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A review: Mangosteen an untapped source of bioactive

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Abstract

The Mangosteen (*Garcinia mangostana*) is a tropical fruit known for its unique taste and potential health benefits. This review paper aims to provide an overview of the applications of mangosteen in various fields and explore its waste utilization potential. The paper begins by introducing the mangosteen fruit, its nutritional composition, and its phytochemical profile, highlighting its rich content of xanthenes, tannins, and other bioactive compounds. The pharmacological properties of mangosteen, such as antioxidant, anti-inflammatory, antimicrobial, and anticancer activities, are discussed, shedding light on its potential therapeutic applications in traditional medicine and functional foods. Furthermore, this review delves into the industrial applications of mangosteen, including the utilization of its rind, seeds, and pericarp for the extraction of bioactive compounds and the development of value-added products. Studies exploring the utilization of mangosteen waste as a source of natural dyes, functional additives, and biofuels are presented, showcasing the sustainable utilization of this fruit and its by-products.

Keywords: Mangosteen, benefits, nutritional compositions, types

Introduction

Mangosteen (*Garcinia mangostana*), also called purple mangosteen, is an edible fruit-bearing tropical evergreen tree indigenous to tropical regions bordering the Indian Ocean. It is primarily prevalent in tropical areas of Southeast Asia, southwest India, and other countries. The height of the tree ranges from 20 to 82 feet (or 6 to 25 meters). When ripe, mangosteen fruit has a deep reddish-purple exocarp that is inedible, sweet, acidic, juicy, and fibrous with fluid-filled vesicles (similar to citrus flesh). Endocarp, which refers to the inner layer of the ovary, is the botanical name for the flavorful edible flesh that envelops each seed in each fruit. The edible seeds are shaped and sized like almonds. The juicy, delicate texture and sweet-tart flavor of mangosteen are highly regarded. A Southeast Asian plant known as mangosteen has white flesh and a delicious

sweet and sour flavor. According to the Chinese chronicle Yingya Shenglan written in the 15th century, mangosteen was first grown in English greenhouses in 1855. When its culture was introduced to the Western Hemisphere, where it established itself in West Indian islands, mangosteen came to be known as the "Queen of Fruit" in Southeast Asia. "Xango juice" is the term used to describe mangosteen juice, which is becoming more and more well-liked as a "health drink." Some marketers claim that Xango juice helps treat disorders like TB, diarrhea, menstruation issues, and urinary tract infections. The vitamins and minerals included in mangosteen are essential for a variety of body processes, including DNA synthesis, muscular contraction, wound healing, immunity, and nerve transmission. Additionally, this fruit supplies 14% of the daily need for fiber, a nutrient that is frequently lacking in people's diets, in just one cup (196 g). The abundance of fiber in mangosteen provides numerous health advantages. A higher-fiber diet can help lower your body's inflammatory response, according to animal studies. Fibre helps to maintain a balanced gut flora, which is essential for immunity. Due to its well-known health advantages and the presence of numerous antioxidants like vitamin C and folate, mangosteen has long been in great demand on the market. Recent scientific studies suggest that mangosteen has potent antioxidant, anti-cancer, anti-inflammatory, anti-allergic, anti-microbial, and anti-malarial capabilities. Cancer, osteoarthritis, dysentery, menstruation abnormalities, diarrhea, gonorrhoea, thrush, and intestinal infections are among the conditions that mangosteen is used to treat. Additionally, it is used to strengthen the immune system and improve mental health. Mangosteen contains fewer calories than other fruits. Figure 1.1 shows a thorough illustration of the mangosteen fruit's component sections.

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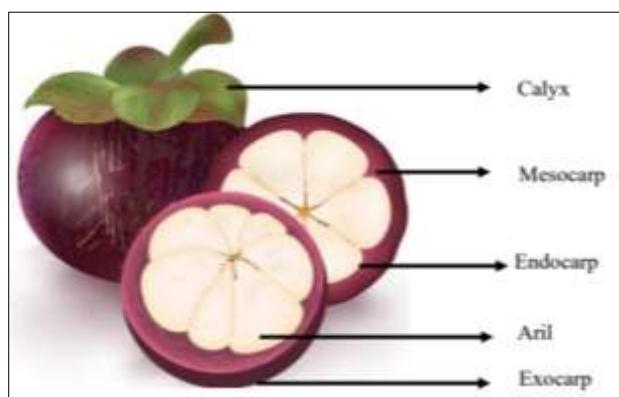


Fig 1: Parts of Mangosteen fruit

Table 1: Nutritional Composition of Mangosteen

Nutritional content	Amount
Calorie	34.0 kcal
Water	87.6%
Soluble amount	15-19%
Protein	6 g
Fat	1.0 g
Carbohydrate	5.6 g
Fibre	5.1g
Ash	0.1 g
Calcium	7.0 mg
Phosphorus	13.0 mg
Iron	1.0 mg
Potassium	45.0 mg
Vitamin B1	0.03 mg
Vitamin B2	0.03 mg
Niacin (Vitamin B3)	0.3 mg
Vitamin C	4.2 mg

Review of literature

A tropical fruit in the Guttiferae family is called *Garcinia mangostana* Linn. Dark purple to red purple is the colour spectrum for mangosteen fruits. The aril edible fruit is white, soft, and juicy, and it tastes sweet and somewhat acidic. It also has a pleasant aroma. "Queen of fruit" is another name for it. It is grown in a number of nations, including Malaysia, Indonesia, and Thailand. The pericarp of mangosteen has long been used in traditional Thai medicine to heal wounds, diarrhoea, and skin diseases (Ovalle-Magallanes *et al.*, 2017) [12]. According to (Chaovanalikit *et al.*, 2012) [2], the primary bioactive compounds found in mangosteens include phenolic acid, prenylated xanthone derivatives, anthocyanins, and procyanidins. Nata de coco refers to meals that have been fermented with coconut water using the bacterium *Acetobacter xylinum*. Nata de coco is typically produced by immediately injecting the inoculum into a liquid media. A method for encasing cells in a matrix is cell immobilisation. Use of Immobilised cells for nata de coco production, which yields a cell-free nata, is one substitute for the product. Immobilised *Acetobacter xylinum* was used to make nata on a coconut water medium. By encasing it in a Ca-alginate matrix, *Acetobacter xylinum* was rendered immobile. The cells that had been Immobilised were subsequently used to ferment nata de coco many times (Nugroho & Aji, 2015) [11]. Due to its strong antioxidant and nutrient content, this fruit provides a variety of health benefits. Xanthones are phytochemicals and nutrients found in mangosteen that have positive effects on cardiovascular disease, including heart disease, atherosclerosis (hardening of the arteries),

hypertension (high blood pressure), and thrombosis by lowering cholesterol levels and lowering the risk of heart attack (formation of blood clots). More study has revealed that xanthone activity lowers inflammation and acts as analgesic (Suttirak & Manurakchinakorn, 2014) [16].

A variety of cancer cells, including leukaemia, liver, breast, colon, stomach, and lung, are prevented from proliferating by the anti-tumor properties of mangosteen xanthones and xanthone derivatives. *Staphylococcus aureus*, which causes pneumonia as well as infections of the bones, skin, and circulatory system, and tuberculosis have both been proven to be suppressed by mangosteen's antibacterial properties. The living organism in charge of producing Nata de Coco is *Acetobacter xylinum*, a gram-negative bacterium. Nata de Coco is a bacterial cellulose made by *Acetobacter xylinum* that develops over a sugary medium. Although, *Acetobacter xylinum* is the most prevalent, acetic acid bacteria of different species can generate cellulose. Microbial beginning culture is the element that is most important in the production of Nata de Coco. By removing a tiny amount of Nata medium formula and fermenting it for three to five days before utilising it as a starter, post fermentation liquid is used at the manufacturing to create a culture. The possibility of the starting culture being contaminated, however, is very significant with this method. As a result, utilising post-fermentation liquid to prepare beginning culture after the product has been collected is preferable (Shaharudin *et al.*, 2022) [13].

Mangosteen has low calorie content (only 63 calories per 100 g), no cholesterol, and no saturated fats. Additionally, it is abundant in dietary fibre (100 g offers 13% of RDA). With roughly 12% of the RDA per 100 g, mangosteen is also a good source of vitamin C. This fruit also contains a modest amount of B complex vitamins, including thiamin, niacin, and folates, which serve as cofactors in the body's metabolism of carbs, protein, and lipids. Additionally, it has a very good concentration of minerals including copper, manganese, and magnesium. Since it helps regulate blood pressure and heart rhythm, potassium is a crucial part of body fluids and cells (Aizat *et al.*, 2019) [1].

Alpha-Mangostin is an aromatic tricyclic ring compound with hydroxyl and isoprenyl groups. Mangosteen contains xanthone chemicals that have pharmacological properties such as apoptosis induction, cellular metabolic impairment, and cyclooxygenase inhibition. Between 5.5 and 18.7 percent of the total phenolic acids in mangosteen fruits were free phenolic acids (peel and rind, respectively). In the peel and rind, hydroxybenzoic acid derivatives were the primary phenolic acids found. Traditional medicine has utilised mangosteen berries to cure skin conditions, wounds, and diarrhoea. According to (Zadernowski *et al.*, 2009) [23], the total amount of phenolic acids in mangosteen berries ranged from 265.7 12.9 (aril) to 5027.7 188.0 mg per kilogram. Studies have revealed that xanthones from the fruit shell have antibacterial and anti-inflammatory activities. According to (Weecharangsan *et al.*, 2006) [18], the ethanol extract of *Garcinia mangostana* Linn. (GM) inhibits the formation of prostaglandin E2, histamine, and HIV-1 protease. As a carbon source, the coconut water's glucose is metabolised by *Acetobacter xylinum* into metabolites that become nata de coco's extracellular cellulose. In order to produce acetic acid, the acetic acid bacterium *Acetobacter xylinum* must first break down several types of alcohol and carbohydrates. Acetic acid bacteria are also gram-negative and aerobic. The most promising biopolymer is produced by *Acetobacter*

xylinum and is utilised in a range of applications as a high-performance audio membrane. The traditional dessert known as nata de coco was first prepared using bacterial cellulose produced in a static culture using natural media like coconut water ((Halib *et al.*, 2012)^[4].

The mangosteen tree's fruit, leaf, and bark have all been used in traditional medicine to cure a range of ailments, such as fever, skin infections, and diarrhoea. Mangosteen is commonly consumed raw or in juice form these days. It's also used in a lot of vitamins, extracts, and cosmetic products because of its potential health benefits.

Mangosteen's most typical usage and applications include

Mangosteen contains a lot of antioxidants, which can help prevent damage from free radicals. It has been proven that these antioxidants help in cancer prevention, inflammation reduction, and general health enhancement. The ability to reduce inflammation Several anti-inflammatory substances found in the fruit may aid to reduce pain and swelling. As a result, it can be applied to treat inflammatory diseases like arthritis, allergies, and other autoimmune disorders.

Due to its anti-cancer qualities, which include the capacity to halt the formation and spread of cancer cells, mangosteen may be utilised as a treatment for a number of cancers. The outer skin of the mangosteen fruit is referred to as the peel or pericarp. Fruit skin is typically discarded when eaten, despite the fact that studies have shown it to be highly concentrated in antioxidants, xanthenes, and other beneficial compounds. The mangosteen fruit's skin may be anti-inflammatory, antimicrobial, and anti-cancer. Some studies suggest that mangosteen peel may also assist in lowering cholesterol and enhancing blood sugar control.

Along with potential health advantages, mangosteen peel is utilised in traditional medicine in various cultures. Frequently, it is used to make tea or is added to dishes like soups. Mangosteen skin can be consumed in a number of different ways, such as a tea, powder, or dietary supplement. Additional study is required to fully understand the benefits and drawbacks of utilising mangosteen peel in these forms. A healthcare professional should always be consulted before utilising any new supplements or products (Lin *et al.*, 2020).

Cultivation of Mangosteen

As the "Queen of Fruits," mangosteen is a tropical fruit beloved for both its sweet and tart flavour and its numerous health benefits. Originating in Southeast Asia, the fruit is currently produced all over the world, but is most popular in Africa, Australia, and the Americas.

Mangosteen trees may grow up to 80 feet in height and need a warm, humid environment to thrive. In addition to a lot of tightly packed dark green foliage, the trees also produce small, fragrant blossoms that beg pollinators. After pollination, the fruit takes around 3–4 months to mature and ripen. Because the trees require frequent trimming, fertilization, and pest control, mangosteen farming is a labor-intensive process. Because it is also highly perishable, the fruit must be physically harvested when fully ripe. Because the fruit is so delicate, it is often carried in specialized containers that maintain the proper temperatures and humidity levels.

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Despite the challenges in growing it, mangosteen is appreciated for its numerous health benefits, such as its anti-inflammatory and antioxidant properties. The fruit is commonly used in conventional medicine to treat a variety of ailments, including diarrhoea, dysentery, and skin infections. A number of crucial requirements must be met for a mangosteen plant to grow healthily and bear as many fruits as feasible. The trees require, first and foremost, a warm, humid climate with temperatures ranging from 20 to 35 °C (68 to 95 °F) and an average annual rainfall of 1500 to 2500 mm. Mangosteen trees need soil with a pH range of 5.5 to 6.5 since they cannot handle moist conditions. They also need a well-drained environment. Mangosteen can be grown from seeds, although this approach is not recommended because the resulting trees may take up to 10 years to bear fruit. In contrast, vegetative propagation techniques, such as air layering or grafting, are favored since they result in plants that are genetically similar to the parent tree and can start yielding fruit in 3–4 years (Kusumawati *et al.*, 2017)^[6]. Mangosteen trees should be frequently pruned when they are established to maintain their shape and promote new growth. In addition, fertilization is required, with a 2:1:1 ratio of nitrogen, phosphorus, and potassium recommended for application. Pests like fruit flies, scales, and mealybugs are another reason why pest control is so important (Wong & Klemmer, 2008).

Mangosteen must be hand-picked when fully ripe because the fruit is delicate and easy to damage during the delicate picking procedure. The fruit is typically harvested over the period of two to three weeks in two to three rounds, with each round yielding fruit that is at a different stage of ripeness. For successful mangosteen farming, it is generally required to carefully evaluate a variety of elements, including climate, soil properties, propagation, pruning, fertilizer, pest management, and harvesting techniques. However, if grown and harvested properly, mangosteen can be a profitable crop that brings farmers and growers satisfaction. Overall, cultivating mangosteens requires specialist knowledge and abilities, but many farmers and producers throughout the globe believe the benefits of farming this tasty and healthy fruit to be well worth the effort (Yao *et al.*, 2023)^[22].

Biology of Mangosteen

Biology

The mangosteen tree, or *Garcinia mangostana*, is a member of the Clusiaceae family of tropical fruit trees. The tree's dense canopy, which can grow up to 80 feet tall and is made up primarily of glossy, dark-green leaves, provides shade for the fruit. The fruit, which is either round or oval in shape, has a hard, reddish-purple outer shell and white, delectable flesh within that is filled with multiple segments of sweet and sour pulp. Mangosteen trees are dioecious, meaning that each tree

is either male or female. The trees must cohabit in order to bear fruit. Bees and butterflies use the trees' tiny, fragrant flowers, which are produced frequently, to pollinate other plants. After pollination, the fruit takes several months to grow and mature.



Fig 2: Mangosteen

Mangosteen cultivation requires a lot of labour because the trees require regular feeding, pruning, and pest control. Because it takes a while for the new trees to start bearing fruit, seeds are typically not advised for propagation; instead, vegetative techniques like grafting or air layering are employed. Mangosteen cultivation requires a lot of labour because the trees require regular feeding, pruning, and pest control. Because it takes a while for the new trees to start bearing fruit, seeds are typically not advised for propagation; instead, vegetative techniques like grafting or air layering are employed. Because the fruit must be personally chosen when fully ripe to avoid manipulation, the harvesting process is particularly sensitive. Mangosteens are highly valued for their many healthful qualities in addition to their delectable flavour. The fruit contains a lot of antioxidants, with xanthones in particular having been shown to have anti-inflammatory and anti-cancer qualities. It also contains large amounts of fibre, vitamin C, and several B vitamins.

Storage and Processing of Mangosteen

The flavour and freshness of the tropical fruit mangosteen must be maintained through careful storage. To encourage airflow, fruit should be cleaned, sorted, and placed in perforated containers after harvest. By doing this, the chance of spoilage and the growth of fungus is decreased by the reduction of moisture buildup. At a temperature of 10 to 12 °C and relative humidity of 85 to 90%, mangosteen can be stored. With this humidity and temperature, the fruit can last up to two to three weeks. In the event that the temperature is too low, the fruit may suffer from chilling injury, which causes discoloration and a loss of flavour. Both fresh and processed mangosteen products, such as juice, jam, and puree, are available for consumption. After the fruit's skin has been removed, the pulp and seeds are separated. After that, by blending the pulp, juice, puree, or concentrate can be created. The purée and sugar are cooked together until the jam thickens.

Finally, for optimum storage of mangosteen, it is required to clean, sort, and place the fruit into perforated containers to allow for air circulation. For a fruit's longest possible shelf life, storage should be kept at 10–12 °C and 85–90% relative humidity. The procedures in the processing of mangosteen to produce a variety of products, including juice, jam, and puree (Wathoni *et al.*, 2019) [17], including peeling, separating the pulp from the seeds, and blending.

Mangosteen Properties

A popular tropical fruit with a distinctive flavour and maybe beneficial properties for health is the mangosteen. The fruit has several attributes that add to its nutritional worth and health-improving effects. Some of the main characteristics of mangosteen are as follows:

- ✓ **Antioxidants:** Xanthones, in particular, which are found in abundance in mangosteen, protect cells from oxidative stress and lower the risk of chronic illnesses like cancer, heart disease, and Alzheimer's disease.
- ✓ **Anti-inflammatory:** It has also been discovered that the xanthones present in mangosteen have anti-inflammatory characteristics, which may lessen the symptoms of inflammation and lower the chance of developing chronic illnesses.
- ✓ **Anti-cancer:** Due to its high antioxidant and anti-inflammatory qualities, some studies have suggested that mangosteen may have anti-cancer effects.
- ✓ **Immune-stimulating:** Mangosteen is also thought to contain immune-stimulating characteristics that may help bolster the body's built-in defenses against infections and illnesses.
- ✓ **Anti-microbial:** Mangosteen has been discovered to have anti-microbial qualities that may aid in preventing bacterial and fungal infections.
- ✓ **High in nutrients:** Vitamin C, folate, potassium, magnesium, and other vitamins and minerals are all present in mangosteen in significant amounts (Sukma *et al.*, 2011) [15].

Mangosteen Applications

Mangosteen contains xanthones, which have been shown to reduce inflammatory reactions in the body and are responsible for its anti-inflammatory properties. This makes it an option for therapy for a range of inflammatory conditions, such as rheumatoid arthritis, asthma, and allergies. The body can avoid oxidative stress and cellular damage caused by free radicals thanks to the antioxidant properties of mangosteen. As a result, it may be utilised as a preventative measure for a variety of diseases, such as cancer, cardiovascular disease, and Alzheimer's disease. Mangosteen may offer anti-diabetic properties, according to research that has been done on the subject. Research has shown that mangosteen can help type 2 diabetics better control their blood sugar levels and insulin sensitivity.

Bioactive in mangosteen

The types bioactive in Mangosteen

Mangosteen (*Garcinia mangostana*) is a tropical fruit known for its delicious taste and potential health benefits. It is also considered an untapped source of various bioactive compounds, which are substances that have specific biological effects in the body. While the exact composition can vary depending on the variety and ripeness of the fruit, here are some of the bioactive commonly found in mangosteen:

- ✓ **Xanthones:** Mangosteen is particularly rich in a group of bioactive compounds called xanthones. These compounds have been studied for their potential antioxidant, anti-inflammatory, anti-cancer, and anti-microbial properties. Some notable xanthones found in mangosteen include alpha-mangostin, beta-mangostin, and gamma-mangostin.
- ✓ **Flavonoids:** Mangosteen contains various flavonoids,

which are known for their antioxidant and anti-inflammatory effects. These compounds help protect the body's cells from damage caused by free radicals and have been associated with potential benefits for cardiovascular health and immune function.

- ✓ **Polyphenols:** Polyphenols are a diverse group of bioactive compounds found in plants, and mangosteen is a good source of them. These compounds have been studied for their potential anti-cancer, anti-inflammatory, and neuroprotective properties. Mangosteen contains several polyphenols, including catechins, proanthocyanins, and tannins.
- ✓ **Quinones:** Mangosteen contains quinones, which are organic compounds that have been linked to various biological activities. Quinones have been studied for their potential anti-inflammatory, antioxidant, and anti-cancer effects.
- ✓ **Carotenoids:** Mangosteen contains carotenoids, which are pigments responsible for the fruit's vibrant color. Carotenoids have antioxidant properties and are known for their potential benefits for eye health and immune function. Some carotenoids found in mangosteen include beta-carotene, lutein, and zeaxanthin.
- ✓ **Vitamin C:** Mangosteen is a good source of vitamin C, a powerful antioxidant that supports immune function, collagen synthesis, and iron absorption in the body. Vitamin C also plays a role in protecting cells from oxidative stress.

Xanthenes

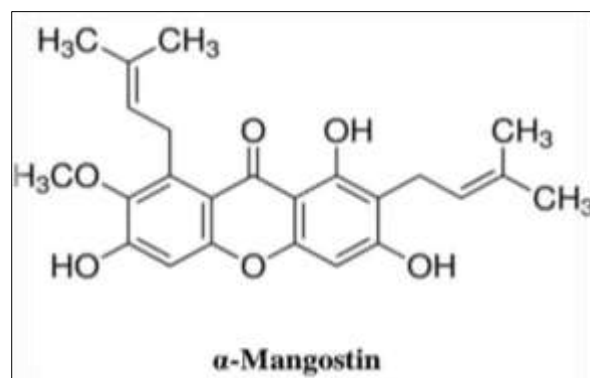
Xanthenes are a class of natural compounds that possess various biological activities, including antioxidant, anti-inflammatory, antimicrobial, and anticancer properties. These bioactive are predominantly found in the pericarp (rind) of the mangosteen fruit. The pericarp contains a diverse array of xanthenes, with over 200 different types identified. Some of the notable xanthenes found in mangosteen include alpha-mangostin, beta-mangostin, gamma-mangostin, and garcinone E. These compounds have been the subject of numerous scientific studies, aiming to understand their potential health benefits and therapeutic applications. Research suggests that mangosteen xanthenes may have antioxidant properties, which can help protect cells from oxidative damage caused by free radicals. They have also shown promising anti-inflammatory effects by inhibiting the activity of certain enzymes and signaling pathways involved in inflammation. Additionally, xanthenes derived from mangosteen have demonstrated antimicrobial activity against various bacteria and fungi, making them potential candidates for natural antimicrobial agents.

In terms of potential health benefits, mangosteen xanthenes have been studied for their anticancer properties. Some research suggests that these compounds may inhibit the growth of cancer cells and induce apoptosis (programmed cell death) in certain types of cancer, including breast, colon, and leukemia. While the research on mangosteen bioactive, particularly xanthenes, is still in its early stages, these compounds show promise as potential therapeutic agents. However, it's important to note that most studies have been conducted in laboratory settings or animal models, and more research is needed to understand their effects in humans. It's worth mentioning that consuming mangosteen fruit or its extracts doesn't guarantee a specific health outcome, as the bioavailability and effectiveness of these bioactive in the

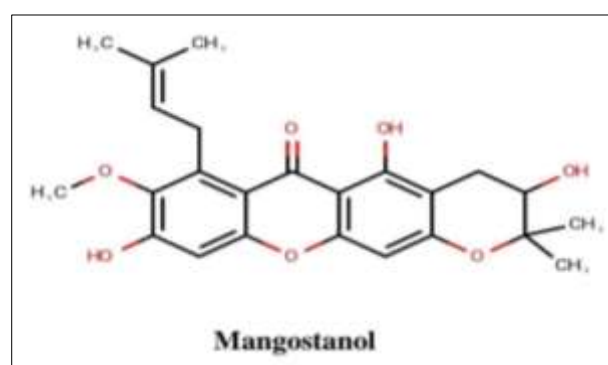
human body can vary. It's always advisable to consult with a healthcare professional before considering any specific dietary supplement or using mangosteen extracts for medicinal purposes.

Xanthenes are subcategorized into

- i) α – Mangostin
- ii) γ – Mangostin
- iii) Mangostanol
- iv) α – Mangostin



α -Mangostin is a prominent xanthone compound found in the fruit of the mangosteen tree (*Garcinia mangostana*). Research suggests that alpha-mangostin and other xanthenes present in mangosteen may possess numerous pharmacological properties. These include antioxidant, anti-inflammatory, antimicrobial, anticancer, cardioprotective, and neuroprotective effects. Furthermore, alpha-mangostin has demonstrated anti-inflammatory effects by inhibiting the production of inflammatory molecules and enzymes, thereby reducing inflammation in the body. This property may be beneficial for managing inflammatory conditions, such as arthritis and inflammatory bowel disease. Additionally, alpha-mangostin has been investigated for its potential cardiovascular benefits, such as reducing cholesterol levels, improving blood vessel function, and protecting against heart disease.



iii) Mangostanol

Mangostanol is a xanthone compound derived from the mangosteen fruit (*Garcinia mangostana*). It is a natural product that has gained attention for its potential health benefits and medicinal properties. Additionally, mangostanol has shown anti-inflammatory effects in some studies. It may help reduce inflammation by inhibiting the production of inflammatory molecules and enzymes, which can be beneficial for managing inflammatory conditions.

Furthermore, mangostanol has demonstrated potential anticancer activity in preclinical studies. It has been found to inhibit the growth of cancer cells, induce apoptosis, and interfere with various cancer-related pathways. However, it is important to note that further research, including human studies, is needed to better understand its effectiveness and safety in treating cancer.

Flavonoids

Flavonoids are a diverse group of plant-derived compounds that are known for their antioxidant and anti-inflammatory properties. They are widely distributed in fruits, vegetables, and other plant-based foods, and they have been associated with various health benefits. In mangosteen, several flavonoids have been identified and studied for their potential bioactivities. The most abundant and well-researched flavonoids in mangosteen are called xanthenes. These include compounds such as alpha-mangostin, beta-mangostin, gamma-mangostin, and garcinone E. Research on mangosteen flavonoids suggests that they possess several health-promoting properties. They have been shown to have potent antioxidant effects, which means they can help neutralize harmful free radicals in the body and protect cells from oxidative damage. Oxidative stress and damage are implicated in various chronic diseases, including cardiovascular diseases, neurodegenerative disorders, and cancer.

Furthermore, mangosteen flavonoids have demonstrated anti-inflammatory properties. They can help reduce the production of inflammatory compounds in the body, potentially contributing to the management of inflammatory conditions and associated diseases. In addition to their antioxidant and anti-inflammatory effects, mangosteen flavonoids have been investigated for their potential anti-cancer properties. Some studies have shown that they can inhibit the growth of cancer cells and induce apoptosis (programmed cell death) in certain types of cancer, although more research is needed to fully understand their mechanisms of action and therapeutic potential. Other potential bioactivities of mangosteen flavonoids include antimicrobial effects, antidiabetic properties, and cardiovascular benefits, although these areas require further exploration and scientific investigation. Overall, mangosteen represents an intriguing and relatively untapped source of bioactive flavonoids, particularly xanthenes, which possess various health-promoting properties. However, it's important to note that while the preliminary research is promising, further studies, including clinical trials, are needed to fully understand the potential benefits and establish recommended doses for therapeutic use.

Polyphenols

Research has shown that mangosteen polyphenols possess strong antioxidant properties, meaning they can help neutralize harmful free radicals in the body and protect cells from oxidative stress. Oxidative stress is associated with various chronic diseases, including cardiovascular disease, cancer, and neurodegenerative disorders. Moreover, mangosteen polyphenols have been found to exhibit anti-inflammatory effects. Chronic inflammation is a common underlying factor in many diseases, and the ability of mangosteen polyphenols to reduce inflammation may contribute to their potential health benefits. Several studies have also suggested that mangosteen polyphenols have antimicrobial properties, potentially inhibiting the growth of certain bacteria and fungi. Additionally, these bioactive have

been investigated for their anticancer properties, showing promising results in laboratory and animal studies by inhibiting the proliferation of cancer cells and inducing apoptosis (cell death) in certain types of cancer. Furthermore, mangosteen polyphenols have demonstrated potential in supporting immune function. They may enhance the activity of immune cells and modulate immune responses, which could have implications for immune-related disorders.

Despite the growing body of research on mangosteen polyphenols, it's important to note that most studies have been conducted in laboratory settings or animal models. Further research, including human clinical trials, is needed to fully understand the bioactive potential of mangosteen polyphenols and their specific mechanisms of action in the human body. In conclusion, mangosteen is an untapped source of bioactive, particularly polyphenols such as xanthenes. These polyphenols exhibit antioxidant, anti-inflammatory, antimicrobial, anticancer, and potential immune-supporting properties. While promising, more research is required to explore their full therapeutic potential and evaluate their effectiveness in humans.

Quinones

Quinones are aromatic compounds that possess a unique chemical structure and are known for their diverse biological activities. In mangosteen, several types of quinones have been identified, such as α -mangostin, γ -mangostin, and gartanin. These quinones are primarily found in the pericarp, or the rind, of the fruit.

Research has shown that quinones from mangosteen exhibit a wide range of potential health benefits. They have been found to possess antioxidant properties, which help protect cells from oxidative damage caused by free radicals. Oxidative stress is associated with various chronic diseases, including cardiovascular disease, cancer, and neurodegenerative disorders. The antioxidant activity of mangosteen quinones may contribute to their potential therapeutic effects. Moreover, quinones from mangosteen have demonstrated antimicrobial activity against various pathogens, including bacteria, fungi, and viruses. They have been studied for their potential as natural antibiotics and antiviral agents. Additionally, some quinones have exhibited anti-inflammatory properties, which could have implications in the treatment of inflammatory conditions. Furthermore, preliminary studies suggest that mangosteen quinones may have anticancer properties. They have been shown to inhibit the growth of cancer cells and induce apoptosis, or programmed cell death, in certain cancer cell lines. These findings are promising and warrant further investigation to explore the potential of mangosteen quinones as anticancer agents. In conclusion, mangosteen represents an untapped source of bioactive, including quinones, with diverse biological activities. These compounds, such as α -mangostin, γ -mangostin, and gartanin, exhibit antioxidant, antimicrobial, anti-inflammatory, and potentially anticancer properties. Continued research on mangosteen and its bioactive quinones may lead to the development of novel therapeutic agents and functional foods for various health benefits.

Carotenoids

Mangosteen contains several carotenoids, including beta-carotene, lutein, and zeaxanthin. Beta-carotene is a precursor to vitamin A and plays a vital role in vision, immune function, and cell growth. Lutein and zeaxanthin are particularly

beneficial for eye health and have been shown to reduce the risk of cataracts and age-related macular degeneration, two common eye conditions. In addition to their antioxidant properties, carotenoids in mangosteen may also have anti-inflammatory and anti-cancer effects. Research suggests that these compounds can help modulate the immune response, reduce inflammation, and inhibit the growth of cancer cells. However, further studies are needed to fully understand the mechanisms and potential health benefits of carotenoids in mangosteen. Despite the potential health benefits, mangosteen is still considered an untapped source of bioactive. The fruit is highly perishable and has a relatively short shelf life, making it challenging to distribute and commercialize on a large scale. However, with advancements in processing and preservation techniques, there is growing interest in unlocking the bioactive potential of mangosteen and developing innovative products that harness its health-promoting properties.

Vitamins

Mangosteen contains various vitamins, including vitamin C, vitamin E, and several B vitamins. Vitamin C, also known as ascorbic acid, is a potent antioxidant that helps protect cells from oxidative stress and supports immune function. It plays a crucial role in collagen synthesis, which is important for maintaining healthy skin, blood vessels, and connective tissues. Vitamin E is another antioxidant found in mangosteen. It helps protect cells from damage caused by free radicals, thus reducing the risk of chronic diseases. Vitamin E also plays a role in supporting immune function and promoting healthy skin. The B vitamins present in mangosteen include thiamine (B1), riboflavin (B2), niacin (B3), and folate (B9). These vitamins are essential for energy production, nerve function, and the synthesis of DNA and red blood cells. They also contribute to brain health, cardiovascular health, and the maintenance of a healthy nervous system. In addition to vitamins, mangosteen contains other bioactive compounds like xanthenes, which are unique to this fruit. Xanthenes have been studied for their potential anti-inflammatory, antioxidant, and anticancer properties. These compounds may also have antimicrobial and antiviral effects. It is important to note that while mangosteen is rich in bioactives, further research is needed to fully understand their mechanisms of action and potential health benefits. Additionally, the bioavailability of these compounds and their effects on the human body can vary based on factors such as fruit ripeness, preparation methods, and individual differences.

In conclusion, mangosteen is an untapped source of bioactives, including vitamins such as vitamin C, vitamin E, and various B vitamins. These vitamins contribute to overall health and wellbeing by supporting immune function, protecting against oxidative stress, and promoting healthy skin, among other benefits. Further exploration of the bioactive compounds in mangosteen may lead to new insights and potential applications in the field of nutrition and health.

Mangosteen Products

Mangosteen juice

The tropical fruit mangosteen, which is highly regarded for its health benefits, is used to make the beverage mangosteen fruit juice (Wong & Klemmer, 2008). To make juice from mangosteen fruit, other juices or water are typically blended in. The use of mangosteen juice as a natural remedy for a

number of conditions, such as inflammation, digestive problems, and high blood pressure, is commonly promoted. This is a result of the amount of xanthenes, antioxidants, and other beneficial compounds in mangosteen fruit, which include those that are anti-inflammatory, anti-cancer, and antibacterial. Mangosteen juice's flavour, which is described as sweet and tart with a sliver of bitterness as an aftertaste, is another distinguishing feature. Some companies might use sugar or other sweeteners to improve flavour (Manurakchinakorn *et al.*, 2016)^[9].

Mangosteen Powder

The fruit of the mangosteen is dried and processed to produce mangosteen powder, a dietary supplement. It is typically sold as a powder and can be mixed with other dishes, smoothies, and beverages. Mangosteen powder contains lots of antioxidants, xanthenes, and other healthy compounds with anti-inflammatory, anti-cancer, and antibacterial properties. It is believed that these compounds can help prevent the cellular damage caused by free radicals, which can play a role in a variety of health problems. As a natural remedy for a number of illnesses, such as inflammation, gastrointestinal difficulties, and skin disorders, mangosteen powder is commonly advocated. It is also touted as possibly having anti-aging benefits.

Mangosteen Skincare products

Mangosteen skincare products are cosmetics that contain mangosteen extract or peel. They are frequently marketed for their anti-aging and anti-inflammatory properties. Mangosteen is well known for having strong anti-inflammatory properties that can help calm irritated skin as well as a high concentration of antioxidants that can help prevent free radical damage.

Using skincare products containing mangosteen may have several advantages, such as;

- ✓ Anti-aging: Mangosteen contains antioxidants that can protect skin from free radical damage and diminish signs of ageing including wrinkles and fine lines.
- ✓ Brightening: Mangosteen contains chemicals that may help to balance out skin tone, lighten skin tone, and minimise the appearance of dark spots.
- ✓ Calming: Mangosteen's anti-inflammatory properties can help to calm irritated or inflamed skin, making it an excellent choice for persons with sensitive skin or conditions like rosacea or eczema.

Mangosteen is an ingredient in numerous types of skincare products, including cleansers, toners, serums, masks, and moisturisers. A patch test should always be performed before using a new product, and you should always visit a dermatologist if you have any concerns about your skin or any underlying skin disorders, even though it is generally believed that using mangosteen skincare products is safe for the majority of individuals.

Mangosteen Jam

The mangosteen berry is used to make a sweet spread known as mangosteen jam. The fruit is cooked with sugar until it resembles jam after being peeled and skinned. The final jelly had a sweet, zesty flavour with a slight bitter aftertaste. Mangosteen jam is often spread on toast, scones, and other baked goods. As a filling for desserts like cakes and pastries, it is also an option. In addition to having a great flavour,

mangosteen jam may also offer some health benefits. High amounts of antioxidants contained in mangosteen are believed to help stop the cellular damage caused by free radicals. It may also have antibacterial and anti-inflammatory properties.

Mangosteen Honey

The form of honey known as mangosteen honey is produced by bees who collect nectar from mangosteen flower flowers. The flavour of mangosteen honey is recognised for being unique; it is described as sweet, subtly acidic, and somewhat bitter. It is smooth in texture and golden in tone. In addition to having a great flavour, mangosteen honey may also offer some health benefits. Like other types of honey, it contains antibacterial, anti-inflammatory, and antioxidant effects. Mangosteen honey may help the immune system and digestion. Mangosteen honey is still rich in sugar and should only be consumed in moderation as part of a healthy diet, despite the fact that it may have some potential health benefits.

Mangosteen Tea

Mangosteen tea is tea produced from dried, crushed mangosteen fruit or its skin. Antioxidants found in mangosteen in high concentrations are believed to help prevent cellular damage brought on by free radicals. It is consequently extensively advertised for its purported health advantages.

Mangosteen tea has a fruity, mildly sweet flavour with a finish that leans slightly bitter. It can be used as a beverage to cool off and can be consumed warm or cold.

The following are possible health advantages of mangosteen tea:

- ✓ **Antioxidant qualities:** The high amounts of antioxidants in mangosteen can help stop cellular damage caused by free radicals.
- ✓ **Anti-inflammatory characteristics:** Mangosteen's anti-inflammatory properties may help reduce inflammation and improve general health.
- ✓ **Immune system support:** According to certain research, mangosteen may help boost the immune system and improve general health (Xie *et al.*, 2015) ^[21].

Mangosteen peel and applications

Mangosteen peel powder

Tropical mangosteen fruit, which originates in Southeast Asia, is prized for its sour and sweet flavour. Fruit peels, while being frequently discarded, are a fantastic source of antioxidants and other beneficial substances that are found in many health and wellness products. Mangosteen peel powder includes a lot of xanthenes, a group of naturally occurring compounds with a reputation for being antioxidants (Manurakchinakorn *et al.*, 2016) ^[9]. These compounds are believed to help the body figurant itself from the damage that free radicals can inflict, which can lead to chronic illnesses including cancer, heart disease, and Alzheimer's disease. In addition to its antioxidant properties, mangosteen peel powder may also possess anti-inflammatory, antibacterial, and antifungal properties that make it useful for treating a variety of medical conditions (Iradukunda *et al.*, 2021) ^[5]. There are several methods to consume mangosteen peel powder, including as a tea ingredient, smoothie ingredient, or dietary supplement. Despite being generally considered to be safe, mangosteen peel powder may interact with some medications or have negative side effects in some individuals. As with any

new supplement or dietary item, it is advisable to check with a healthcare professional before including mangosteen peel powder into your diet (Widowati *et al.*, 2013) ^[19].

Mangosteen peel juice

Mangosteen peel juice is a beverage prepared from the skin of the mangosteen fruit. Even though the fruit's skin is typically discarded when eaten, it has been found to contain a considerable quantity of antioxidants and other beneficial compounds. Before the juice from the mangosteen fruit can be recovered by boiling the peel in water, the skin must first be removed. Sugar or other sweeteners are typically added to improve the liquid's flavour. Mangosteen skin juice is frequently advertised as a natural health beverage (Chitchumroonchokchai *et al.*, 2012) ^[3]. According to its proponents, it can boost immune health, reduce inflammation, and support digestive health. However, there isn't much reliable empirical data to support these claims. Despite the fact that mangosteen peel juice is generally viewed as safe for the majority of people, it is always a good idea to see a healthcare professional before adding any new supplements or products to your regimen, especially if you have any prior medical conditions or are taking medication. In addition, some persons who consume too much mangosteen peel juice could have diarrhoea or stomachache (Wathoni *et al.*, 2019) ^[17]. In order to make mangosteen peel juice, you typically boil the peel in water, filter away the solids, and then drink the liquid. Mangosteen peel juice is rich in xanthenes and antioxidants, which are beneficial components that may have potential health benefits. These compounds' anti-inflammatory, anti-cancer, and antibacterial properties have been proven. Mangosteen peel juice can have a variety of chemical compositions, depending on how it is produced and processed (Lakshan, 2016) ^[7]. However, it frequently contains a range of vitamins and minerals, including calcium, magnesium, potassium, and vitamins C and B6. It also contains a very small amount of protein and fibre. In addition to its potential health advantages, mangosteen peel juice is well known for its distinctive flavour, which has been described as sweet and tangy with a mildly bitter aftertaste (Nakthong & Eshtiaghi, 2021) ^[10].

Waste Utilization of Mangosteen

Mangosteen is valued for its ability to reduce waste in addition to its fantastic flavour and health benefits. Fruit peels, seeds, and other byproducts can be processed and used in a number of different ways. It may be possible to use mangosteen peel as a natural source of antioxidants. Research has demonstrated the antioxidant, anti-inflammatory, and anti-cancer benefits of the polyphenolic compound, xanthenes, present in the peel. For usage in cosmetics, dietary supplements, and functional foods, the peel can be dried and ground into a powder. Due to their high nutritional value, mangosteen seeds are extremely valuable. Protein, fat, fibre, and minerals are all included in the seeds, which can be made into flour or oil. The significant fatty acid composition of mangosteen seed oil may have positive effects on the culinary and cosmetic industries (Suttirak & Manurakchinakorn, 2014) ^[16]. The leftover mangosteen pulp, skin, and seeds can either be fed to animals or used as a source of biogas through anaerobic digestion. This may provide a sustainable energy source and facilitate the decrease of garbage. Mangosteen waste has many applications, including the production of natural antioxidants, dietary supplements, animal feed, and

energy. The numerous applications for these waste products serve as a reminder of the importance of considering efficient and sustainable resource use (Shan *et al.*, 2020)^[14].

Conclusion

Mangosteen has emerged as an untapped source of bioactive, showcasing its potential for various applications. The fruit is rich in natural compounds, such as xanthones and antioxidants, which have been found to possess numerous health benefits. These bioactive exhibit anti-inflammatory, anti-cancer, and antimicrobial properties, among others. Furthermore, Mangosteen extracts and supplements have shown promising results in preclinical and clinical studies, demonstrating their potential as therapeutic agents. However, further research is necessary to fully understand the mechanisms of action and evaluate the long-term effects of Mangosteen bioactive. Nevertheless, the exploration of Mangosteen's bioactive compounds opens up new opportunities for pharmaceutical, nutraceutical, and cosmetic industries, providing a basis for future developments and utilization of this remarkable fruit. Additionally, mangosteen has shown potential in promoting cardiovascular health, supporting immune function, and protecting against neurodegenerative diseases. Despite its promising bioactive profile, mangosteen remains largely underutilized and underexplored. Further research is needed to unlock its full potential, including studying its bioavailability, understanding its mechanisms of action, and exploring its applications in functional foods, nutraceuticals, and pharmaceuticals. The findings from such investigations could lead to the development of novel therapeutic agents and dietary supplements derived from mangosteen, contributing to the advancement of healthcare and nutrition.

Reference

1. Aizat WM, Ahmad-Hashim FH, Syed Jaafar SN. Valorization of mangosteen, "The Queen of Fruits," and new advances in postharvest and in food and engineering applications: A review. *Journal of Advanced Research*, 2019;20:61–70. <https://doi.org/10.1016/j.jare.2019.05.005>
2. Chaovanalikit A, Mingmuang A, Kitbunluewit T, Choldumrongkool N, Sondee J, Chupratum S. Anthocyanin and total phenolics content of mangosteen and effect of processing on the quality of Mangosteen products. *International Food Research Journal*. 2012;19(3):1047–1053.
3. Chitchumroonchokchai C, Riedl KM, Suksumrarn S, Clinton SK, Kinghorn AD, Failla ML. Xanthones in mangosteen juice are absorbed and partially conjugated by healthy adults. *Journal of Nutrition*. 2012;142(4):675–680. <https://doi.org/10.3945/jn.111.156992>
4. Halib N, Amin MCIM, Ahmad I. Physicochemical Properties and Characterization of Nata de Coco from Local Food Industries as a Source of Cellulose. *Sains Malaysiana*. 2012;41(2):205–211.
5. Iradukunda Y, Wang G, Li X, Shi G, Hu Y, Luo F. High performance of activated carbons prepared from mangosteen (*Garcinia mangostana*) peels using the hydrothermal process. *Journal of Energy Storage*. 2021;39(May):102577. <https://doi.org/10.1016/j.est.2021.102577>
6. Kusumawati N, Santoso AB, Sianita MM, Muslim S. Extraction, characterization, and application of natural dyes from the fresh mangosteen (*Garcinia mangostana* L.) peel. *International Journal on Advanced Science, Engineering and Information Technology*. 2017;7(3):878–884. <https://doi.org/10.18517/ijaseit.7.3.1014>
7. Lakshan S. Development of Ready to Serve Fruit Juice Using Mangosteen Peel. *International Journal of Innovative Research in Science, Engineering and Technology*. 2016;5(6):9892–9897. <https://doi.org/10.15680/ijirset.2015.0506051>
8. Lin D, Liu Z, Shen R, Chen S, Yang X. Bacterial cellulose in food industry: Current research and future prospects. *International Journal of Biological Macromolecules*. 2020;158:1007–1019. <https://doi.org/10.1016/j.ijbiomac.2020.04.230>
9. Manurakchinakorn S, Chainarong Y, Sawatpadungkit C. Quality of mangosteen juice colored with mangosteen pericarp. *International Food Research Journal*. 2016;23(3):1033–1039.
10. Nakthong N, Eshtiaghi MN. Development of Mangosteen Juice using Mangosteen Peel Extract Mixed with Tropical Fruits. 2021;9(4):289–295.
11. Nugroho DA, Aji P. Characterization of Nata de Coco Produced by Fermentation of Immobilized *Acetobacter xylinum*. *Agriculture and Agricultural Science Procedia*, 2015;3:278–282. <https://doi.org/10.1016/j.aaspro.2015.01.053>
12. Ovalle-Magallanes B, Eugenio-Pérez D, Pedraza-Chaverri J. Medicinal properties of mangosteen (*Garcinia mangostana* L.): A comprehensive update. *Food and Chemical Toxicology*. 2017;109:102–122. <https://doi.org/10.1016/j.fct.2017.08.021>
13. Shaharudin MA, Zaki NM, Saleh MN, Mohd Noor N, Midin MR. The origin of mangosteen: A review. *Genetic Resources and Crop Evolution*. 2022;69(7):2291–2299. <https://doi.org/10.1007/s10722-022-01426-2>
14. Shan R, Shi Y, Gu J, Bi J, Yuan H, Luo B, Chen Y. Aqueous Cr(VI) removal by biochar derived from waste mangosteen shells: Role of pyrolysis and modification on its absorption process. *Journal of Environmental Chemical Engineering*. 2020;8(4):103885. <https://doi.org/10.1016/j.jece.2020.103885>
15. Sukma M, Ngawhirunpat T, Opanasopit P, Siripong P. Antioxidant properties of squeezed mangosteen juice. *Thai Journal of Pharmaceutical Sciences*. 2011;35(4):176–187.
16. Suttirak W, Manurakchinakorn S. *In vitro* antioxidant properties of mangosteen peel extract. *Journal of Food Science and Technology*. 2014;51(12):3546–3558. <https://doi.org/10.1007/s13197-012-0887-5>
17. Wathoni N, Yuan Shan C, Yi Shan W, Rostinawati T, Indradi RB, Pratiwi R. Characterization and antioxidant activity of pectin from Indonesian mangosteen (*Garcinia mangostana* L.) rind. *Heliyon*. 2019;5(8):e02299. <https://doi.org/10.1016/j.heliyon.2019.e02299>
18. Weecharangsan W, Opanasopit P, Sukma M, Ngawhirunpat T, Sotaphun U, Siripong P. Antioxidative and neuroprotective activities of extracts from the fruit hull of mangosteen (*Garcinia mangostana* Linn.). *Medical Principles and Practice*. 2006;15(4):281–287. <https://doi.org/10.1159/000092991>
19. Widowati W, Rusmana D, Herdiman H, Tiono H, Wargasetia TL, Pujimulyani D. Mangosteen Peel (*Garcinia mangostana* L.) Extract for Effervescent

- Tablet. World Academy of Science, Engineering and Technology 2013;82:192.
20. Wong LP, Klemmer PJ. Severe Lactic Acidosis Associated With Juice of the Mangosteen Fruit *Garcinia mangostana*. American Journal of Kidney Diseases, 2008;51(5):829–833.
<https://doi.org/10.1053/j.ajkd.2007.12.043>
 21. Xie Z, Sintara M, Chang T, Ou B. Daily consumption of a mangosteen-based drink improves *in vivo* antioxidant and anti-inflammatory biomarkers in healthy adults: A randomized, double-blind, placebo-controlled clinical trial. Food Science and Nutrition. 2015;3(4):342–348.
<https://doi.org/10.1002/fsn3.225>
 22. Yao TL, Nazre M, McKey D, Jalonen R, Duminil J. The origin of cultivated mangosteen (*Garcinia mangostana* L. var. mangostana): Critical assessments and an evolutionary-ecological perspective. Ecology and Evolution. 2023;13(3):1–17.
<https://doi.org/10.1002/ece3.9792>
 23. Zadernowski R, Czaplicki S, Naczki M. Phenolic acid profiles of mangosteen fruits (*Garcinia mangostana*). Food Chemistry. 2009;112(3):685–689.
<https://doi.org/10.1016/j.foodchem.2008.06.030>