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Conference Paper

Potency of Mangosteen Pericarp as Source of Antioxidant in Tea to Enhance Immune System: A Review

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ABSTRACT

Mangosteen is one of the tropical fruits that is widely planted in Indonesia. This fruit has a pericarp that is rich in antioxidant compounds that would be beneficial to be fortified in foods. Application in food can be found in food products rich in fats and oils to avoid rancidity or in medicinal products that can boost the immune system. One of the medicinal products that can be fortified with antioxidants is tea. Therefore, this paper is aimed to review the characteristics of bioactive compounds in mangosteen, the potency of antioxidants to enhance the immune system, and the application of mangosteen pericarp simplicial in tea production. The review of those studies is expected to enlighten not only the characteristics of mangosteen pericarp but also its potential applications in food products. Moreover, it would increase zero-waste food production, hence supporting the sustainability aspect for the environment.

Keywords: Antioxidant, immune system, mangosteen, pericarp, tea

Introduction

Mangosteen is one of the tropical fruits that is widely cultivated in South- and South-East Asian countries, including Indonesia, Thailand, Malaysia, Philippines, Myanmar, Sri Lanka, and India. The Garcinia genus contains about 35 genera and up to 800 species worldwide (Al-Massarani, et al. 2013). This fruit is covered by a thick skin when viewed from the inside it is purple. Mangosteen pericarp contains compounds that taste bitter, especially xanthones and tannins. In the mangosteen pericarp, there is a purple-brown pigment that is soluble in water. Mangosteen peel can be used as a dye or traditional medicine to treat a disease. In Thailand, mangosteen peel has been a traditional herb for generations to treat skin infections, wounds, and diarrhea (Jung et al., 2006). According to Pebriyanthi (2010), the chemical composition of mangosteen peel consists of 61.83% of moisture, 3.29% of ash (dry basis), 1.23% of fat (dry basis), 21.04% of fiber (dry basis), 2.66% of proteins (dry basis), and 30.99% of carbohydrates (by different). Besides, the bioactive compounds present in mangosteen peel are xanthone (165.90 mg/100mL), anthocyanin (17.52 mg/g), and tannin (3.32%).

Extensive research both *in vitro* and *in vivo* has been performed to identify and examine the pharmacological effect of mangosteen pericarp, which include antioxidant, anticancer, antinociceptive, anti-inflammatory, neuroprotective, anti-obesity, anti-hyperglycemic (Ovalle-Magallanes et al., 2017). Another research also indicated that mangosteen pericarp can be a source of antimicrobial compounds. According to Rahmawati et al. (2021), the mixture of mangosteen pericarp and bay leaves powder could inhibit the growth of *Staphylococcus aureus* stored in refrigerated temperature within 12 days. Those beneficial aspects indicate that all the parts of mangosteen fruit are the potential to be further applied both in food and medicinal products. One

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of the medicinal products widely consumed by Indonesian people is tea. The processing of mangosteen pericarp into tea is expected to make it easier for people to consume and utilize the benefits of mangosteen pericarp (Sugito, 2003). In general, tea is prepared by infusing the plant matrix into a boiling water (up to 100 °C) placed in container, then it is capped. After that, it is rested for about 5 to 10 minutes. Subsequently, the liquid is used for consumption or scientific research (Chávez-González et al., 2020).

This review article aims to to review the characteristics of bioactive compounds in mangosteen, the potency of antioxidants to enhance the immune system, and the application of mangosteen pericarp simplicial in tea production.

Material and Methods

This review was prepared by searching and screening relevant literature with regards to antioxidant sources from mangosteen, especially the part of the pericarp, and its beneficial health effect on the immune system. Some keywords used in this literature review were “antioxidant”, “immune system”, “mangosteen”, “pericarp”, and “tea”. The analysis in this review was elaborated by a minimum of 20 articles and books published in the last 20 years. Then, all the explanation that falls under the scope of those keywords were used to conceptualize the manuscript.

Results and Discussion

Bioactive compounds in mangosteen pericarp as a source of antioxidant

Antioxidants have been shown to prevent premature aging (antiaging), prevent heart disease, prevent various types of cancer, and increase immunity. Antioxidants are substances that can slow down or prevent the oxidation process. Oxidation reactions can produce free radicals which are very harmful to human health. Free radicals are molecules that are unstable because they lose electrons, and to achieve stability, free radicals take electrons from molecules or cells in the body so that they will cause damage to body cells and various degenerative diseases such as coronary heart disease, atherosclerosis, osteoporosis, cancer, liver cirrhosis, Alzheimer's, pulmonary obstruction, diabetes, chronic kidney disease, and stroke (Putra & Sitiatava, 2011). The mechanism of antioxidants in preventing the oxidation process consists of two ways (Figure 1), namely transferring the single electron or transferring the hydrogen atom to free radicals (Siddeeg et al. 2021).

Chemical components that act as antioxidants are phenolic and polyphenolic compounds. These group compounds are widely found in nature, especially in plants, which can scavenge free radicals. Many natural antioxidants are found in our diet, including ascorbate (vitamin C), tocopherols (vitamin E), carotenoids (vitamin A), and polyphenols (antioxidants in tea and leaves). But all these abilities are far below xanthones from mangosteen. For example, antioxidants in oranges have a value of 2400 ORAC per 100 oz, while xanthones have a value of 20,000 ORAC (Oxygen Radical Absorbance Capacity). A laboratory test known as ORAC, for example, shows that one ounce of mangosteen juice provides 20 to 30 times greater capacity to absorb free radicals than one ounce of most fruits and vegetables (Paramawati, 2010).

Mangosteen pericarp contains chemicals such as xanthones, mangostin, garsinone, flavonoids and tannins (Miryanti et al., 2011). Xanthones and anthocyanins found in mangosteen peel are compounds with strong antioxidant effects that bind unstable free oxygen, namely free radicals that destroy cells in the body, hence it can inhibit the process of cell degeneration (damage). Some xanthones of mangosteen included α-mangostin, β-mangostin, ɣ-mangostin, gartanine, 8-deoxygartanine, mangostinone, 11α-mangostin, mangostanol, 1-isomangostin, 3-isomangostin, and garcinone E. The most abundant xanthones in mangosteen pericarp and bark are α- and γ-mangostin (Shandiz et al., 2017). The chemical structure of xanthones consists of three rings and this makes it very stable when in the body and hot or cold conditions. There are more than 200 types of xanthones in nature but more than 40 types of xanthones are found in the mangosteen fruit and this is the highest content. The best properties of xanthones are antioxidant

properties that inhibit the oxidation process or the aging process of the body/ body cells. Xanthones will protect cells and reduce damage to cells caused by free radicals.

Flavonoids are a group of naturally occurring polyphenolic compounds ubiquitously found in fruits and vegetables (Hollman & Arts, 2000). Flavonoids generally have a generic structure consisting of two aromatic rings (rings A and B) linked by three carbons which are usually in an oxygenated heterocyclic ring, or C ring. The difference in the generic structure of the C heterocyclic ring classifies them as flavonols, flavones, flavanols (catechins), flavanones, anthocyanidins, and isoflavonoids. Flavonols (quercetin, kaempferol, and myricetin) and flavones (luteolin and apigenin) are common flavonoids in the daily diet. Flavonoids are mostly found in nature as glycosides, sometimes also as aglycones, mainly because of food processing (Liu, 2002).

There has been much convincing evidence *in vitro*, *in vivo*, and epidemiological studies showing the benefits of flavonoids in fruits and vegetables for the prevention of chronic diseases because they have bioactivity as antioxidant, anticancer, and cardiovascular protective effects (Liu, 2002). As free radical scavenging, it plays a significant role in the antioxidant activity of flavonoid compounds (Middleton et al., 2000). Phenolic compounds, such as flavonoids, have a much stronger antioxidant capacity than vitamins C and E.

The flavonoid group that has many functions is anthocyanins which have the function of protecting chloroplasts from photodegradation by absorbing high-energy quanta and ROS (Gould, 2004). Secondary metabolites, in addition to playing a role in survival or adaptive strategies, are also used as dyes, adhesives, flavorings, antibiotics, insecticides, and herbicides (Croteau et al., 2000; Dewick, 2002). In recent years, phenolic compounds and flavonoids are important protective constituents in human nutrition in the long term, which can show potential in modulating human metabolism which is beneficial in preventing or reducing the risk of degenerative diseases such as heart disease, diabetes, obesity, and cancer (Fraga, 2009). According to Geethma and Dias (2020), the highest total phenolic content (TPC) and total flavonoid content (TFC) of mangosteen fruit were observed in the pericarp (Table 1). Moreover, the specific antioxidant activity was quite different when measured with 1-Diphenyl-2-picrylhydrazyl (DPPH) and 2,2-Azino-bis (3-ethylbenzthiazoline-6-sulfonic) acid (ATBS) methods (Table 2).

Table 1. The concentration of the phenolic compound in mangosteen

Sample	Peel	Pericarp	Pulp	Seed
Total Phenolic Content (μg/mL)	6.40 ± 0.63	8.56 ± 1.17	2.64 ± 0.10	2.47 ± 0.29
Total Flavonoid Content (μg/mL)	7.08 ± 0.74	9.64 ± 0.65	6.56 ± 0.12	6.32 ± 0.34

Table 2. The average percentage of antioxidant activity in mangosteen

Sample	Peel	Pericarp	Pulp	Seed
DPPH (%)	92.35 ± 2.13	95.22 ± 1.11	61.82 ± 0.86	94.06 ± 0.42
ABTS (%)	98.00 ± 1.06	98.31 ± 0.70	77.42 ± 3.02	98.13 ± 0.50

Antioxidant potency to enhance the immune system

An immune system is a group of cells, chemicals, and processes that function to protect the human body, including the skin, respiratory passages, intestinal tract, and other areas from foreign antigens. These foreign antigens can be microbes (bacteria, fungi, and parasites), viruses, cancer cells, and toxins (Marshall et al., 2018). The immune system consists of two subsystems, namely the innate (non-specific) immune system, and the adaptive (specific) immune system. According to Institute for Quality and Efficiency in Health Care (IQWiG) (2020), these subsystems are closely linked and work together whenever a harmful substance triggers an immune response. One of the immunological responses is inflammation. Inflammation is a response to the immune

system to protect the human body from infection. However, uncontrolled acute inflammation can cause chronic inflammation, leading to life-threatening hypersensitivity reactions. It can also cause progressive organ damage, such as cancer, heart, and neurodegenerative diseases. To alleviate those negative impacts, Nonsteroidal anti-inflammatory drug (NSAIDs) is used as an effective medicine, but it possesses adverse effects at therapeutic doses, including stomach ulcers, heart attack, and stroke (Wong & Mah 2021). Therefore, alternative drugs are important and needed to reduce the immune response, one of which is antioxidants.

Antioxidants from vitamins such as vitamins C, E, and A, are crucial in reducing and controlling oxidative stress and infectious diseases. These vitamins protect the immune system and enhance resistance against infectious microbes. Hence, it is highly recommended to include antioxidants in the daily diet (Khadim & Al-Fartusie 2021). Tang et al. (2009) examined the effect of a mangosteen product containing multivitamins and essential minerals were tested on immune function and well-being in healthy adults (40-60 years old). The results indicated that the consumption of products containing abundant antioxidants significantly enhanced immune responses and improved the subject's self-appraisal of his or her overall health status. Another research on immunomodulatory activities of alpha-mangostin on lymphocyte lineage and cytokine production in human peripheral blood mononuclear cells (PBMCs) indicated that alpha-mangostin was able to inhibit IL-2 release without interfering with human immune cells (Kasemwattanaroj et al., 2013).

Application of extract of mangosteen pericarp in tea

Processing of mangosteen pericarp into tea can use extract or use simplicia powder of mangosteen pericarp. Simplicia is a natural material that has been dried which is used for treatment and has not been processed unless otherwise stated the drying temperature is not more than 60°C (BPOM, 2014). Types of simplicia for mangosteen peel are vegetable Simplicia: simplicia in the form of whole plants, plant parts or plant exudates. Plant exudates are cell contents that spontaneously come out of plants or cell contents that are in some way separated from the plant and are not yet in the form of pure chemical compounds. Safe and efficacious simplicia are simplicia that do not contain chemical, microbiological, and physical hazards, and contain active substances that are efficacious. The characteristics of good simplicia are in dry conditions (moisture content < 10%), for leaf simplicia, when crushed, they rustle and turn into flakes, flower simplicia when squeezed rustle and turn into flakes or are easily broken, and fruit and rhizome simplicia (slices) when crushed. kneaded easily to break. Another characteristic of a good simplicia is that it is not moldy and has a distinctive smell resembling the fresh ingredients (Herawati et al., 2012).

The use of mangosteen pericarp simplicia powder as processed products such as tea must be careful because of the high content of saponins and tannins in the mangosteen pericarp. Especially on the exocarp skin (peel). The results of the preliminary test of the mangosteen pericarp simplicia powder (*Garcinia mangostana* L.) showed that the mangosteen rind simplicia used was positive for saponins (Irmayanti et al., 2021). Other phytochemical studies have shown that mangosteen peel contains the most active ingredients such as xanthones, flavonoids, saponins, and tannins (Pasaribu & Bahri, 2012; Suttirak & Manurakchinakorn, 2014; Manimekalai et al., 2016).

However, there have been safety concerns about saponins. In some animals, saponin can cause hemolysis of erythrocytes (red blood cells), inhibit physical growth, causes bloat in ruminants, inhibits the activity of several enzymes, irritates the lining of the mouth and digestive tract so that it can inhibit the absorption of nutrients (vitamins and minerals such as Fe) in the digestive tract of livestock. Meanwhile, tannins in high concentrations also cause toxic effects on rumen microbes through enzyme inhibition mechanisms, damage to cell walls and/or microbial membranes, and the binding of various types of minerals. The toxic effects of tannins on ruminants include bleeding in the digestive tract, liver necrosis, and kidney damage (Jayanegara et al., 2019).

Moreover, there have been safety concerns regarding the chemical compound added to the mangosteen pericarp, which may affect the chemical composition of simplicia made of mangosteen pericarp. Mostly, the sellers apply the wax emulsion to prevent physical bruise and extend the shelf life of mangosteen. The wax substance used is beeswax contained in the beehive itself, the wax substance is used to coat fruit or vegetables so that they do not quickly decay or damage. Preservation process by waxing. very supportive in processing and storage. In addition, candles cannot be digested by the digestive system, and if consumed continuously will have an impact on consumer health, for example, the incidence of liver cancer, colon cancer, and leukemia (Dwiari et al., 2008).

Conclusion

To summarize, mangosteen pericarp is one of the potential sources of antioxidants that can be used in the production of food and medical products, one of which is tea. Several secondary metabolites act as antioxidants produced from mangosteen pericarp, namely xanthone, mangostin, garcinones, tannin, and saponins. Each of those bioactive compounds can induce the immune system in destroying free radicals which cause adverse health effects in human body. Nevertheless, further research is importantly required to ensure the safe dose of extract of mangosteen pericarp, especially for vulnerable groups or YOPI (Young, Old, Pregnant, and Immuno-compromised) people.

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