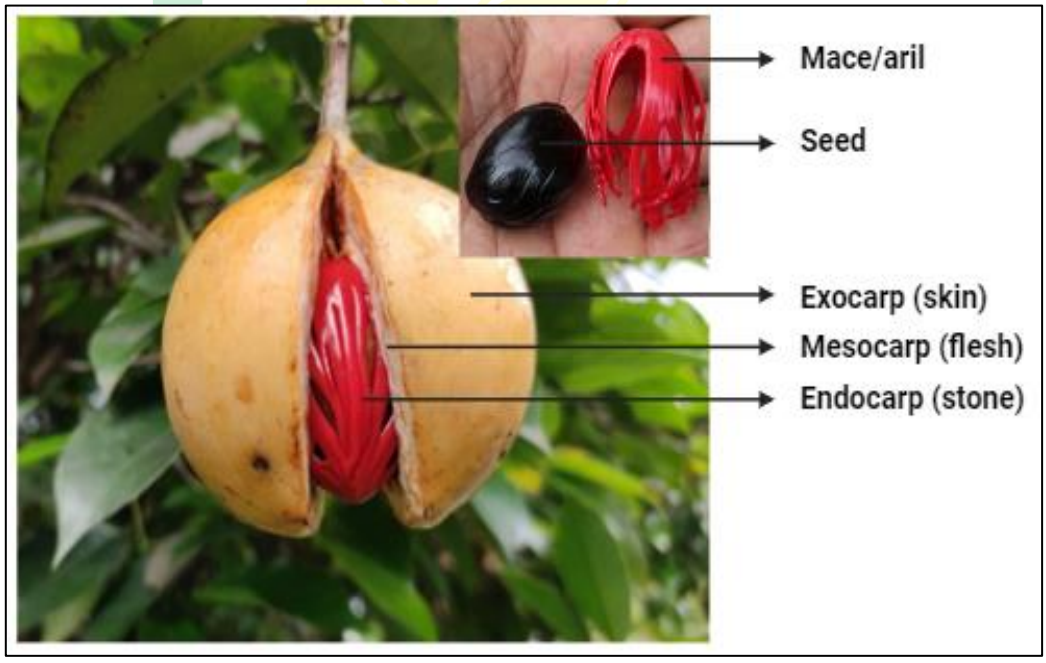

Figure 1. Parts of Nutmeg fruit

The components contained in the pericarp are similar or not substantially different with nutmeg, and mace oil, but differ substantially in concentrations (Table 1). The chemical composition of the pericarp, nutmeg, and mace oil from Indonesia is higher than in Malaysia

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and India, especially in the content of myristicin and sabine. Myristicin content in pericarp is higher than nutmeg and mace.

Table 1. Phytochemical composition of volatile oil from parts of Nutmeg

Part of Plant	Major component	Yield (%)
Seed	Sabine	15-50
	4-Terpineol	0-11
	Myristicin	0.-13.5
	α-Pinene	10.22
	β-Pinene	7-18
	Mycrene	0.7-3
	Limonene	2.7-4.1
	Safrol	0.1-3.2
Mace/Aril	α-Pinene	15.24
	ɣ-Terpinene	1.82
	β-Pinene	45.52
	Myristicine	5.92

Potential benefits of *Myristica fragrans* human health

Nutmeg has been used in culinary and medicinal. It contains a variety of chemical components that have been shown to have anti-oxidant, health-promoting, and disease-preventing qualities. Due to its phytochemical qualities, nutmeg is considered a nutraceutical that is good for human health. These capabilities include antibacterial, anti-inflammatory, anti-oxidant, anti-diabetic, antidepressant, anticonvulsant, and anticancer effects.

- **Anti-inflammatory and antidiabetes activity:** Inflammation is a typical mechanism for protecting or infected tissue as well as to eliminating dead or damaged host cells. Phenylpropene is a natural organic compound contained in nutmeg myristicin which acts as an anti-inflammatory such as non-steroidal anti-inflammatory drugs. It has been reported that the development of new anti-inflammatory drugs has currently more focused on natural ingredients, to reduce the side effects of chemical drugs. Studies of the anti-inflammatory activity in the model of nutmeg in a lipopolysaccharide-stimulated macrophage has been reported that nutmeg extract has anti-inflammatory potential, it can reduction of interleukin IL-6 or tumor necrosis factor (TNF a),

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increased production of IL-10, or reduction in the expression of cyclooxygenase-2 (COX-2) or inducible nitric oxide synthase (iNOS). Extracts from nutmeg can also treat diabetes and obesity. These results indicate that final body weight and weight gain rats treated with tetrahydrofuran (THF was significantly lower than that induce obesity mice t a high-fat diet (HFD). M fragrans petroleum ether extract can reduce blood glucose levels to normal in diabetic rats given glucose fed and alloxan. The hypoglycemic effect is due to the potential for insulin release from beta cells. The pericarp *M. fragrans* was evaluated for its bioactive components using in vitro antioxidant and anti-inflammatory assays. These results showed that the extract of hexane, ethyl acetate and methanolic inhibited lipid peroxidation (LPO) by 82.5, 70.1 and 73.2%, and cyclooxygenase enzymes COX-1 by 44, 44 and 42% and COX-2 by 47, 41 and 36%, respectively, at 100 µg/mL.

- **Antitumor and anticancer:** The benefits of nutmeg as an anti-cancer have been reported by several researchers. Myristicin compounds have cytotoxic and apoptotic effects on human neuroblastoma SK N-SH cells with cytochrome accumulation and activation of caspase 3 in the cytosol, myristicin is an anticancer agent. Cytotoxic activity test against cancer cells in mice with 4 ligands Meso dihydroguaiaretic acid (DHGA), macelignan, fragransin A2 and nectandrin B isolated from nutmeg, found that DHGA has strong cytotoxic activity against H358 with an IC50 value of 10.1 lM. In addition, DHGA exhibited antitumor activity in a mouse model of allogeneic tumor carriers.
- **Neuropharmacological properties:** The results of a recent study reported that nutmeg is a recreational drug used by adolescents as a substitute for marijuana. Nutmeg has long been used as a pain reliever and thus has been commonly used to replace the narcotic drug morphine. Oral administration of nutmeg extract with hexane at a dose of 5 mg/kg for 3 consecutive days can improved learning and memory in young and old mice and reverse diazepam and scopolamine-induced learning and memory impairment, whereas that administration of nutmeg extract with hexane at a dose of 500 mg/kg gave a stimulant effect on the locomotor activity of rats.
- **Antimicrobial and antifungal activity:** Many studies have shown that nutmeg has good anti-microbial activity. The extract of mace with water and ethanol showed good

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anti-microbial property against both the Gram-positive and Gram-negative species and can inhibit the growth of *E. coli* and *Staphylococcus aureus*. Concentration of 0.1% nutmeg essential oil can inhibit the radial growth of Colletotrichum gloeosporoides (98%), *Colletotrichum musae* (97%), *Fusarium oxysporum* (75%), *Fusarium semitectum* (78%), *Aspergillus niger* (71%) and *Aspergillus glaucus* (60%). Concentration of 0.3% inhibition increased, growth could be inhibited from 85% to 100%. Nutmeg pericarp oil has a higher linalool content than nutmeg oil from seeds and mace (0.2%). Terpinene-4-ol is the main component of *Melaleuca alternifolia* (tea tree oil) and has strong anti-microbial, anti-inflammatory, anti-oxidant activity and antifungal.

- **Antioxidant:** Nutmeg oil extracted from nutmeg and mace has long been used clinically as an antioxidant. Nutmeg has antioxidant properties due to its ability to inhibit lipid peroxidase and inhibit superoxidation radical scavenging activity in animal experiments. During the processing and storage of foods, deterioration is caused by lipid peroxidation. Polyphenolic compounds contribute multiple biological effects including antioxidant activities in both edible and inedible plants. To increase the shelf life and retard auto-oxidation in oils and fatty foods, anti-oxidants are mostly used. The study showed that anti-lipid peroxidant properties are seen in *M. fragrans* seeds. The antioxidants in flesh/pericarp, seeds, and mace extracts have a rather large difference of reduction potential with radical species formed during the linoleic acid peroxidation.

Uses and application in functional foods: Definition of functional foods are foods that can improve physical or mental health, reduce the risk of some illnesses, and cure some diseases. However, there are several different rules regarding the definition of functional food among regulatory bodies, namely

1. Academy of Nutrition and Dietetics, functional foods are fortified or enriched whole foods that have potential beneficial effects on health when consumed as part of a regular diet and effective.
2. The Institute of Food Technologists, functional foods as Foods and food components that give a health benefit beyond basic nutrition (for the intended population).
3. The Ministry of Health, Labour and Welfare, Japan, FOSHU (Food for Specified Health Uses), functional foods are foods containing an ingredient with functions for health and officially approved to claim its physiological effects on the human body.

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In Indonesia, according to the POM, functional foods are food that naturally or have been processed contains one or more compounds that are based on scientific studies are considered to have specific physiological functions that are beneficial to health. Functional food consumed as a food or drink, have sensory characteristics, namely the appearance, color, texture, and flavor acceptable to consumers, and not give contraindications and adverse effects on the metabolism of other nutrients when used in the recommended amounts. Although they contain compounds that are beneficial to health, functional foods are not in the form of capsules, tablets, or powders derived from natural compounds. From this classification, functional foods are produced by enriching or strengthening food components/ingredients to increase their beneficial effects on health. Food fortification is a challenging process because it can cause several problems, such as changes in organoleptic properties, in fortified foods. While fortification materials such as encapsulations have been widely reported to address organoleptic problems, it is the best approach to incorporate health-promoting ingredients into the food system as they can mask the undesirable odors and tastes of bioactive compounds.

Product safety must be maintained for that a risk assessment for functional foods must be carried out (Table 2.). Food safety issues associated with *M. fragrans* and its constituents are needed to determine a working strategy to obtain maximum benefits from nutmeg without being exposed to unwanted side effects. Products from nutmeg have been used to flavor many kinds of baked goods, breads, confections, puddings, dairy products, meats, sausages, saucers, vegetables, and beverages. It is also used as a component of candies, chewing gum, syrups, curry powder, teas, and soft drinks, or is mixed in milk and alcohol.

Table 2. Overview of nutmeg-infused functional foods and their potential health benefits.

Functional food	Description	Potential benefits
Nutmeg-Infused Teas	Herbal teas enhanced with nutmeg	Improved digestion, relaxation
Nutmeg-Enhanced Smoothies	Smoothies incorporating nutmeg	Antioxidant properties
Nutmeg Yogurt	Yogurt flavoured with nutmeg	Digestive benefits
Nutmeg-Spiced Granola	Granola with nutmeg	Anti-inflammatory effects
Nutmeg-Enriched Baked Goods	Breads, muffins, and cookies with nutmeg	Flavor enhancement, health benefits

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Nutmeg-Infused Sauces and Dressings	Sauces and dressings with added nutmeg	Enhanced flavor, functional benefits
Nutmeg-Based Supplements	Dietary supplements with nutmeg extract	Therapeutic properties

Nutmeg essential oil has been used as a natural flavoring as a flavoring agent, replacing nutmeg powder to avoid leaving particles in food and drink. application of essential oils (EOs) in food preservation has been strengthened because (1) it is desirable to reduce the potential health risks and improve the negative perceptions of consumers about synthetic preservatives; and (2) foodborne disease is a growing public health problem throughout the world, demanding a more effective conservation strategy. Nutmeg essential oil and its oleoresin extract are used as antimicrobials and antioxidants which show promising natural food preservative properties to replace synthetic preservatives.

Conclusion

Nutmeg (*Myristica fragrans*) contains therapeutic value and acts as an anti-microbial, anti-inflammatory, anti-oxidant, anti-diabetic, anti-depressant, anti-convulsant and anti-cancer agent. The phytochemical components of the pericarp are similar to those of nutmeg and mace. Pericarp has the potential to be developed as a functional food with high value and as a socio-economic food because it is still an agricultural waste and the price is relatively cheap.

References

Ameen, S. J. (2012). Antimicrobial activity of nutmeg extracts against Staphylococcus aureus and Escherichia coli. *Journal of Techniques*, *25*(2).

Directorate General of Estate Crops, Tree crop estate statictics of Indonesia, Pala Comodity 2017-2019, (Direct. General of Estate Crops, Ministry of Agriculture, 2019)

Kapoor, I. P. S., Singh, B., Singh, G., De Heluani, C. S., De Lampasona, M. P., & Catalan, C. A. (2013). Chemical composition and antioxidant activity of essential oil and oleoresins of nutmeg (Myristica fragrans Houtt.) fruits. *International journal of food properties*, *16*(5), 1059-1070.

Ministry of Agriculture, Nutmeg Production by Province (Ministry of Agriculture, 2019)

Ministry of Health, Labour, and Welfare, Japan. Food for Specified Health Uses (FOSHU). (2015)

Raj, N. M., Vikram, H. C., Philip, M., & Deepa, E. T. (2016). Fruit rind constituents in nutmeg (Myristica fragrans) morphotypes. *J. Plant. Crops*, *44*(3), 153-157.

Stein, A. J., & Rodríguez-Cerezo, E. (2008). Functional food in the European Union, a report based on the ESTO study Functional Food in European Union. *European Commission JRC IPTS, Seville*.

Suwarda, R., Suneth, R. F., & Sondari, D. (2021). Potential and opportunities of nutmeg pericarp as functional foods. In *E3S Web of Conferences* (Vol. 306, p. 04007). EDP Sciences.

Ulfah, T., Hardjomidjodjo, H. H., & Anggraeni, E. (2020, April). Nutmeg determination as the main commodity in South Aceh; a literature review. In *IOP Conference Series: Earth and Environmental Science* (Vol. 472, No. 1, p. 012040). IOP Publishing.