International Journal of Agriculture and Biosciences 2024 13(4): 689-700.
https://doi.org/10.47278/journal.ijab/2024.177

REVIEW ARTICLE
eISSN: 2306-3599; pISSN: 2305-6622

Phytochemical Analysis and Medicinal Properties of Some Selected Traditional Medicinal Plants

Elham Bagheri [1], Amal Bakr Shori [2], Chin Wai Peng[1], Ahmad Salihin Baba [1] and Ashwag Jaman Alzahrani [3]

[1]Biomolecular Research Group, Division of Biochemistry, Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia
[2]King Abdulaziz University, Faculty of Science, Department of Biological Sciences, Jeddah 21589, Saudi Arabia
[3]University of Jeddah, Department of Biological Sciences, Faculty of Sciences, Jeddah, Saudi Arabia
*Corresponding author: shori_7506@hotmail.com

ABSTRACT

Interest in and awareness of health attributes by natural resources such as herbs, spices, and fruits have resulted in increased consumption of natural products for a safe and effective resolution for illness and also promoting good health. Plants are rich in diverse chemical substances, including polyphenols, flavonoids, and xanthones, many of which have demonstrated medicinal effects or pharmacological benefits. Chinese clinical studies have identified many useful plants that can increase the effectiveness of modern drug treatment and reduce its side effects. The scientific basis for using traditional medicinal plants such as *Garcinia mongostana*, *Lycium barbarum*, *Momordica grosvenori*, and *Psidium guajava* has been established. Therefore, this review research aims to highlight these four traditional medicinal plants' chemical components and medicinal effects.

Keywords: Medicinal properties; Phytochemical; *Garcinia mangostana*; *Lycium barbarum*; *Mormodica grosvenori*; *Psidium guajava*

Article History
Article # 24-749
Received: 07-Aug-24
Revised: 05-Oct-24
Accepted: 10-Oct-24
Online First: 23-Oct-24

INTRODUCTION

In many parts of the world, ethnomedicines focus on traditional medical intervention and the interpretation of health and diseases by indigenous populations (Díaz-de-Cerio et al., 2017). In addition, it addresses the process of seeking healthcare and the practices associated with healing. Medicinal plants have been used to treat human diseases for thousands of years, and this practice is even more common nowadays. Medical plants usually have a more permanent and stronger long-term effect without bringing any side effects to our bodies compared to synthetic medications. *Garcinia mangostana, Lycium barbarum, Mormodica grosvenori,* and *Psidium guajava* are four important traditional medicinal plants in Southeast Asia (Fig. 1). Due to their widespread usage as herbal medicines, this group of plants is currently being studied to discover new bioactive compounds (Ansori et al., 2020; Zhao et al., 2020; Kaur et al., 2020; Tun et al., 2020).

G. mangostana Linn (purple mangosteen) contains xanthones as one of its main compounds (Dharmayani et al., 2022). There are several xanthones that have been studied extensively: a-, b-, and c-angostins, garcinone E, 8-deoxygartanin, and gartanin (Pedraza-Chaverri et al., 2008) which possess a wide range of health-promoting properties, including antioxidant (Krisanti et al., 2021), anti-inflammatory (Gondokesumo et al., 2020)., antimicrobial (Pohan & Rahmawati, 2022) as well as anticancer properties (Nauman & Johnson, 2022).

L. barbarum L. (goji) is rich in zeaxanthin, which exists as dipalmitate (Tang et al., 2011) and polysaccharide protein. Moreover, various bioactive components (hydrophilic, lipophilic) were also isolated from goji (Zhang et al., 2021a; Liu et al., 2022). According to Chinese medicinal monographs, *L. barbarum* fruits were recorded as nourishing the liver and kidney (Byambasuren et al., 2019), and enhancing eyesight (Liu et al., 2022). More functions were reported as anti-oxidation (Liu et al., 2020; Shori & Baba, 2023), anticancer (Qi et al., 2022), anti-inflammatory (Liu et al., 2021), anti-diabetes properties (Luo et al., 2004) and antihypertensive activity (Shori et al., 2021a).

Cite this Article as: Bagheri E, Shori AB, Peng CW, Baba AS and Alzahrani AJ, 2024. Phytochemical analysis and medicinal properties of some selected traditional medicinal plants. International Journal of Agriculture and Biosciences 13(4): 689-700. https://doi.org/10.47278/journal.ijab/2024.177

A Publication of Unique Scientific Publishers

Fig. 1: Pictures of *Garcinia mangostana*, *Mormodica grosvenori*, *Lycium barbarum*, and *Psidium guajava*.

The sweetness of *M. grosvenori* fruit (monk fruit) or (luo han guo) is attributed to mogrosides as a main bioactive component (Shen et al., 2014). Studies on *M. grosvenori* have demonstrated a wide pharmacological spectrum, including antioxidant, anticancer, and antidiabetic properties (Chen et al., 2019; Li et al., 2022).

A variety of phytochemicals have been isolated from *Psidium guajava L.* leaves, such as essential oils, phenols, flavonoids, and quercetin with their derivatives (Weli et al., 2019). These compounds exhibit biological properties, including antioxidant, antitumoral, antiallergic, Anti-diabetic, Antimicrobial, and Anti-diarrhoeal (Koriem et al., 2019; Riaz et al., 2020; Kumar et al., 2021). Recently, there has been a surge in the development of pharmaceutical drugs based on the therapeutic benefits of medicinal plants. In addition, Chinese clinical studies have identified many useful plants that can increase the effectiveness of modern drug treatment and reduce its side effects (Shori, 2015; Kee et al., 2017; Shori et al., 2021b). Since medicinal plants have been proven to have excellent properties in maintaining health, the purpose of this research is to highlight the chemical components and medicinal effects of the four traditional medicinal plants i.e. *Garcinia mongostana, Lycium barbarum, Momordica grosvenori,* and *Psidium guajava*.

Traditional Medicinal Plants

Garcinia mangostana Linn.

The *G. mongostana* L. fruit simply called "purple mangosteen", is a seasonal tropical fruit with white and juicy edible pulps which are protectively covered by a thick layer of dark purple pericarp (Pedraza-Chaverri et al., 2008). Mangosteen trees are primarily distributed in Southeast Asia, such as Malaysia, Thailand, and Indonesia, because of geographical and climate factors. It belongs to the family Guttiferae (or Clusiaceae) characterized by having secretory cavities and/or canals throughout most of the plant body (Pedraza-Chaverri et al., 2008). Change in color of the mangosteen pericarp from light greenish yellow into dark purple or reddish is seen over the ripening period. Munawaroh et al., (2016) found that the purple color of mangosteen pericarp is caused by the presence of anthocyanins. More surprisingly, it was found that the pericarp of mangosteen is the most nutritious part of mangosteen fruits but not the white pulps. It is rich in bioactive secondary metabolites, such as xanthones and oligomeric proanthocyanins, in considerable quantities (Fu et al., 2007), with α-, β- and γ- mangostin having high priority in terms of relative abundance (Suttirak & Manurakchinakorn, 2014). In contrast to mangosteen pericarp, the pulps of mangosteen relatively lack essential macro- and micronutrients. Dietary Reference Intake (DRI) values and some vitamins and minerals are too low to be detectable. Still, they are a good source of carbohydrates and dietary fiber (Gross & Crown, 2007).

Chemical Components

Xanthones are a class of polyphenolic compounds with a similar chemical structure to bioflavonoids (Fig. 2) and have great biological activity (Pedraza-Chaverri et al., 2008). Xanthones endow mangosteen with significant antioxidant activity, with its oxygen radical absorbance capacity (ORAC) values falling between 17,000 and 24,000 μmol TE/g (Suttirak & Manurakchinakorn, 2014). In addition to xanthones, tannins such as condensed tannins (proanthocyanidins) and hydrolysable tannins in the pericarp of mangosteens have the ability to bind and precipitate protein (Moosophin et al., 2010). The condensed tannins are resistant to enzymatic degradation. Acid hydrolysis of condensed tannins leads to the production of a small amount of anthocyanidins and amorphous phlobaphens (tannins red) (Moosophin et al., 2010). In contrast, hydrolysable tannins can be easily hydrolyzed by weak acids to yield sugars and phenol carboxylic acid such as gallic acid. Other phytochemicals that exist in mangosteen pericarp are garcimangosone D, benzophenones, aristophenones, depsidones, polysaccharides, and terpenoids (Gross & Crown, 2007).

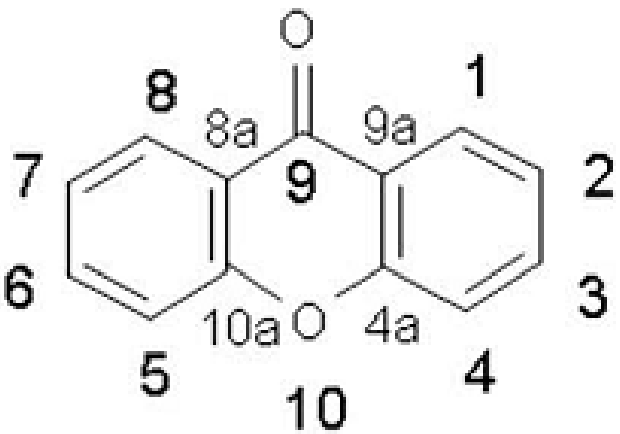

Fig. 2: Chemical structure of xanthone nucleus (Masters & Bräse, 2012).

Medicinal Properties of *G. mangostana*

Antioxidant Properties

Together with other components such as sterols, catechins, xanthones, and their derivatives react with the free radicals generated during oxidation stress (Chavan &

Muth, 2021). Free radicals are active and attack cellular components, resulting in cellular damage. α- Mangostin reduced light-density lipoprotein (LDL) oxidation and α tocopherol consumption in humans (Ibrahim et al., 2017; Chavan & Muth, 2021). The antioxidant analysis revealed that the pericarp extract of *G. mangostana* offers significant health benefits, particularly through its potent antioxidant properties. (Geetha et al., 2020; Krisanti et al., 2021). This effect is attributed to the presence of flavonoids and polyphenols, which help reduce the generation of reactive oxygen species (ROS) within cells (Wimanshinee et al., 2021; Fadhila et al., 2022).

Antitumoral Properties

Xanthones, a class of polyphenolic compounds found in *Garcinia mangostana* (mangosteen), exhibit significant antitumor properties through multiple mechanisms. Studies by Herdiana et al. (2021) and Vania et al. (2021) showed that mangosteen extracts containing α-mangostin inhibit breast cancer cell growth and induce apoptosis by interfering with cellular signaling pathways that regulate cell proliferation. These compounds modulate PI3K/AKT and MAPK pathways, commonly implicated in cancer progression. It inhibits the PI3K/Akt pathway signaling, reducing cancer cell proliferation (Nauman & Johnson, 2022). Inhibition of this pathway results in decreased activity of downstream proteins that regulate cell cycle progression, effectively halting the growth of cancer cells. Furthermore, xanthones have also demonstrated an ability to inhibit cancer metastasis. The anti-metastatic activity of α-mangostin was associated with downregulation of mRNA expression of MMP-2 and MMP-9 through inhibiting NFκB and Akt pathways (Wang, 2012).

Studies on liver cancer and colorectal adenocarcinoma have shown that α-mangostin induces apoptosis by activating the caspase cascade, leading to cell death (Ong et al., 2020; Veeraraghavan et al., 2020). Apoptosis, or programmed cell death, is often dysregulated in cancer cells, allowing them to survive and proliferate indefinitely. Xanthones can restore this process by upregulating pro-apoptotic proteins (e.g., Bax, caspase-3) and downregulating anti-apoptotic proteins (e.g., Bcl-2; Gunter et al., 2023). In addition, xanthones exhibit anti-inflammatory properties by inhibiting pro-inflammatory cytokines (e.g., TNF-α, IL-6), thus potentially reducing the inflammatory environment that promotes cancer growth and progression (Gunter et al., 2020).

In summary, α-mangostin and other xanthones from *Garcinia mangostana* exhibit potent antitumor activities by targeting cancer cell proliferation, inducing apoptosis, inhibiting metastasis, and providing anti-inflammatory and antioxidant benefits, making them promising agents for cancer therapy (Nauman & Johnson, 2022).

Lycium barbarum

α-Mangostin has inhibitory effects on histamine release and prostaglandins synthesis, both of which are important factors in regulating allergic inflammation (Pedraza-Chaverri et al., 2008). Inflammation has negative impacts on the human body. For instance, it may stimulate the transformation of abnormal cells into cancer cells, destabilize cholesterol deposits, damage nerve cells, etc. Several anti-inflammatory activities of *G. mangostana* Linn are shown in Table 1.

Table 1: Anti-inflammatory effects of *Garcinia mangostana* Linn. (GML).

Effects	References
In several experimental models of inflammation in rats and guinea pigs showed anti-inflammatory effects by α-Mangostin.	Gopalakrishnan (1980)
The crude methanol extract from GM legume blocked the histaminergic and serotonergic response in isolated rabbit aorta strips. The histaminergic response was blocked by α-mangostin and c-mangostin blocked the serotonergic response.	Chairungsrilerd et al. (1996a)
α-Mangostin ameliorates the histamine-induced contraction of the aorta and trachea from male guinea pigs.	Chairungsrilerd et al. (1996b)
c-Mangostin inhibits 5-fluoro-a-methyltryptamine (5-FMT)-induced head twitch response in mice by blocking 5HT2A receptors.	Chairungsrilerd et al. (1997)
c-Mangostin is a 5HT2A receptor antagonist in vascular smooth muscles and platelets.	Chairungsrilerd et al. (1998)
c-Mangostin inhibited A2318 induced PGE2 release in C6 cells and arachidonic acid conversion to PGE2 in isolated microsomes as well as the activities of both constitutive COX-1 and inducible COX-2.	Nakatani et al. (2002a)
Extracts of *mangosteen* pod inhibited histamine release in RBL-2H3 cells and decreased A23187 induced PGE2 synthesis in C6 rat glioma cells.	Nakatani et al. (2002b)
inhibited COX-1 and -2 activity and PGE2 synthesis in C6 rat glioma cells was inhibited by c-Mangostin (a), LPS-induced expression of COX-2 protein and its mRNA was inhibited by c-Mangostin (b), c- Mangostin (c), reduced the LPS-inducible activation of NF-kB, and c- Mangostin (d), inhibited rat carrageenan-induced paw edema.	Nakatani et al. (2004)
PGE2 was induced by A23187 and LPS induced transcription of NFkB- mediated in C6 rat glioma cells that A23187 and LPS was reduced by garcinone B.	Yamakuni et al. (2006)
α-Mangostin inhibits human 12-LOX.	Deschamps et al. (2007)
LPS-stimulated cytotoxicity was inhibited by α- and c-mangostins. α- Mangostin showed potent inhibition on paw oedema in mice.	Chen et al. (2008)
Anti-inflammatory activity has been shown by α-mangostin, 1- isomangostin, and mangostin triacetate in several experimental models in rats.	Mansour, (2013)
An animal model of peripheral LPS-induced neuroinflammation showed a reduced level of interleukin-6 (IL-6), cyclooxygenase-2 (COX-2), and 18 kDa translocator protein (TSPO).	Catorce et al. (2016)
Anti-inflammatory activity by α-mangostin inhibited the production of PGE2, nitric oxide, iNOS protein expression, TNF-α, and IL-6 cytokines, and COX-2 enzymes in RAW 264.7 cells	Mohan et al. (2018)
GME dramatically suppresses the expression of pro-inflammatory cytokines namely, TNF-α, IL-6, and IL-1β via the TLR-2 pathway, and also promote the wound healing process.	Tatiya-Aphiradee et al. (2019)
Mangosteen and propolis extracts worked well together as an anti-inflammatory and *in vitro* bone-forming agent.	Lim et al. (2020)
Mangosteen peel extract has four primary chemicals with anti-inflammatory which play a role in the healing process of burns through signaling the interleukin 6 pathway, epidermal growth factor, and transforming growth factors beta 1, which controls the growth of epithelial cells.	Gondokesumo et al. (2020)

Antimicrobial Properties

Several studies have highlighted the efficacy of mangosteen extract, particularly α-mangostin, against pathogenic bacteria like *Escherichia coli* and *Staphylococcus aureus* (Pohan & Rahmawati, 2022; So-In & Sunthamala, 2022). α-Mangostin exhibits antibacterial activity by disrupting bacterial membranes. It inserts into the lipid bilayer of bacterial cell membranes, increasing membrane permeability and leading to the leakage of cellular contents, ultimately causing bacterial death (Phuong et al., 2017). Phuong et al., (2017) demonstrated that α-mangostin with a purity that exceeded 98%, had minimal inhibitory concentrations between 4.6 and 9.2 µmol/L for *Staphylococcus aureus* (*S. aureus*), methicillin-resistant *S. aureus* (MRSA), and methicillin-sensitive *S. aureus* (MSSA). According to Phitaktim et al., (2016), the benzene ring and the isoprenyl group of α-mangostin may play a significant role in inhibiting the growth of MRSA strains by direct interactions with the membrane. Furthermore, it has been observed that α-mangostin can inhibit enzymes involved in glycolysis, such as aldolase, glyceraldehyde-3-phosphate dehydrogenase, and lactate dehydrogenase, in *Streptococcus mutans*, further compromising bacterial survival (Nguyen & Marquis, 2011). Guzmán-Beltrán et al. (2016), showed that α-mangostin directly inhibits *M. tuberculosis* growth in a liquid medium with Minimal Inhibitory Concentrations (MIC) of 62µg/mL. Besides, polysaccharides from the rind enhance polymorphonuclear phagocytes' activity against *Salmonella enteritidis* (Karim & Tangpong, 2018).

Mangosteen extracts have been shown to possess potent antifungal activity, particularly against pathogenic fungi (Abd Murad et al., 2022; Ye et al., 2020). Mohamed et al. (2014), reported that xanthones exhibited their antifungal effect through the inhibition of sterol biosynthesis and lowering levels of ergosterol, compromising the integrity of fungal cell membranes.

Mangosteen and its bioactive compounds have shown potential antiviral effects (Sugiyanto et al., 2019). Xanthones have also been shown to prevent viral entry into host cells by interacting with viral envelope proteins or host cell surface receptors, blocking the virus from attaching and penetrating cells (Ansori et al., 2024). Ansori et al. (2022) demonstrated the potential therapeutic benefits of alpha-mangostin and gamma-mangostin, extracted from mangosteen in inhibiting SARS-CoV-2 proteases.

Lycium barbarum

L. barbarum refers to Chinese wolfberry, which is widely recognized as goji or goji berry (Bagheri et al., 2021). It is classified under the same family as tomatoes, i.e., Solanaceae. These small, red berries primarily grow in the north-central part of China, Tibet, and Mongolia (Gao et al., 2017). Goji is a key component of traditional Chinese medicine and is also used in Chinese cooking to boost nutritional content and improve flavor. Other parts of the *L. barbarum* plant, for example, the root bark, is used for the purpose of treating cough and bleeding disorder whereas the leaves can be used as a tea substitute (Potterat, 2010).

Chemical Components

Goji, celebrated as a superfood, is highly nutrient-dense and contains a range of beneficial compounds. It is rich in beta-carotene, beta-sitosterol, linoleic acid, and sesquiterpenoids such as cyperone and solavetivone, along with tetraterpenoids like zeaxanthin and physalin. Additionally, goji provides immunologically active polysaccharides and betaine (Toyoda-Ono et al., 2004). According to Shi et al. (2017), treatment with *L. barbarum* polysaccharide (40mg/kg) in diabetic mice significantly improved sperm parameters. Additionally, antioxidant enzyme activity increased to varying degrees, expression of caspase-3 decreased, and the Bcl-2/Bax ratio rose compared to untreated diabetic mice. The fruit is abundant in vitamins and minerals, with vitamin C levels potentially up to 500 times greater than those found in oranges (Jeszka-Skowron et al., 2017). It also includes vitamins B1, B2, B6, and E (Szot et al., 2020), and contains 21 trace minerals, including calcium, iron, zinc, phosphorus, selenium, and germanium (Proestos, 2018). Goji provides 18 amino acids, eight of which are essential, with L-leucine present in notably high concentrations (Chen et al., 2017). The polysaccharides in *L. barbarum* can be either water-soluble, such as glucurono-β-glucan and β-glucan, or water-insoluble, including xylo-β-glucan, xylomann-β-glucan, hetero-β-glucan, and manno-β-glucan (Shori et al., 2021c). High-performance liquid chromatography (HPLC) analysis reveals that LBP consists primarily of glucose and fructose in a 1:2 molar ratio (Lu & Zhao, 2010), while other polysaccharide compounds in *L. barbarum* contain over 100 monosaccharide units.

Zeaxanthin, the major carotenoid in goji (Fig. 3), exists as dipalmitate (Tang et al., 2011). It is mainly found in the macular pigment of the eye with a concentration 85 times higher than its concentration in blood (Manikandan et al., 2016). Another predominant carotenoid pigment in goji is β-carotene, an important precursor for the biosynthesis of vitamin A and also serves as an antioxidant. Goji contains about 7mg of β-carotene per 100 grams of its dried fruits (Gross & Crown, 2007).

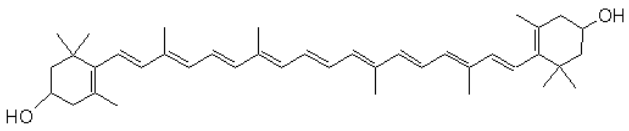

Fig. 3: The chemical structure of zeaxanthin (Roberts & Dennison, 2015).

Medicinal Properties of *L. barbarum*

Antioxidant Properties

L. barbarum L. (Goji) is abundant in antioxidants and phytochemicals, including beta-carotene, zeaxanthin, beta-cryptoxanthin, lutein, lycopene, and fatty acids such as linoleic, palmitic, and oleic acids (Skenderidis et al., 2019; Shori et al., 2021d). These substances help mitigate cellular damage caused by free radicals, thus contributing to longer cell lifespan (Baba et al., 2014). *L. barbarum* exhibits the highest levels of free radical scavenging activity, specifically against 2,2-diphenyl-1-picrylhydrazyl and 2,2'-azino-bis (3-ethylbenzthiazoline-sulfonic acid; Henning et al., 2014; Mocan et al., 2014; Byambasuren et al., 2019).

Polysaccharides extracted from dried *L. barbarum* (LBPs) demonstrate strong antioxidant properties in the mitochondrial membranes of rat liver *in vitro*. Li et al. (2007) reported that LBPs significantly protect against radiation-induced loss of protein thiols and inactivation of SOD, CAT, and GSH-Px. Additionally, Feng et al. (2001) indicated that *L. barbarum* is effective in protecting the retina from oxidative injury in diabetic individuals. Castrica et al. (2020) observed that 3% w/w of Goji supplementation in rabbits was associated with reduced lipid oxidation. The antioxidant properties of *L. barbarum* are well-documented and offer notable health benefits, particularly due to its hydrophilic components like ascorbic acid, total phenolics, and total flavonoids, as well as lipophilic components such as total carotenoids (Zhang et al., 2021a; Liu et al., 2020).

Antidiabetic Properties

L. barbarum has demonstrated anti-diabetic properties, including its ability to decrease oxidative stress in individuals with retinopathy (Byambasuren et al., 2019; Liu et al., 2022). Additionally, the polysaccharides found in *L. barbarum* help lower glucose absorption in the intestines and support insulin release (Huizhen, 2020; Shori et al., 2021d). In diabetic rabbits' studies, a water extract of *L. barbarum* fruit (250mg/kg.d) effectively lowered blood glucose levels and exhibited significant hypoglycemic effects (Luo et al., 2004). Moreover, the protein component of *L. barbarum* (10mg/kg.d) has shown insulin-mimetic impact, helping to reduce blood sugar levels and enhance fat metabolism by increasing glucose transporter 4 (GLUT4) on the cell surface, improving GLUT4 trafficking, and boosting intracellular insulin signaling (Zhao et al., 2005).

Anti-inflammatory

Consumption of *L. barbarum* has been shown to provide anti-inflammatory effects by targeting TLR4 and NF-κB pathways (Fig. 4), modulating the expression of inflammatory markers such as TNF-α and IL-6, and mitigating damage to the liver and intestines (Ávila et al., 2020; Liu et al., 2021). These anti-inflammatory benefits may be attributed to acacetin-7-O-rutinoside, luteolin-7-O-glucoside, chlorogenic acid, and wolfberry polysaccharides (Zhang et al., 2019). Additionally, 5% of *L. barbarum* has demonstrated protective effects for the skin against immune suppression and oxidative stress when consumed for two weeks before UV exposure (Reeve et al., 2010).

Anticancer

L. barbarum polysaccharides (LBPs) exhibit anti-tumor properties by boosting the levels of CD4(+) and CD8(+) T cells within tumor-infiltrating lymphocytes. This action helps counteract immunosuppression and strengthens the body's anti-tumor immune response (Kulczyński and Gramza-Michałowska 2016). Additionally, research by Qi et al. (2022) demonstrated that LBPs can inhibit apoptosis in MCF-7 human breast cancer cells by activating ERK and p53 pathways. *In vitro*, *L. barbarum* polysaccharide at doses ranging from 20 to 1000 mg/L inhibited the growth of human leukemia HL-60 cells and decreased the membrane fluidity (Zhang et al., 2005).

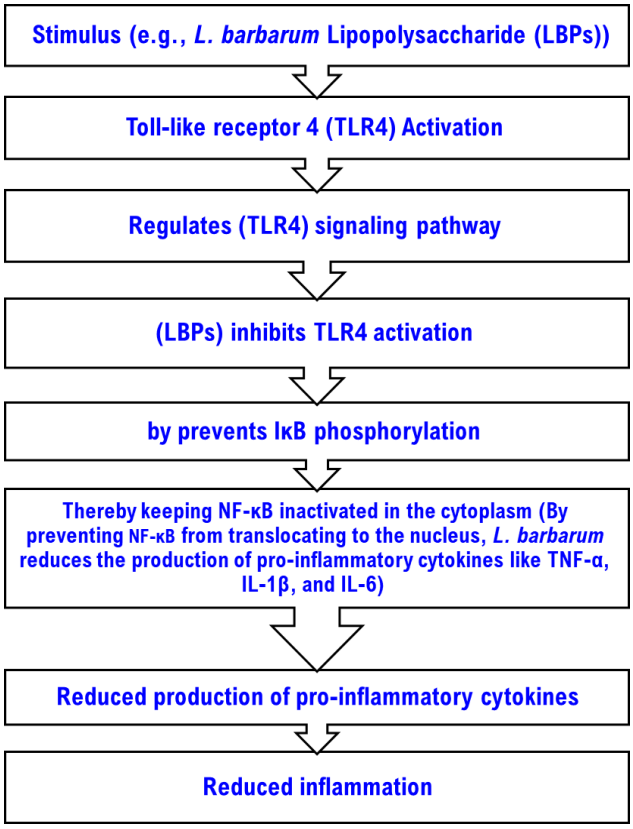

Fig. 4: The pathway illustrates the anti-inflammatory effect of *L.barbarum* by targeting the TLR4/NF-κB signaling axis (Gan et al., 2018; Linghu et al., 2020).

Eye Health Benefits

Oral intake of 250–280 g of *L. barbarum* has been shown to mitigate the loss of retinal ganglion cells (RGCs), though it does not significantly affect elevated intraocular pressure (IOP) (Chan et al., 2007). This indicates that *L. barbarum* may offer therapeutic potential in preventing retinal neurodegeneration associated with ocular hypertension, making it a promising candidate for developing neuroprotective treatments for glaucoma-related RGC loss (Li et al., 2007). Additionally, the lutein and zeaxanthin found in *L. barbarum* have been observed to restore visual functions in models of light-induced phototoxicity and macular degeneration. These compounds likely protect RGCs by counteracting neuronal apoptosis induced by glutamate and nitric oxide (NO) in the retina (Rhee, 2010). Several studies have found that the polysaccharides, polyphenols, carotenoids, and amino acids of *L. barbarum* protect the eyes from disease by scavenging oxygen free radicals. (Liu et al., 2022; Lin & Wu, 2022). Additional research has shown that 10mg/kg of *L. barbarum* offers protective effects against light-induced damage in various retinal layers, including the stem cell pyramid layer, the outer nuclear layer, and the retinal pigment epithelium in rats (Luo et al., 2006).

Immune System

Four main bioactive *L. barbarum* polysaccharides (LBP) i.e. LBP1, LBP2, LBP3, and LBP4 in goji are known to help strengthen the immune system through increased T cells, cytotoxic T cells, and natural killer cells activity (Deng et al.,

2018). These polysaccharides have chemical structures similar to the compounds present in maitake *mushrooms* and *Echinacea*. Polysaccharides LBP1, LBP2, LBP3, and LBP4 are glycoconjugates, serving as the sources of essential cell nutrients (glucose, galactose. mannose, xylose, rhamnose, and arabinose; Yong et al., 2022) which are required for boosting the immune system as well as proper intercellular communication. Furthermore, *L. barbarum* may increase immunoglobulin A levels, suggesting its ability to regenerate old cells (de Souza Zanchet et al., 2017).

Momordica grosvenori

Monk fruit which is scientifically referred to as *Siraitia grosvenorii* formerly known as *Momordica grosvenorii* is an herbaceous perennial vine primarily cultivated in southwestern China (Shori et al., 2018). *M. grosvenori* is classified under cucurbitaceae family. It produces fruits called Luo Han Guo which are well-known for their intense sweetness and medicinal properties. The primary bioactive compounds in monk fruit, known as mogrosides, are responsible for its sweetness. Additionally, the fruit is reputed to offer various health benefits (Gangoso et al., 2019).

Chemical Components

The active compounds present in luo han guo extract are mogrosides, a group of triterpene glycosides that make up about 1% of the fleshy part of the fruit. These compounds give a sweet taste to luo han guo (Tang et al., 2011). Generally, five different mogrosides have been isolated from these fruits and numbered from I to V (Chen et al., 2022). Mogroside V (formerly known as esgoside; Fig. 5) is the most abundant mogroside among the five, hence, it determines the level of sweetness and quality of a luo han guo (Chen et al., 2022). A previous study found that the sweetness of the mixed mogrosides can be about 300 times higher than that of sugar by weight but contains lower calories, i.e., 2.3kcal/g, whereas sugar gives approximately 4.5kcal/g (Muñoz-Labrador et al., 2022). Due to this reason, luo han guo extract is widely used as a sweetener in beverages and cooked foods (Muñoz-Labrador et al., 2022). Other similar compounds such as siamenoside and neomogroside have also been found in luo han guo extract.

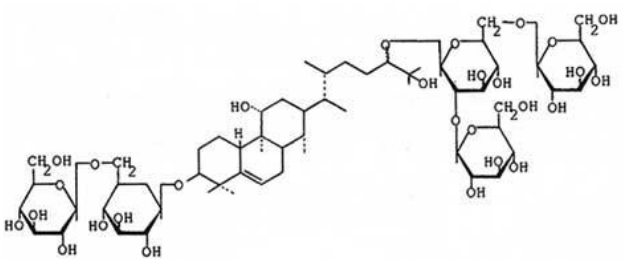

Fig. 5: Chemical structure of Mogroside V (Wang et al., 2014).

Medicinal Properties of *M. grosvenori*

Low Glycemic Index

Luo han guo is a good and safe alternative sweetener, especially for diabetics. Despite its intense sweetness, luo han guo sweetener does not cause a spike in insulin levels or result in extreme fluctuations in blood glucose levels (Gangoso et al., 2019). It is because the triterpene glycosides in luo han guo are not metabolized into glucose to generate energy. Furthermore, studies showed that triterpene glycosides have an inhibitory effect on maltase, suppressing the rise in blood sugar levels in rats (Lee et al., 2016; Pandey & Chauhan 2019) and *in vitro* using human HepG2 cells (Li et al., 2017). This suggests that luo han guo has an anti-hyperglycemic effect. In addition, Zhang et al., (2021b) reported that *M. grosvenori* fruits have antidiabetic properties by modifying the gut microbiota. Luo han guo extract exhibits anti-diabetic effects by enhancing insulin sensitivity during fasting, improving kidney function, and boosting antioxidant activity in both the liver and plasma (Li et al., 2022).

Antioxidant Properties

The glycoside components of luo han guo extract, including cucurbitane glycosides, mogroside IV, mogroside V, 11-oxo-mogroside V, and siamenoside I, demonstrate antioxidant properties. These compounds effectively prevent oxidation of copper-mediated and cell-mediated low-density lipoprotein in a dose-dependent fashion (Wang et al., 2014; Cheng et al., 2017). Previous studies concluded that extract of *M. grosvenori* could be used as an antioxidant (Shori et al., 2021d; Konno et al., 2022). Wuttisin & Boonsook, (2019) indicated that the antioxidant activity of *M. grosvenori* extracts might be due to the flavonoid compounds.

Anticancer Properties

M. grosvenori has been investigated for its potential anticancer effects, with evidence suggesting it can inhibit cancer cell growth and shield normal cells from oxidative damage (Konno et al., 2022; Li et al., 2022). Research has indicated that luo han guo may be effective in treating colorectal and laryngeal cancers (Liu et al., 2016), possesses anti-tumor activity and offers lung protection (Chen et al., 2019), and can suppress the proliferation of K562 leukemic cells (Liu et al., 2015), primarily due to its cucurbitane glycosides and related compounds (Liu et al., 2016). Additionally, the extract has been found to inhibit the activation of Epstein-Barr virus early antigen (EBV-EA) at levels comparable to or exceeding those of beta-carotene (Konoshima & Takasaki, 2002). In further studies, 11-oxo-mogroside V and mogroside V exhibited potent inhibitory effects (Takasaki et al., 2003). In a 2-stage skin carcinogenesis model in mice, administration of mogroside V or 11-oxo-mogroside V led to a delay in tumor development and a reduction in the number of papillomas over 10 and 15 weeks, respectively, compared to controls (Takasaki et al., 2003).

***Psidium guajava* L.**

P. guajava L., commonly called guava in English, is classified under the family Myrtaceae (Shori et al., 2022). It is believed that guava is considered native to the American tropics (the area between Mexico and Peru) and spread throughout tropical and subtropical countries. *P. guajava* is a small tree reaching up to 10

meters in height, characterized by its broad, spreading branches and square, fuzzy twigs (Gutiérrez et al., 2008). Ripe guava fruits can be eaten fresh or processed into juice, jelly, jam, or preserved foods.

Each part of the plant has its respective medicinal properties (Joseph & Priya, 2011). In the indigenous system of medicine, the flowers of guava are used to remove internal body heat and treat eye sores and bronchitis. The fruits, which are rich in vitamin C, are effective in curing bleeding gums (Joseph & Priya, 2011). Fresh leaves are used topically to treat wounds, ulcers, and rheumatic pain (Gutiérrez et al., 2008). Additionally, an infusion made from the new shoots of *P. guajava* is utilized as a tonic, febrifuge, and spasmolytic agent (Joseph & Priya, 2011). In traditional medicine, *P. guajava* is also widely applied for treating diarrhea, gastroenteritis, dysentery, inflammation, and respiratory problems (Gonçalves et al., 2005; Ojewole, 2006; Gutiérrez et al., 2008).

Chemical Components

Spectral analysis has identified over 20 phytochemical compounds in guava leaves, including essential oils, flavonoids, anthocyanins, carotenoids, phenols, saponins, tannins, triterpenes, lectins, fatty acids, and vitamin C (Shori et al., 2020). The essential oils contain α- pinene, β-pinene, menthol, limonene, isopropyl alcohol, curcumene, etc (Gutiérrez et al., 2008; Weli et al., 2019). Five essential oils i.e. β-sitosterol, nerolidiol, crategolic, ursolic and guayavolic acids are present in *P. guajava* (Weli et al., 2019). The presence of flavonoids quercetin (Fig. 6) and avicularin gives guava leaves antimicrobial properties.

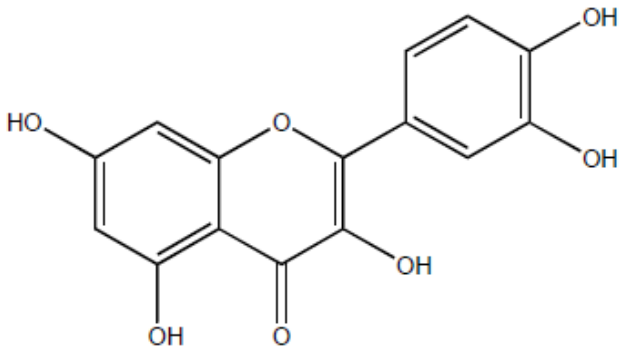

Fig. 6: The chemical structure of quercetin (Kumar et al., 2017).

Medicinal Properties of *P. guajava*

Antidiarrhoeal Properties

Many studies have proved that the extract of guava leaves has anti-diarrhoeal properties owing to the presence of quercetin and quercetin-3 arabinose (Gupta & Birdi, 2015; Koriem et al., 2019). At a concentration of 1.6µg/mL, these compounds behave like morphine, inhibiting the release of acetylcholine, reducing peristaltic motion of the ileum, and permeability of the capillary in the intestinal lumen. Besides, galactose-specific lectin prevents *E. coli* from adhering to the intestinal wall and therefore, avoids infection that results in diarrhea (Upadhyay & Dass, 2020).

Antimicrobial Properties

Methanolic extract of guava leaves rich in phenolic, flavonoid, and quercetin with its derivatives (Naseer et al., 2018). These compounds exhibit antimicrobial properties against a range of pathogens, including both gram-positive and gram-negative bacteria, as well as fungal strains, yeasts, molds, and bacteria isolated from urine samples (Naseer et al., 2018). Additionally, they have been shown to inhibit spore formation and enterotoxin production by Clostridium perfringens type A (Gitika, 2016; Farhana et al., 2017; Bhambar, 2021). According to Shetty et al. (2018), Guava extract may show significant activity against both *P. gingivalis* and *A. actinomycetemcomitans*. Quercetin in guava leaves reported to have inhibitory effects on the growth of *Stapylococcus aures*, *Escherichia coli, Salmonella enteritidis, Streptoccus mutans, Pseudomonas aeruginosa* and *Shigella* spp. (Ugbogu et al., 2022).

Antioxidant Properties

Guava leaves are rich in antioxidants (Shori et al., 2018), with their extract demonstrating significant antioxidant activity. This is attributed to the high levels of phenolic compounds present, including protocatechuic acid, ferulic acid, quercetin, guavin B, gallic acid, and caffeic acid (Fernandes et al., 2014; Zahin et al., 2017). Moreover, the polysaccharides in guava leaves may serve as potential antioxidants (Luo et al., 2019; Kumar et al., 2021).

Anti-allergic and Antitumor Effect

A meroterpenoid known as guajadial, isolated from *P. guajava* leaves, exhibited antineoplastic activity against non-small-cell lung carcinoma by inhibiting the proliferation and migration of A549 and H1650 lung cancer cell lines (Wang et al., 2018). Additionally, quercetin demonstrated strong inhibitory effects on SGC-7901 and HeLa cells, with IC50 values of 7.878 and 10.260µg/mL, respectively (Feng et al., 2015). The guajadial fraction also showed significant antiproliferative effects against MCF-7 and MCF-7 BUS breast cancer cells, with TGI values of 5.59 and 2.27 µg/mL, respectively (Bazioli et al., 2020). Furthermore, an aqueous extract of *P. guajava* leaves significantly inhibited MCF-7 cell viability at a concentration of 100 g, indicating its potential for breast cancer treatment (Sukanya et al., 2017). The dichloromethane and methanol (1:1, v/v) extracts of *P. guajava* leaves exhibited the highest inhibitory activity against MCF-7 breast cancer cells, with an IC50 value of 55µg/mL after 24 hours (Kaileh et al., 2007). Additionally, benzophenone extracted from *P. guajava* leaves showed significant inhibitory effects on cell viability and a potent ability to induce apoptosis in cancer cells. At a concentration of 100 µM, benzophenone inhibited 81.4% of HCT116 cell growth after 72 hours, with an IC50 value of 60 µM (Zhu et al., 2019). Moreover, hexane fractions from a methanolic extract of guava leaves induced cytotoxicity and apoptosis in PC-3 prostate cancer cells, arresting the cell cycle in the sub-G1 phase and causing cell death even at 50 g/mL (Ryu et al., 2012). The methanolic extract of *P.*

guajava leaves also significantly inhibited the viability of leukemia cells, with an IC50 value of 200µg/mL, attributed to the presence of gallic acid and flavonoids such as kaempferol and quercetin (Levy & Carley, 2012). Seo et al. (2005) reported that guava leaf extract has anti-allergic effects against Th2 cell-mediated allergies and provides protective action against tumor development. Additionally, monoterpenes in the essential oil of guava leaves effectively suppress cancer cell growth by reducing T helper cell 1 activity. Several studies have highlighted the potential of guava leaves as chemotherapeutic antitumor and anti-allergic agents (Sato et al., 2010; Moon et al., 2011; Alhamdi et al., 2019; Patil, 2024).

Anti-diabetic Properties

The decoction of guava leaves can induce hypoglycaemic activity and significantly inhibit LDL glycation in a dose-dependent manner (Dange et al., 2020). The hypoglycemic effect of guava leaves are linked to their content of tannins, flavonoids, pentacyclic triterpenoids, ursolic acid, oleanolic acid, arjunolic acid, glucuronic acid, and other bioactive compounds (Hsieh et al., 2007). Research has shown that guava leaves hold promise as a potential anti-diabetic agent (Luo et al., 2019; Shabbir et al., 2020).

Conclusion

The four traditional medicinal plants i.e., *G. mongostana, L. barbarum, M grosvenori,* and *P guajava* contained several chemical compounds. These components have been proven to have excellent properties in maintaining health through various pharmacological activities such as antioxidant, antibacterial, antidiabetic, anti-inflammatory, and antitumor. The use of natural substances presents in *P. guajava* and *L. barbarum* may have the potential to treat and prevent illnesses such as gastroenteritis, dysentery, respiratory disturbances, and protect the eyes. In addition, we recommend using *M. grosvenori* extract as a sweetener in beverages and cooked foods. Further study is needed to investigate how the sweetener from *M. grosvenori* affects the whole body metabolism. Furthermore, due to the phytochemical content of these four plants, it is important to investigate their further use in the food industry as supplements and functional food ingredients.

REFERENCES

Abd Murad, N. B., Mustafa, M., Shaari, K., & Mohd Zainudin, N. A. I. (2022). Micrograph analysis of morphological alteration and cellular damage of fruit rot fungal pathogens treated with *Averrhoa bilimbi* fruit and *Garcinia mangostana* pericarp ethanolic extracts. *Letters in Applied Microbiology*.

Alhamdi, H., Boadi, W., & Tiriveedhi, V. (2019). Investigating the anti-tumor potential of *Psidium guajava* extracts on PC-3, A549, and BT-549. *MedCrave Online Journal of Cell Science & Report, 6*(1), 10-15.

Ansori, A. N. M., Susilo, R. J. K., Fadholly, A., Hayaza, S., Nugraha, A. P., & Husen, S. A. (2020). Antidiabetes type 2 phytomedicine: mangosteen (*Garcinia mangostana* l.)-A review. *Biochemical and Cellular Archives, 20*, 3173-3177.

Ansori, A. N. M., Kharisma, V. D., Parikesit, A. A., Dian, F. A., Probojati, R. T., Rebezov, M., & Zainul, R. (2022). Bioactive Compounds from Mangosteen (*Garcinia mangostana* L.) as an Antiviral Agent via Dual Inhibitor Mechanism against SARSCoV-2: An in Silico Approach. *Pharmacognosy Journal, 14*(1).

Ansori, A. N. M., Murtadlo, A. A. A., Dhea, V., Turista, D. R., Rosadi, I., Jakhmola, V., & Zainul, R. (2024). Alpha-Mangostin as an Antiviral Candidate: A Mini Review. *Journal of Medicinal and Chemical Sciences, 7*, 275.

Ávila, C. N., Trindade, F. M. R., Penteado, J. O., Janke, F., Schneider, J. P., Uecker, J. N., & Pieniz, S. (2020). Anti-inflammatory effect of a goji berry extract (*Lycium barbarum*) in rats subjected to inflammation by lipopolysaccharides (LPS). *Brazilian Archives of Biology and Technology, 63*.

Baba, A. S., Najarian, A., Shori, A. B., Lit, K. W., & Keng, G. A. (2014). Viability of lactic acid bacteria, antioxidant activity and in vitro inhibition of angiotensin-I-converting enzyme of *Lycium barbarum* yogurt. *Arabian Journal for Science and Engineering, 39*(7), 5355-5362.

Bagheri, E., Shori, A. B., & Baba, A. S. (2021). Effects of *Garcinia mongostana, Lycium barbzarum, Momordica grosvenori*, and *Psidium guajava* on the Growth of *Lactobacillus spp.* and *Streptococcus thermophilus*. *Asian Food Science Journal, 20*(3), 30-39.

Bazioli, J. M., Costa, J. H., Shiozawa, L., Ruiz, A. L. T. G., Foglio, M. A., & Carvalho, J. E. D. (2020). Anti-estrogenic activity of guajadial fraction, from guava leaves (*Psidium guajava* L.). *Molecules, 25*(7), 1525.

Bhambar, R. S. (2021). A Review on Antimicrobial Activity of *Psidium guajava* L. Leaves on Different Microbial Species, Antioxidant Activity Profile and Herbal Formulations. *Journal of Pharmaceutical Sciences and Research, 13*(7), 406-411.

Byambasuren, S. E., Wang, J., & Gaudel, G. (2019). Medicinal value of wolfberry (*Lycium barbarum* L.). *Journal of Medicinal Plants Studies, 7*(4), 90-97.

Castrica, M., Menchetti, L., Balzaretti, C. M., Branciari, R., Ranucci, D., Cotozzolo, E., & Miraglia, D. (2020). Impact of dietary supplementation with goji berries (*Lycium barbarum*) on microbiological quality, physico-chemical, and sensory characteristics of rabbit meat. *Foods, 9*(10), 1480.

Catorce, M. N., Acero, G., Pedraza-Chaverri, J., Fragoso, G., Govezensky, T., & Gevorkian, G. (2016). Alpha-mangostin attenuates brain inflammation induced by peripheral lipopolysaccharide administration in C57BL/6J mice. *Journal of Neuroimmunology, 297*, 20-27.

Chairungsrilerd, N., Furukawa, K. I., Ohta, T., Nozoe, S., & Ohizumi, Y. (1996a). Histaminergic and serotonergic receptor blocking substances from the medicinal plant Garcinia mangostana. *Planta Medica, 62*(05), 471-472.

Chairungsrilerd, N., Furukawa, K. I., Ohta, T., Nozoe, S., & Ohizumi, Y. (1996b). Pharmacological properties of α-mangostin, a novel histamine H1 receptor antagonist. *European Journal of Pharmacology, 314*(3), 351-356.

Chairungsrilerd, N., Furukawa, K. I., Ohta, T., Nozoe, S., & Ohizumi, Y. (1997). γ-Mangostin, a novel type of 5-hydroxytryptamine 2A receptor antagonist. *Naunyn-Schmiedeberg's Archives of Pharmacology, 357*(1), 25-31.

Chairungsrilerd, N., Furukawa, K. I., Tadano, T., Kisara, K., & Ohizumi, Y. (1998). Effect of γ-mangostin through the inhibition of 5-hydroxytryptamine2A receptors in 5-fluoro-α-methyltryptamine-induced head-twitch responses of mice. *British Journal of Pharmacology, 123*(5), 855.

Chan, H. C., Chang, R. C. C., Ip, A. K. C., Chiu, K., Yuen, W. H., Zee, S. Y., & So, K. F. (2007). Neuroprotective effects of *Lycium barbarum* Lynn on protecting retinal ganglion cells in an ocular hypertension model of glaucoma. *Experimental Neurology, 203*(1), 269-273.

Chavan, T., & Muth, A. (2021). The diverse bioactivity of α-mangostin and its therapeutic implications. *Future Medicinal Chemistry, 13*(19), 1679-1694.

Chen, C., Xu, M., Wang, C., Qiao, G., Wang, W., Tan, Z., Wu, T., & Zhang, Z. (2017). Characterization of the *Lycium barbarum* fruit transcriptome and development of EST-SSR markers. *PloS One, 12*(11), e0187738.

Chen, H. Y., Lin, C. H., Hou, C. Y., Lin, H. W., Hsieh, C. W., & Cheng, K. C. (2022). Production of Siamenoside Ⅰ and Mogroside Ⅳ from *Siraitia grosvenorii* Using Immobilized β-glucosidase. *Molecules, 27*(19), 6352..

Chen, J., Jiao, D., Li, Y., Jiang, C., Tang, X., Song, J., & Chen, Q. (2019). Mogroside V inhibits hyperglycemia-induced lung cancer cells metastasis through reversing EMT and damaging cytoskeleton. *Current Cancer Drug Targets, 19*(11), 885-895.

Chen, L. G., Yang, L. L., & Wang, C. C. (2008). Anti-inflammatory activity of mangostins from Garcinia mangostana. *Food and Chemical Toxicology, 46*(2), 688-693.

Cheng, J. R., Liu, X. M., Zhang, Y. S., Zhang, Y. H., Chen, Z. Y., Tang, D. B., & Wang, J. Y. (2017). Protective effects of *Momordica grosvenori* extract against lipid and protein oxidation-induced damage in dried minced pork slices. *Meat Science, 133*, 26-35.

Dange, S. S., Rao, P. S., & Jadhav, R. S. (2020). Traditional uses of guava: a review. *World Journal of Pharmaceutical Research, 9*(5), 452-464.

de Souza Zanchet, M. Z., Nardi, G. M., de Oliveira Souza Bratti, L., Filippin-Monteiro, F. B., & Locatelli, C. (2017). *Lycium barbarum* reduces abdominal fat and improves lipid profile and antioxidant status in patients with metabolic syndrome. *Oxidative Medicine and Cellular Longevity, 2017*.

Deng, X., Luo, S., Luo, X., Hu, M., Ma, F., Wang, Y., & Huang, R. (2018). Fraction from *Lycium barbarum* polysaccharides reduces immunotoxicity and enhances antitumor activity of doxorubicin in mice. *Integrative Cancer Therapies, 17*(3), 860-866.

Deschamps, J. D., Gautschi, J. T., Whitman, S., Johnson, T. A., Gassner, N. C., Crews, P., & Holman, T. R. (2007). Discovery of platelet-type 12-human lipoxygenase selective inhibitors by high-throughput screening of structurally diverse libraries. *Bioorganic & Medicinal Chemistry, 15*(22), 6900-6908.

Dharmayani, N. K. T., Garnasih, I., Yuanita, E., Ulfa, M., Sudirman, S., Darmayanti, M. G., & Septiyana, M. (2022). Antibacterial Test and Isolation of Xanthones from Pericarps Mangosteen (*Garcinia mangostana* L.) using Calcium Oxide (CaO) as a Vacuum Liquid Chromatography (VLC) Stationary Phase. *Acta Chimica Asiana, 5*(1), 181-185.

Díaz-de-Cerio, E., Verardo, V., Gómez-Caravaca, A. M., Fernández-Gutiérrez, A., & Segura-Carretero, A. (2017). Health effects of *Psidium guajava* L. leaves: an overview of the last decade. *International Journal of Molecular Sciences, 18*(4), 897.

Fadhila, N. A., Sriwidodo, S., & Chaerunisa, A. Y. (2022). Instant Granules of Mangosteen Peel (*Garcinia Mangostana* L.) Ethanol Extract as Antioxidants. *Sciences of Pharmacy, 1*(1), 1-7.

Farhana, J. A., Hossain, M. F., & Mowlah, A. (2017). Antibacterial effects of guava (*Psidium guajava* L.) extracts against food borne pathogens. *International Journal of Food Science*, *6*, 1-5.

Feng, H. J., Jie, Y. C., Yun, P. L., & Gui, Z. L. (2001). The Effect of *Lycium barbarum* (Wolfberry) on Antioxidant Activity in the Retina of Diabetic Rats. *Retrieved June, 3*, 2010.

Feng, X. H., Wang, Z. H., Meng, D. L., & Li, X. (2015). Cytotoxic and antioxidant constituents from the leaves of *Psidium guajava*. *Bioorganic & Medicinal Chemistry Letters, 25*(10), 2193-2198.

Fernandes, M. R. V., Dias, A. L. T., Carvalho, R. R., Souza, C. R. F., & Oliveira, W. D. (2014). Antioxidant and antimicrobial activities of *Psidium guajava* L. spray dried extracts. *Industrial Crops and Products, 60*, 39-44.

Fu, C., Loo, A. E. K., Chia, F. P. P., & Huang, D. (2007). Oligomeric proanthocyanidins from mangosteen pericarps. *Journal of Agricultural and Food Chemistry, 55*(19), 7689-7694.

Gan, F., Liu, Q., Liu, Y., Huang, D., Pan, C., Song, S., & Huang, K. (2018). *Lycium barbarum* polysaccharides improve CCl4-induced liver fibrosis, inflammatory response and TLRs/NF-kB signaling pathway expression in wistar rats. *Life Sciences, 192*, 205-212.

Gangoso, A., Robben, D. M., Wesley, M. C., Red, P., & Rodriguez, R. (2019). Comparison of the glycemic response of white sugar and monk fruit sweetener among normoglycemic subjects. *Printed In the Philippines Issn 2599-5456*, 21.

Gao, Y., Wei, Y., Wang, Y., Gao, F., & Chen, Z. (2017). *Lycium barbarum*: a traditional Chinese herb and a promising anti-aging agent. *Aging and Disease, 8*(6), 778.

Geetha, S., Saraswathi, K., Chakrapani, G. D., Sivaraj, C., Dhivya, M., & Chittibabu, C. V. (2020). Antioxidant and anticancer activities of pericarp of *Garcinia mangostana* L. *Journal of Pharmacognosy and Phytochemistry, 9*(4), 1805-1809.

Gitika, K. M. (2016). Antibacterial activity of *Psidium guajava* L. leaves extracts against some gram-positive and gram-negative bacteria. *European Journal of Pharmaceutical and Medical Research, 3*, 261-266.

Gonçalves, J. L. S., Lopes, R. C., Oliveira, D. B., Costa, S. S., Miranda, M. M. F. S., Romanos, M. T. V., & Wigg, M. D. (2005). *In vitro* anti-rotavirus activity of some medicinal plants used in Brazil against diarrhea. *Journal of Ethnopharmacology, 99*(3), 403-407.

Gondokesumo, M. E., Sumitro, S. B., Handono, K., Pardjianto, B., Widowati, W., & Utomo, D. H. (2020). A Computational Study to Predict Wound Healing Agents from the Peel of the Mangosteen *Garcinia mangostana* L.) Extract. *The International Journal Bioautomation, 24*(3), 265-276.

Gopalakrishnan, C. (1980). Effect of mangostin, a xanthone from *Garcinia mangostana* Linn. in immunopathological & inflammatory reactions. *Indian Journal of Experimental Biology*, *18(8), 6-843*.

Gross, P. M., & Crown, I. (2007). Is mangosteen a superfruit? Nutrient and antioxidant properties, natural products information center.

Gunter, N. V., Teh, S. S., Jantan, I., Cespedes-Acuña, C. L., & Mah, S. H. (2023). The mechanisms of action of prenylated xanthones against breast, colon, and lung cancers, and their potential application against drug resistance. *Phytochemistry Reviews, 22*(3), 467-503.

Gunter, N. V., Teh, S. S., Lim, Y. M., & Mah, S. H. (2020). Natural xanthones and skin inflammatory diseases: Multitargeting mechanisms of action and potential application. *Frontiers in Pharmacology, 11*, 594202.

Gupta, P., & Birdi, T. (2015). *Psidium guajava* leaf extract prevents intestinal colonization of Citrobacter rodentium in the mouse model. *Journal of Ayurveda and Integrative Medicine, 6*(1), 50.

Gutiérrez, R. M. P., Mitchell, S., & Solis, R. V. (2008). *Psidium guajava*: a review of its traditional uses, phytochemistry and pharmacology. *Journal of Ethnopharmacology, 117*(1), 1-27.

Guzmán-Beltrán, S., Rubio-Badillo, M. Á., Juárez, E., Hernández-Sánchez, F., & Torres, M. (2016). Nordihydroguaiaretic acid (NDGA) and α-mangostin inhibit the growth of *Mycobacterium tuberculosis* by inducing autophagy. I*nternational Immunopharmacology, 31,* 149-157.

Henning, S. M., Zhang, Y., Rontoyanni, V. G., Huang, J., Lee, R. P., Trang, A., & Heber, D. (2014). Variability in the antioxidant activity of dietary supplements from pomegranate, milk thistle, green tea, grape seed, goji, and acai: effects of *in vitro* digestion. *Journal of Agricultural and Food Chemistry, 62*(19), 4313-4321.

Herdiana, Y., Wathoni, N., Shamsuddin, S., & Muchtaridi, M. (2021). α-Mangostin Nanoparticles Cytotoxicity and Cell Death Modalities in Breast Cancer Cell Lines. *Molecules, 26*(17), 5119.

Hsieh, C. L., Yang, M. H., Chyau, C. C., Chiu, C. H., Wang, H. E., Lin, Y.C., Chiu, W.T. & Peng, R.Y. (2007). Kinetic analysis on the sensitivity of glucose- or glyoxal-induced LDL glycation to the inhibitory effect of *Psidium guajava* extract in a physiomimic system. *Biosystems, 88*(1-2), 92-100.

Huizhen, C. (2020). Hyperglycemic Effect of Goji (*Lycium barbarum*) Polysaccharides. In *Phytochemicals in Goji Berries* (pp. 79-92). CRC Press.

Ibrahim, U. K., Kamarrudin, N., Suzihaque, M. U. H., & Abd Hashib, S. (2017). Local fruit wastes as a potential source of natural antioxidant: an overview. In *IOP conference series: Materials Science and Engineering* (Vol. 206, No. 1, p. 012040). IOP Publishing.

Jeszka-Skowron, M., Zgoła-Grześkowiak, A., Stanisz, E., & Waśkiewicz, A. (2017). Potential health benefits and quality of dried fruits: Goji fruits, cranberries and raisins. *Food Chemistry, 221*, 228-236.

Joseph, B., & Priya, M. (2011). Review on nutritional, medicinal and pharmacological properties of guava (*Psidium guajava* Linn.). *International Journal of Pharma and Bio Sciences, 2*(1), 53-69.

Kaileh, M., Berghe, W. V., Boone, E., Essawi, T., & Haegeman, G. (2007). Screening of indigenous Palestinian medicinal plants for potential anti-inflammatory and cytotoxic activity. *Journal of Ethnopharmacology, 113*(3), 510-516.

Karim, N., & Tangpong, J. (2018). Biological properties in relation to health promotion effects of *Garcinia mangostana* (queen of fruit): A short report. *Journal of Health Research, 32*(5), 364-370.

Kaur, G., Singh, A., & Dar, B. N. (2020). Mangosteen (*Garcinia mangostana* L.). In *Antioxidants in Fruits: Properties and Health Benefits* (pp. 83-101). Springer, Singapore.

Kee, L. A., Shori, A. B., & Baba, A. S. (2017). Bioactivity and health effects of Mentha spicata. *Integrative Food, Nutrition and Metabolism, 5*(1), 1-2.

Konno, S., Elyaguov, J., & Dixon, A. (2022). Anticancer and Antioxidant Effects of Bioactive Extracts from Monk Fruit (*Siraitia grosvenori*) with Potential Clinical Implications. *Cancer Science & Research, 5*(1), 1-10.

Konoshima, T., & Takasaki, M. (2002). Cancer-chemopreventive effects of natural sweeteners and related compounds. *Pure and Applied Chemistry, 74*(7), 1309-1316.

Koriem, K. M., Arbid, M. S., & Saleh, H. N. (2019). Antidiarrheal and protein conservative activities of *Psidium guajava* in diarrheal rats. *Journal of Integrative Medicine, 17*(1), 57-65.

Krisanti, E. A., Farizal, A. N., & Mulia, K. (2021). *Garcinia mangostana* L. fruit rind extract in ethyl acetate, n-butanol and water fractions: phytochemical analysis, antioxidant assay and cytotoxicity assay. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1053, No. 1, p. 012040). IOP Publishing.

Kulczyński, B., & Gramza-Michałowska, A. (2016). Goji berry (*Lycium barbarum*): composition and health effects–a review. *Polish Journal of Food and Nutrition Sciences, 66*(2), 67-76.

Kumar, M., Tomar, M., Amarowicz, R., Saurabh, V., Nair, M. S., Maheshwari, C., & Satankar, V. (2021). Guava (*Psidium guajava* L.) leaves: nutritional

composition, phytochemical profile, and health-promoting bioactivities. *Foods, 10*(4), 752.

Kumar, R., Vijayalakshmi, S., & Nadanasabapathi, S. (2017). Health benefits of quercetin. *Def. Life Science Journal*, *2*(10).

Lee, Y. J., Jeong, J., Kim, M. O., & Nam, J. O. (2016). The positive effect of luohanguo as sugar substitute on blood glucose and metabolism in streptozotocin-induced diabetic mice. *Applied Microscopy, 46*(3), 140-149.

Levy, A. S., & Carley, S. K. (2012). Cytotoxic activity of hexane extracts of *Psidium guajava* L (Myrtaceae) and *Cassia alata* L (Caesalpineaceae) in Kasumi-1 and OV2008 cancer cell lines. *Tropical Journal of Pharmaceutical Research, 11*(2), 201-207.

Li, F., Yang, F., Liu, X., Wang, L., Chen, B., Li, L., & Wang, M. (2017). Cucurbitane glycosides from the fruit of *Siraitia grosvenori* and their effects on glucose uptake in human HepG2 cells in vitro. *Food Chemistry, 228*, 567-573.

Li, H., Li, R., Jiang, W., & Zhou, L. (2022). Research progress of pharmacological effects of *Siraitia grosvenorii* extract. *Journal of Pharmacy and Pharmacology, 74*(7), 953-960.

Li, X. L., Zhou, A. G., & Li, X. M. (2007). Inhibition of *Lycium barbarum* polysaccharides and *Ganoderma lucidum* polysaccharides against oxidative injury induced by γ-irradiation in rat liver mitochondria. *Carbohydrate Polymers, 69*(1), 172-178.

Li, X. M., Ma, Y. L., & Liu, X. J. (2007). Effect of the *Lycium barbarum* polysaccharides on age-related oxidative stress in aged mice. *Journal of Ethnopharmacology, 111*(3), 504-511.

Lim, Y. K., Yoo, S. Y., Jang, Y. Y., Lee, B. C., Lee, D. S., & Kook, J. K. (2020). Anti-inflammatory and *in vitro* bone formation effects of *Garcinia mangostana* L. and propolis extracts. *Food Science and Biotechnology, 29*(4), 539-548.

Lin, Y., & Wu, H. (2022). Research Progress in the Application of *Lycium barbarum* Polysaccharide in Ophthalmic Diseases. *Proceedings of Anticancer Research, 6*(3), 17-22.

Linghu, K. G., Zhao, G. D., Xiong, W., Sang, W., Xiong, S. H., Tse, A. K. W., & Yu, H. (2020). Comprehensive comparison on the anti-inflammatory effects of three species of *Sigesbeckia* plants based on NF-κB and MAPKs signal pathways *in vitro*. *Journal of Ethnopharmacology, 250*, 112530.

Liu, C., Zeng, Y., Dai, L. H., Cai, T. Y., Zhu, Y. M., Dou, D. Q., & Sun, Y. X. (2015). Mogrol represents a novel leukemia therapeutic, via ERK and STAT3 inhibition. *American Journal of Cancer Research, 5*(4), 1308.

Liu, C., Dai, L., Liu, Y., Rong, L., Dou, D., Sun, Y., & Ma, L. (2016). Antiproliferative activity of triterpene glycoside nutrient from monk fruit in colorectal cancer and throat cancer. *Nutrients, 8*(6), 360.

Liu, B., Xu, Q., & Sun, Y. (2020). Black goji berry (*Lycium ruthenicum*) tea has higher phytochemical contents and *in vitro* antioxidant properties than red goji berry (*Lycium barbarum*) tea. *Food Quality and Safety, 4*(4), 193-201.

Liu, H., Cui, B., & Zhang, Z. (2022). Mechanism of glycometabolism regulation by bioactive compounds from the fruits of *Lycium barbarum*: A review. *Food Research International*, 111408.

Liu, Z. C., Yu, W. W., Zhou, H. C., Lan, Z. C., Wu, T., Xiong, S. M., & Liu, H. B. (2021). *Lycium barbarum* polysaccharides ameliorate LPS-induced inflammation of RAW264. 7 cells and modify the behavioral score of peritonitis mice. *Journal of Food Biochemistry, 45*(10), e13889.

Lu, S. P., & Zhao, P. T. (2010). Chemical characterization of Lycium barbarum polysaccharides and their reducing myocardial injury in ischemia/reperfusion of rat heart. *International Journal of Biological Macromolecules*, *47*(5), 681-684.

Luo, Q., Cai, Y., Yan, J., Sun, M., & Corke, H. (2004). Hypoglycemic and hypolipidemic effects and antioxidant activity of fruit extracts from *Lycium barbarum*. *Life Sciences, 76*(2), 137-149.

Luo, Q., Li, Z., Huang, X., Yan, J., Zhang, S., & Cai, Y. Z. (2006). Lycium barbarum polysaccharides: Protective effects against heat-induced damage of rat testes and H2O2-induced DNA damage in mouse testicular cells and beneficial effect on sexual behavior and reproductive function of hemicastrated rats. *Life Sciences, 79*(7), 613-621.

Luo, Y., Peng, B., Wei, W., Tian, X., & Wu, Z. (2019). Antioxidant and anti-diabetic activities of polysaccharides from guava leaves. *Molecules, 24*(7), 1343.

Manikandan, R., Thiagarajan, R., Goutham, G., Arumugam, M., Beulaja, M., Rastrelli, L., Skalicka-Woźniak, K., Habtemariam, S., Orhan, I.E., Nabavi, S.F. and Nabavi, S.M. (2016). Zeaxanthin and ocular health, from bench to bedside. *Fitoterapia, 109*, 58-66.

Mansour, N. A. A. (2013). Antioxidant Activity of Crude Extract from Mangosteen (*Garcinia mangostana* Linn.) *Pericarp on the Lung Rat which Exposure by Cigarette* (Doctoral dissertation, Universitas Brawijaya).

Masters, K. S., & Bräse, S. (2012). Xanthones from fungi, lichens, and bacteria: the natural products and their synthesis. *Chemical Reviews*, *112*(7), 3717-3776.

Mocan, A., Vlase, L., Vodnar, D. C., Bischin, C., Hanganu, D., Gheldiu, A. M., & Crișan, G. (2014). Polyphenolic content, antioxidant and antimicrobial activities of *Lycium barbarum* L. and *Lycium chinense* Mill. leaves. *Molecules, 19*(7), 10056-10073.

Mohamed, G. A., Ibrahim, S. R., Shaaban, M. I., & Ross, S. A. (2014). Mangostanaxanthones I and II, new xanthones from the pericarp of Garcinia mangostana. *Fitoterapia, 98*, 215-221.

Mohan, S., Syam, S., Abdelwahab, S. I., & Thangavel, N. (2018). An anti-inflammatory molecular mechanism of action of α-mangostin, the major xanthone from the pericarp of *Garcinia mangostana*: an in silico, *in vitro* and *in vivo* approach. *Food & Function, 9*(7), 3860-3871.

Moon, J. Y., Mosaddik, A., Kim, H., Cho, M., Choi, H. K., Kim, Y. S., & Cho, S. K. (2011). The chloroform fraction of guava (*Psidium cattleianum sabine*) leaf extract inhibits human gastric cancer cell proliferation via induction of apoptosis. *Food Chemistry, 125*(2), 369-375.

Moosophin, K., Wetthaisong, T., Seeratchakot, L. O., & Kokluecha, W. (2010). Tannin extraction from mangosteen peel for protein precipitation in wine. *Asia-Pacific Journal of Science and Technology, 15*(5), 377-385.

Munawaroh, H., Saputri, L. N. M. Z., Hanif, Q. A., Hidayat, R., & Wahyuningsih, S. (2016). The co-pigmentation of anthocyanin isolated from mangosteen pericarp (*Garcinia Mangostana* L.) as Natural Dye for Dye-Sensitized Solar Cells (DSSC). In *IOP Conference Series: Materials Science and Engineering* (Vol. 107, No. 1, p. 012061). IOP Publishing.

Muñoz-Labrador, A., Lebrón-Aguilar, R., Quintanilla-López, J. E., Galindo-Iranzo, P., Azcarate, S. M., Kolida, S., Kachrimanidou, V., Garcia-Cañas, V., Methven, L., Rastall, R.A. and Moreno, F.J. & Hernandez-Hernandez, O. (2022). Prebiotic potential of a new sweetener based on galactooligosaccharides and modified mogrosides. *Journal of Agricultural and Food Chemistry, 70*(29), 9048-9056.

Nakatani, K., Yamakuni, T., Kondo, N., Arakawa, T., Oosawa, K., Shimura, S., Inoue, H. and Ohizumi, Y. (2004). γ-Mangostin inhibits inhibitor-κB kinase activity and decreases lipopolysaccharide-induced cyclooxygenase-2 gene expression in C6 rat glioma cells. *Molecular Pharmacology, 66*(3), 667-674.

Nakatani, K., Nakahata, N., Arakawa, T., Yasuda, H., & Ohizumi, Y. (2002a). Inhibition of cyclooxygenase and prostaglandin E2 synthesis by γ-mangostin, a xanthone derivative in mangosteen, in C6 rat glioma cells. *Biochemical Pharmacology, 63*(1), 73-79.

Nakatani, K., Atsumi, M., Arakawa, T., Oosawa, K., Shimura, S., Nakahata, N., & Ohizumi, Y. (2002b). Inhibitions of histamine release and prostaglandin E2 synthesis by mangosteen, a Thai medicinal plant. *Biological and Pharmaceutical Bulletin, 25*(9), 1137-1141.

Naseer, S., Hussain, S., Naeem, N., Pervaiz, M., & Rahman, M. (2018). The phytochemistry and medicinal value of Psidium guajava (guava). *Clinical Phytoscience*, *4*(1), 1-8.

Nauman, M. C., & Johnson, J. J. (2022). The purple mangosteen (*Garcinia mangostana*): Defining the anticancer potential of selected xanthones. *Pharmacological Research, 175*, 106032.

Nguyen, P. T., & Marquis, R. E. (2011). Antimicrobial actions of α-mangostin against oral streptococci. *Canadian Journal of Microbiology, 57*(3), 217-225.

Ojewole, J. A. O. (2006). Antiinflammatory and analgesic effects of *Psidium guajava* Linn. (Myrtaceae) leaf aqueous extract in rats and mice. *Methods and Findings in Experimental and Clinical Pharmacology, 28*(7), 441-446.

Ong, Y. S., Murugaiyah, V., Goh, B. H., & Khaw, K. Y. (2020). Bioactive xanthones from *Garcinia mangostana*. In *Plant-derived Bioactives* (pp. 281-300). Springer, Singapore.

Pandey, A. K., & Chauhan, O. P. (2019). Monk fruit (*Siraitia grosvenorii*)-health aspects and food applications. *Pantnagar Journal of Research, 17*, 191-198.

Patil, R. (2024). Investigating the Anti-Allergic, Bronchoprotective, and Antioxidant Activities of *Psidium guajava* Extract in Experimental Animals. *Journal of Internal Medicine and Pharmacology, 1*(01), 26-37.

Pedraza-Chaverri, J., Cárdenas-Rodríguez, N., Orozco-Ibarra, M., & Pérez-Rojas, J. M. (2008). Medicinal properties of mangosteen (*Garcinia mangostana*). *Food and Chemical Toxicology, 46*(10), 3227-3239.

Phitaktim, S., Chomnawang, M., Sirichaiwetchakoon, K., Dunkhunthod, B., Hobbs, G., & Eumkeb, G. (2016). Synergism and the mechanism of action of the combination of α-mangostin isolated from *Garcinia mangostana* L. and oxacillin against an oxacillin-resistant *Staphylococcus saprophyticus*. *BMC Microbiology, 16*, 1-14.

Phuong, N. T. M., Van Quang, N., Mai, T. T., Anh, N. V., Kuhakarn, C.,

Reutrakul, V., & Bolhuis, A. (2017). Antibiofilm activity of α-mangostin extracted from *Garcinia mangostana* L. against *Staphylococcus aureus*. *Asian Pacific Journal of Tropical Medicine, 10*(12), 1154-1160.

Pohan, D. J., & Rahmawati, F. (2022). The effect of mangosteen pericarp (*Garcinia mangostana Linn*) extract on inhibits the growth of bacteria *Escherichia Coli* ATCC 25922 and bacteria *Staphylococcus Aureus* ATCC 25923. *International Journal of Research in Pharmacy and Pharmaceutical Sciences, 7*(2), 29-38.

Potterat, O. (2010). Goji (*Lycium barbarum* and *L. chinense*): phytochemistry, pharmacology and safety in the perspective of traditional uses and recent popularity. *Planta Medica, 76*(01), 7-19.

Proestos, C. (2018). Superfoods: Recent data on their role in the prevention of diseases. *Current Research in Nutrition and Food Science Journal, 6*(3), 576-593.

Qi, Y., Duan, G., Fan, G., & Peng, N. (2022). Effect of *Lycium barbarum* polysaccharides on cell signal transduction pathways. *Biomedicine & Pharmacotherapy, 147*, 112620.

Reeve, V. E., Allanson, M., Arun, S. J., Domanski, D., & Painter, N. (2010). Mice drinking goji berry juice (Lycium barbarum) are protected from UV radiation-induced skin damage via antioxidant pathways. *Photochemical & Photobiological Sciences, 9*(4), 601-607.

Rhee, D. (2010). 234 Trifolium pratense (red clover) Douglas Rhee. *Medical Treatment of Glaucoma, 21*, 234.

Riaz, A., Arif, S., Ghaffar, R., Anam, S., & Aslam, R. S. (2020). 100. Evaluation of comparative anti-diabetic effect of guava and mango leaves powder in streptozotocin induced diabetic rats. *Pure and Applied Biology (PAB), 9*(1), 1059-1068.

Roberts, J. E., & Dennison, J. (2015). The photobiology of lutein and zeaxanthin in the eye. *Journal of Ophthalmology*, *2015*.

Ryu, N. H., Park, K. R., Kim, S. M., Yun, H. M., Nam, D., Lee, S. G., & Ahn, K. S. (2012). A hexane fraction of guava leaves (*Psidium guajava* L.) induces anticancer activity by suppressing AKT/mammalian target of rapamycin/ribosomal p70 S6 kinase in human prostate cancer cells. *Journal of Medicinal Food, 15*(3), 231-241.

Sato, R., Dang, K. M., McPherson, B. G., & Brown, A. C. (2010). Anticancer activity of guava (*Psidium guajava*) extracts. *Journal of Complementary and Integrative Medicine, 7*(1).

Seo, N., Ito, T., Wang, N., Yao, X., Tokura, Y., Furukawa, F., & Kitanaka, S. (2005). Anti-allergic *Psidium guajava* extracts exert an antitumor effect by inhibition of T regulatory cells and resultant augmentation of Th1 cells. *Anticancer Research, 25*(6A), 3763-3770.

Shabbir, H., Kausar, T., Noreen, S., Rehman, H. U., Hussain, A., Huang, Q., & Nawaz, A. (2020). *In vivo* screening and antidiabetic potential of polyphenol extracts from guava pulp, seeds and leaves. *Animals, 10*(9), 1714.

Shen, Y., Lin, S., Han, C., Hou, X., Long, Z., & Xu, K. (2014). Rapid identification and quantification of five major mogrosides in *Siraitia grosvenorii* (Luo-Han-Guo) by high performance liquid chromatography–triple quadrupole linear ion trap tandem mass spectrometry combined with microwave-assisted extraction. *Microchemical Journal, 116*, 142-150.

Shetty, Y. S., Shankarapillai, R., Vivekanandan, G., Shetty, R. M., Reddy, C. S., Reddy, H., & Mangalekar, S. B. (2018). Evaluation of the efficacy of guava extract as an antimicrobial agent on periodontal pathogens. *The Journal of Contemporary Dental Practice, 19*(6), 690-7.

Shi, G. J., Zheng, J., Wu, J., Qiao, H. Q., Chang, Q., Niu, Y., & Yu, J. Q. (2017). Beneficial effects of *Lycium barbarum* polysaccharide on spermatogenesis by improving antioxidant activity and inhibiting apoptosis in streptozotocin-induced diabetic male mice. *Food & Function, 8*(3), 1215-1226.

Shori, A. B. (2015). Screening of antidiabetic and antioxidant activities of medicinal plants. *Journal of Integrative Medicine, 13*(5), 297-305.

Shori, A. B., Rashid, F., & Baba, A. S. (2018). Effect of the addition of phytomix-3+ mangosteen on antioxidant activity, viability of lactic acid bacteria, type 2 diabetes key-enzymes, and sensory evaluation of yogurt. *Lwt*, *94*, 33-39.

Shori, A. B., Yong, Y. S., & Baba, A. S. (2020). Effects of herbal yogurt with fish collagen on bioactive peptides with angiotensin-I converting enzyme inhibitory activity. *Food Science and Technology, 41*, 902-907.

Shori, A. B., Ming, K. S., & Baba, A. S. (2021a). The effects of Lycium barbarum water extract and fish collagen on milk proteolysis and in vitro angiotensin I-converting enzyme inhibitory activity of yogurt. *Biotechnology and Applied Biochemistry*, *68*(2), 221-229.

Shori, A. B., Muniandy, P., & Baba, A. S. (2021b). Changes in phenolic compounds profiles in tea extracts and the composition of these phenolic compounds in yogurt. *Recent Patents on Food, Nutrition & Agriculture, 12*(1), 36-44.

Shori, A. B., Ling, Y. H., & Baba, A. S. (2021c). Effects of Lycium barbarum and fish collagen in cheese on the proteolytic degradation profile with anti-ACE activity. *Journal of Food Processing and Preservation*, *45*(3), e15239.

Shori, A. B., Peng, C. W., Bagheri, E., & Baba, A. S. (2021d). Physicochemical analysis, proteolysis activity and exopolysaccharides production of herbal yogurt fortified with plant extracts. *International Journal of Food Engineering, 17*(3), 227-236.

Shori, A. B., Yong, Y. S., & Baba, A. S. (2022). Effects of medicinal plants extract enriched cheese with fish collagen on proteolysis and *in vitro* angiotensin-I converting enzyme inhibitory activity. *LWT, 159*, 113218.

Shori, A. B., & Baba, A. S. (2023). The effect of refrigerated storage on anti-diabetic and antioxidant potency of probiotic yogurt treated with some medicinal plants. *Fermentation*, *9*(5), 427.

Skenderidis, P., Lampakis, D., Giavasis, I., Leontopoulos, S., Petrotos, K., Hadjichristodoulou, C., & Tsakalof, A. (2019). Chemical properties, fatty-acid composition, and antioxidant activity of goji berry (*Lycium barbarum L.* and *Lycium chinense Mill.*) fruits. *Antioxidants, 8*(3), 60.

So-In, C., & Sunthamala, N. (2022). Treatment efficacy of *Thunbergia laurifolia, Curcuma longa, Garcinia mangostana*, and *Andrographis paniculata* extracts in *Staphylococcus aureus*-induced rabbit dermatitis model. *Veterinary World, 15*(1): 188-197.

Sugiyanto, Z., Yohan, B., Hadisaputro, S., Dharmana, E., Suharti, C., Djamiatun, K., & Sasmono, R. T. (2019). Inhibitory effect of alpha-mangostin to dengue virus replication and cytokines expression in human peripheral blood mononuclear cells. *Natural Products and Bioprospecting, 9*(5), 345-349.

Sukanya, S., Sinthu, K., Shazhni, J., & Priya, F. S. (2017). Qualitative phytochemical screening and assessment of antimicrobial activity of *Psidium guajava* and its cytotoxic studies. *Asian Journal Applied Science Technology, 1*, 414-420.

Suttirak, W., & Manurakchinakorn, S. (2014). *In vitro* antioxidant properties of mangosteen peel extract. *Journal of Food Science and Technology, 51*(12), 3546-3558.

Szot, I., Zhurba, M., & Klymenko, S. (2020). Pro-health and functional properties of goji berry (*Lycium spp.*). *Agrobiodiversity for Improving Nutrition, Health and Life Quality*, (4).

Takasaki, M., Konoshima, T., Murata, Y., Sugiura, M., Nishino, H., Tokuda, H., Matsumoto, K., Kasai, R. and Yamasaki, K. (2003). Anticarcinogenic activity of natural sweeteners, cucurbitane glycosides, from *Momordica grosvenori*. *Cancer Letters, 198*(1), 37-42.

Tang, L., Zhang, Y., Jiang, Y., Willard, L., Ortiz, E., Wark, L., Medeiros, D. & Lin, D. (2011). Dietary wolfberry ameliorates retinal structure abnormalities in db/db mice at the early stage of diabetes. *Experimental Biology and Medicine, 236*(9), 1051-1063.

Tatiya-Aphiradee, N., Chatuphonprasert, W., & Jarukamjorn, K. (2019). Anti-inflammatory effect of *Garcinia mangostana* Linn. pericarp extract in methicillin-resistant *Staphylococcus aureus*-induced superficial skin infection in mice. *Biomedicine & Pharmacotherapy, 111*, 705-713.

Toyoda-Ono, Y., Maeda, M., Nakao, M., Yoshimura, M., Sugiura-Tomimori, N., & Fukami, H. (2004). 2-O-(β-D-Glucopyranosyl) ascorbic acid, a novel ascorbic acid analogue isolated from *Lycium* fruit. *Journal of Agricultural and Food Chemistry, 52*(7), 2092-2096.

Tun, A., Baranov, I. V., Krylov, V. A., & Tambulatova, E. V. (2020). Results of temperature effect on thermo-physical properties of guava fruit of Southeast Asia. In *IOP Conference Series: Materials Science and Engineering* (Vol. 826, No. 1, p. 012044). IOP Publishing.

Ugbogu, E. A., Emmanuel, O., Uche, M. E., Dike, E. D., Okoro, B. C., Ibe, C., Ude, V.C., Ekweogu, C.N. & Ugbogu, O. C. (2022). The Ethnobotanical, Phytochemistry and Pharmacological Activities of *Psidium guajava* L. *Arabian Journal of Chemistry*, 103759.

Upadhyay, R., & Dass, F. P. (2020). Guava [*Psidium guavaja*)-Properties and Trend in Functional Foods. *International Journal of Fermented Foods, 9*(2), 51-59.

Vania, L., Widyananda, M. H., Kharisma, V. D., Ansori, A. N. M., Naw, S. W., Maksimiuk, N., & Nugraha, A. P. (2021). Anticancer activity prediction of garcinia mangostana l. against her2-positive breast cancer through inhibiting egfr, her2 and igf1r protein: a bioinformatics study. *Biochemical and Cellular Archives, 21*(2), 3313-3321

Veeraraghavan, V. P., Hussain, S., Balakrishna, J. P., Rengasamy, G., & Mohan, S. K. (2020). Chemopreventive Action of *Garcinia Mangostana* Linn. on Hepatic Carcinoma by Modulating Ornithine Decarboxylase Activity. *Pharmacognosy Journal, 12*(6).

Wang, J. J. (2012). In Vitro Anti-skin Cancer Properties and Mechanisms of Action of Xanthones from the Mangosteen Pericarp. *Flinders University, School of Medicine, Department of Medical Biotechnology*.

Wang, L., Yang, Z., Lu, F., Liu, J., Song, Y., & Li, D. (2014). Cucurbitane glycosides derived from mogroside IIE: structure-taste relationships, antioxidant activity, and acute toxicity. *Molecules, 19*(8), 12676-12689.

Wang, Y., Duan, M., Zhao, L., & Ma, P. (2018). Guajadial inhibits NSCLC growth and migration following activation of the VEGF receptor-2. *Fitoterapia, 129,* 73-77.

Weli, A., Al-Kaabi, A., Al-Sabahi, J., Said, S., Hossain, M. A., & Al-Riyami, S. (2019). Chemical composition and biological activities of the essential oils of *Psidium guajava* leaf. *Journal of King Saud University-Science, 31*(4), 993-998.

Wimanshinee, A. G. N., Shamika, D. G. H., & Arampath, P. C. (2021). Biofunctional stirred yoghurt production using Mangosteen (*Garcinia mangostana* L.) peel powder extrac.

Wuttisin, N., & Boonsook, W. (2019). Total phenolic, flavonoid contents and antioxidant activity of *Siraitia grosvenorii* fruits extracts. *Food and Applied Bioscience Journal, 7*(3), 131-141.

Yamakuni, T., Aoki, K., Nakatani, K., Kondo, N., Oku, H., Ishiguro, K., & Ohizumi, Y. (2006). Garcinone B reduces prostaglandin E2 release and NF-κB-mediated transcription in C6 rat glioma cells. *Neuroscience Letters, 394*(3), 206-210.

Ye, H., Wang, Q., Zhu, F., Feng, G., Yan, C., & Zhang, J. (2020). Antifungal activity of alpha-mangostin against colletotrichum gloeosporioides *in vitro* and *in vivo*. *Molecules, 25*(22), 5335.

Yong, Y. S., Jin, T., Gim, S., Tin, Y. P., Nee, K. J., Shori, A. B., & Baba, A. S. (2022). Growth rate of *Lactobacillus ssp*. and *Streptococcus thermophilus* of some medicinal plants water extracts with fish collagen. *Biointerface Research in Applied Chemistry, 12*(1), 824-832.

Zahin, M., Ahmad, I., & Aqil, F. (2017). Antioxidant and antimutagenic potential of *Psidium guajava* leaf extracts. *Drug and Chemical Toxicology, 40*(2), 146-153.

Zhang, M., Chen, H., Huang, J., Li, Z., Zhu, C., & Zhang, S. (2005). Effect of *lycium barbarum* polysaccharide on human hepatoma QGY7703 cells: inhibition of proliferation and induction of apoptosis. *Life Sciences, 76*(18), 2115-2124.

Zhang, N., He, Z., He, S., & Jing, P. (2019). Insights into the importance of dietary chrysanthemum flower (Chrysanthemum morifolium cv. Hangju)-wolfberry (*Lycium barbarum* fruit) combination in antioxidant and anti-inflammatory properties. *Food Research International, 116*, 810-818.

Zhang, H., Ma, Z., Wang, J., Wang, P., Lu, D., Deng, S., & Tao, Y. (2021a). Treatment with exogenous salicylic acid maintains quality, increases bioactive compounds, and enhances the antioxidant capacity of fresh goji (*Lycium barbarum* L.) fruit during storage. *LWT, 140*, 110837.

Zhang, Y., Peng, Y., Zhao, L., Zhou, G., & Li, X. (2021b). Regulating the gut microbiota and SCFAs in the faeces of T2DM rats should be one of antidiabetic mechanisms of mogrosides in the fruits of *Siraitia grosvenorii*. *Journal of Ethnopharmacology, 274*, 114033.

Zhao, R., Li, Q., & Xiao, B. (2005). Effect of *Lycium barbarum* polysaccharide on the improvement of insulin resistance in NIDDM rats. *Yakugaku Zasshi, 125*(12), 981-988.

Zhao, X. Q., Guo, S., Lu, Y. Y., Hua, Y., Zhang, F., Yan, H., & Duan, J. A. (2020). *Lycium barbarum* L. leaves ameliorate type 2 diabetes in rats by modulating metabolic profiles and gut microbiota composition. *Biomedicine & Pharmacotherapy, 121*, 109559.

Zhu, X., Ouyang, W., Pan, C., Gao, Z., Han, Y., Song, M., & Cao, Y. (2019). Identification of a new benzophenone from *Psidium guajava* L. leaves and its antineoplastic effects on human colon cancer cells. *Food & Function, 10*(7), 4189-4198