Pharmacogn J. 2022; 14(2): 444-455
A Multifaceted Journal in the field of Natural Products and Pharmacognosy
www.phcogj.com

Review Article

Ten Commonly Available Medicinal Plants in Malaysia with Potential Sun Protection Factor and Antioxidant Properties – A Review

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History

- Submission Date: 10-12-2021;
- Review completed: 16-01-2022;
- Accepted Date: 25-01-2022.

DOI : 10.5530/pj.2022.14.57

Article Available online

http://www.phcogj.com/v14/i2

ABSTRACT

Background: Malaysia has a diverse range of medicinal plants that utilized to make effective nutritional, folk medicine, and cosmetic preparations. Natural antioxidants obtained from medicinal plant extracts have recently gained popularity as protective ingredients in sunscreen formulations due to their safety, wide range of biological effects on skin, and environmental sustainability in absorbing Ultraviolet (UV) radiation and preventing skin damage. Prolonged exposure to UV rays may cause skin damages like sunburn, photoaging, erythema, edema, wrinkle, and skin cancer. Natural sunscreen products are becoming more popular among consumers who are becoming more aware of the risks of excessive UV and chemicals in beauty and personal care products. **Objective:** This review aimed to provide brief information about ten commonly available medicinal plants in Malaysia with potential sun protection factor and antioxidant properties. **Methods:** In the present review, the relevant literatures were an extensive search from various scientific database including Pubmed, Google Scholar, ScienceDirect and Scopus. Ten commonly available medicinal plants in Malaysia such as *Graptophyllum pictum, Moringa oleifera, Mangifera indica, Zanthoxylum rhetsa, Andrographis paniculata, Sonneratia caseolaris, Camellia sinensis, Morinda citrifolia, Nephelium lappaceum* and *Murraya koenigii* were included based on its potential sun protection factor (SPF) and antioxidant properties. **Results:** All the ten medicinal plants reported in this review found to have potential antioxidant activities due to the presence of phenolic and flavonoid content in the extracts. All of these findings well correlated to their potential SPF. The *M. indica* extracts had the highest SPF value among the ten plant extracts reported in this review, with a value of ≥30. This is considered high sun protection action. Extracts of *A. paniculata, M. citrifolia, C. sinensis,* and *G. pictum* have a moderate photoprotective effect (SPF value of ≥15). Sun protection activity was low in *M. oleifera* and *S. caseolaris* (SPF value ≤ 2). **Conclusion:** The identification of natural antioxidant and photoprotective ingredients from medicinal plants has demonstrated as a potential natural sunscreen product in protecting UV radiation against damaging UV rays, and therefore recommended to utilize them to replace synthetic chemicals in cosmetics development in the future.

Key words: Medicinal plants, Antioxidant, Total phenol, Total flavonoid, Sun protection factor.

INTRODUCTION

Skin is the outer layer and largest organ of the human body that provides UV protection. UV radiation is a type of electromagnetic radiation that emitted by the sun in the form of waves or particles with varying wavelengths and frequencies.[1] UV radiation generally divided into three subtypes: UVA (320-400 nm), UVB (290-320 nm) and UVC (200-290 nm).[2] The ozone layer absorbs UVC before it reaches the planet, however the ozone layer does not totally filter off UVA and UVB. Hence, both UVA and UVB contribute for the harmful effects on human skin due to the sunburn and accelerates skin aging.[1,3] Excessive radiations of sunrays may initiate the generation of reactive oxygen species (ROS) or free radicals, which induce the oxidative damage and impairment of the antioxidant system. As the consequences, this extensive and chronic UV exposure proven lead to skin side effects such as erythema, edema, photoaging, sunburn, lines and wrinkles, photosensitivity, immunosuppression and carcinogenesis.[1]

Daily use of sunscreen before outdoor activities is the one-step to prevent the skin against the harmful effects of UV radiation and the rising demand for sun protection creams has boost the market growth of sun protection products. However, sunscreen today consist of several synthetic UV filter molecule. Along with the increasing concern on healthy, beauty skin as well as hot weather and pollution, the consumption of products with sunscreen ingredients have reached 87% of global market in 2016.[4] Consumer demands has go beyond simple UV protection to natural ingredient and simpler formulation.[5] Unfortunately, majority products in the existing market are formulated from synthetic active ingredients such as titanum oxide, benzophenone, bisdisolizole disodium which is potentially hazardous for long-term use.[6]

Nowadays, natural substances extracted from plants have been gaining attraction as protective agents incorporated into cosmetic formulations due to their safety, responsible for multiple biological effects on skin and environmental sustainability.[7] Natural constituents have been considered a photoprotection agent because they can prevent UV-ROS or free radical formation and associated lipid peroxidation (LPO) and act as a stimulant in the first phase of photosynthesis due to their potentially important biological antioxidants like Vitamin C, Vitamin E, flavonoids, carotenoids, phenolic acids, and enzymes (Figure 1).[8,9]

Cite this article: Ibrahim ND, Seow LJ, Sekar M, Rani NNIM, Lum PT. Ten Commonly Available Medicinal Plants in Malaysia with Potential Sun Protection Factor and Antioxidant Properties – A Review. Pharmacogn J. 2022;14(2): 444-455.

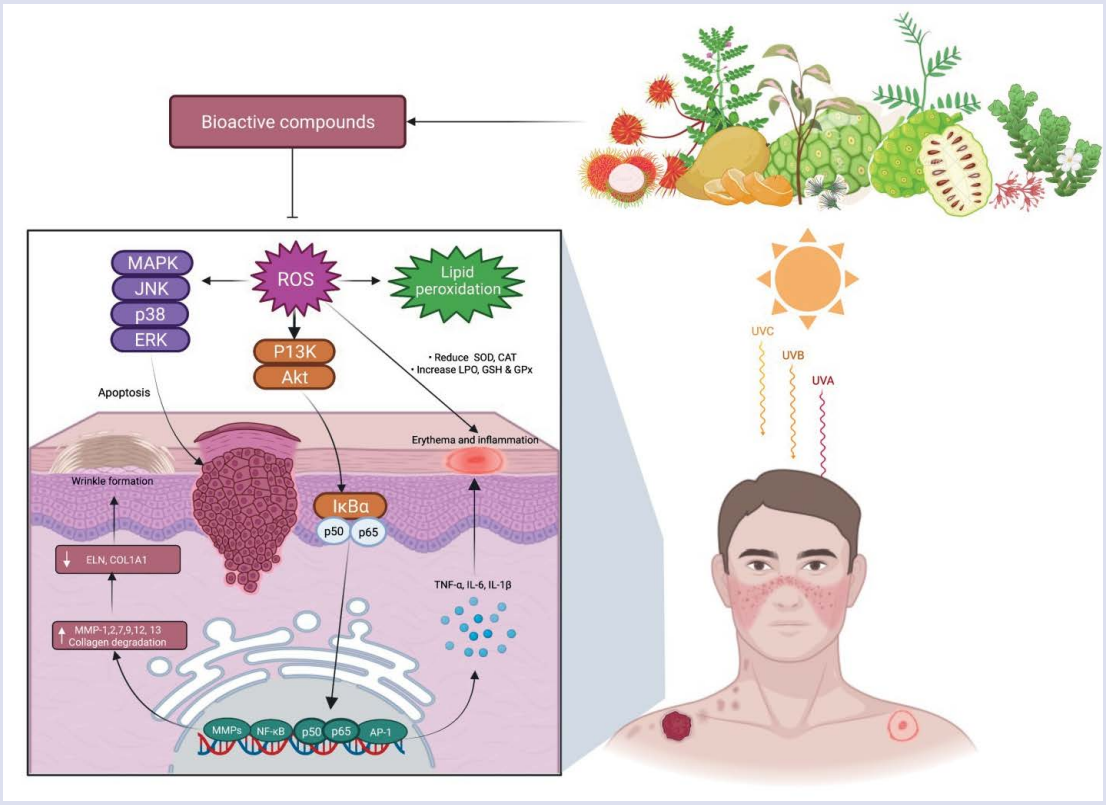

Figure 1: Through a variety of signalling cascades, reactive oxygen (ROS) induces apoptosis, inflammation, and wrinkles. Natural ingredients serve as photoprotective agents, decreasing the formation of reactive oxygen species and related lipid peroxidation, hence reducing release of inflammatory cytokines and collagen degradation.

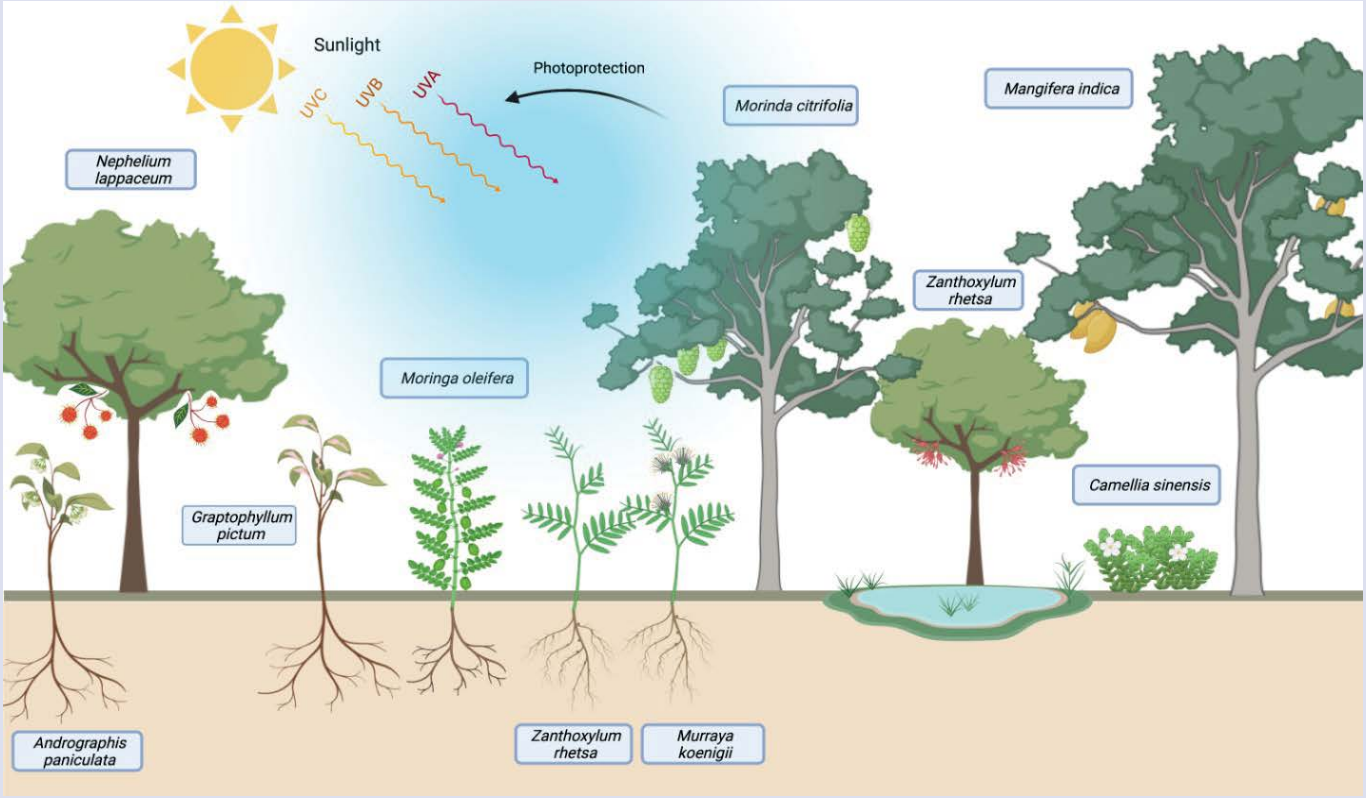

Figure 2: Medicinal plants that are generally available in Malaysia and are reputed to have antioxidant and photoprotective properties.

Among the various phenolic compounds of medicinal plants has been considered as antioxidant and photoprotection sources, flavonoids play as a vital role in UV radiation absorption against skin damages by scavenging UV induced free radical generation.[10,11] Hence, this review focuses on ten commonly available medicinal plants in Malaysia that have been claimed to have possible sun protection effects as well as antioxidant properties (Figure 2).

METHODS

Relevant literature obtained for this review from a variety of scientific databases, including Pubmed, Google Scholar, ScienceDirect, and Scopus. The following keywords were used in search: Sun protection factor AND Antioxidant AND Malaysian medicinal plants AND "*Graptophyllum pictum*" OR "*Moringa oleifera*" OR "*Mangifera indica*" OR "*Zanthoxylum rhetsa*" OR "*Andrographis paniculata*" OR "*Sonneratia caseolaris*" OR "*Camellia sinensis*" OR "*Morinda citrifolia*" OR "*Nephelium lappaceum*" OR "*Murraya koenigii*". An initial screening performed on studies that not written in English or did not have any abstracts. For each medicinal plant, the obtained data separated into five main groups: (1) botanical description (2) traditional uses (3) chemical constituents and biological activities (4) sun protection/UV protection and (5) antioxidant activity. Following a comprehensive review, the scientific evidence acquired is summarised and included.

MEDICINAL PLANTS IN MALAYSIA WITH POTENTIAL SUN PROTECTION FACTOR AND ANTIOXIDANT PROPERTIES

Table 1 summarizes the findings ten commonly available medicinal plants in Malaysia and its antioxidant, SPF value, total phenolic and flavonoid content.

GRAPTOPHYLLUM PICTUM(L.) GRIFF.

Botanical description

Graptophyllum pictum (*G. pictum*) belong to the family *Acanthaceae* and commonly known as caricature, is most likely native to Papua New Guinea. However, this plant is widely distributed and cultivated including India, Ghana, Bolivia Mexico and Asia.[12] It is a well-known traditional medicinal plant and locally named as " Daun Ungu" or "Daun Wungu" in Indonesia, "pudding" or "purple leave" in Malaysia and "Bai Ngeoun" in Thailand.[12-14] It is a tropical evergreen shrub that will grow to 6-9' in height, deep green leaves assorted blotched with cream along the midveins and oval to elliptic shape. The flowers generally bloom in summer with the characteristics such as 3-4' long, tubular flowers consist of protruding stamens and red to purple-red.[15]

Traditional uses

The Malay population has employed the leaves as a natural flavouring element in culinary preparations. Besides it is reported to be effective in traditional medicine including constipation, increase fertility, ulcers treatment, rheumatism, urinary infection, hemorrhoid, maturing boil process, scabies, smoothing skin, ear disease, hepatomegaly, wound healing and reduced swelling.[13-15]

Chemical constituents and biological activities

G. pictum leaves consist of flavonoids, steroids, glycosides, alkaloids, carbohydrate, saponins, phenolics, tannins, coumarins, anthraquinones, and sugars.[13,14,16] In addition, it possesses of various pharmacological activities including antidiabetic, antioxidant, anti-plaque, anti-implantation, anti-inflammatory, anti-bacteria, anti-fungal, anti-viral and laxative.[13,15] Budiaji *et al.*[17] reported the presense of sixteen active bioactive compounds in methanol leaves of *G. pictum* by using GC-MS. This study concluded that hexadecanoic acid is the major compound found in this plant extract that act as an anti-bacterial and antioxidant. Furthermore, it was confirm by another experiment carried out by UV-Vis, IR and GC-MS there were active antioxidant compound in ethanol extract.[16]

Antioxidant activity and SPF

According to Jiangseubchatveera *et al.*[14] the leaves of *G. pictum* are high in antioxidants. The ethyl acetate fraction of *G. pictum* ethanolic leaves extract had a high quantity of phenolic content and showed potential antioxidant activity in the DPPH and ABTS method. Similarly, in the DPPH method, the n-hexane fraction of the ethanolic leaves extract of *G. pictum* revealed a significant quantity of flavonoid content with potential antioxidant activity.[14] According to Goswami and Maurya,[15] an aqueous extract of *G. pictum* (whole plant) showed antioxidant properties as well as a high total phenolic flavonoid contents. In addition, Kusumaningsih *et al.*[18] found that *G. pictum* leaves extract had an antioxidant effect in reducing high Malondialdehyde (MDA) levels in an *in-vivo* model. After a toxic dose of paracetamol induced, a dose of 600 mg/kg found to be the most effective in preventing MDA elevation. Furthermore, in paracetamol-induced mice, the concentration of *G. pictum* leaves extract administration was proportional to its antioxidant activity.[18] Khor *et al.*[13] compared the photoprotective potential of several solvent extracts of *G. pictum* leaves to photo-stability and thermal-stability throughout the course of a 21-day storage process. The maximum SPF value found in methanolic and ethanolic extracts of *G. pictum* leaves. Both the extracts recommended for use in sunscreen formulations based on their findings.

MORINGA OLEIFERA LAM.

Botanical description

Moringa oleifera (*M. oleifera*) or locally known as "merunggai" or "gemunggal" is well known traditional medicinal plant in Malaysia. It commonly known by regional names such as drumstick tree, sajiwan, kelor, murungai kaai, saijhan and sajna, belongs to the *Moringaceae* family. *M. oleifera* according to Parrotta,[19] the height is about 10-12m, small sized tree and fast-growing, deciduous tree. The flowers are fragrance and bisexual, thinly veined, yellowish-white petals, about 2cm in diameter and 0.7 to 1cm long with five petals. The fruit is a three-sided capsule of 20–45 cm size, brown in color, and hanging. It is a plant grows in tropical and subtropical climates and is native to sub-Himalayan regions of India, Pakistan, Bangladesh, Sri Lanka, Afghanistan, East and West Africa, the Arabian Peninsula, Southern Asia, and Southern Florida.

Traditional uses

Traditionally, *M. oleifera* are widely used in cancer treatment, anti-inflammatory and anti-Buruli ulcer activity, enhance fertility, and lifestyle-related diseases, such as hypertension and diabetes mellitus. Besides, several pharmaceutical studies reported on different part of *M. oleifera* that possesses anti-inflammatory, antimicrobial, antioxidant, antiproliferative, antispasmodic, antiulcer, cholesterol lowering, and anti-diabetic.[20]

Chemical constituents and biological activities

Several parts of *M. oleifera* such as leaf, flower and bark are rich in polyphenols, β-carotene, lycopene, anthocyanin, flavonoid and ascorbic acid.[21] In addition, it consists of polyphenols like rutin, ellagic acid, chlorogenic acid, ferulic acid, quercetin glucoside, and kaempferol rhamnoglucoside.[20,22]

Antioxidant activity and SPF

Baldisserotto *et al.*[20] reported the phenolic contents and antioxidant activities of various *M. oleifera* leave extracts. The results exhibited

Table 1: Ten commonly available medicinal plants in Malaysia and its antioxidant, SPF value, total phenolic and flavonoid content.

No.	Scientific Name	Local Name	Plant Part Used	Solvent Used for Extraction	Total Phenol Content	Total Flavonoid Content	Antioxidant activity (IC_{50})	Antioxidant Method	SPF value	References
1	*Graptophyllum pictum*	Puding or Purple Leaves	Leaves	Ethanol	102.57±0.19 mgGAE/g	28.21 ± 0.04 mg QE/g	0.78±0.01 mg/mL	DPPH	ND	Jiangseubchatveera et al.[14]
							69.19±0.73 mg TEAC/g	ABTS	ND	Jiangseubchatveera et al.[14]
			Whole plant	Aqueous	3.33µg GAE/ mL	1.54 µg RE/ mL	22.01µg/mL	DPPH	ND	Goswami and Maurya[15]
							15.28 µg/mL	H_2O_2	ND	Goswami and Maurya[15]
							19.78 µg/mL	ABTS	ND	Goswami and Maurya[15]
			Leaves	Methanol	ND	ND	ND	ND	15.30±0.005	Khor et al.[13]
				Ethanol	ND	ND	ND	ND	13.42±0.004	Khor et al.[13]
2	*Moringa oleifera*	Merunggai or Gemunggal	Leaves	Hydro-alcohol	47.7±1.58µg GAE/mg	ND	232.6±7.61 µg/mL	DPPH	1.71 ± 0.06	Baldisserotto et al.[20]
				Aqueous	51.9±4.88µg GAE/mg	ND	232.8±0.60 µg/mL	DPPH	2.01±0.02	Baldisserotto et al.[20]
			Flowers	Hydro-ethanol	6.03±0.06 mg GAE/g	3.5±0.1 mg QE/g	405 µg/mL	DPPH	ND	Vats and Gupta[21]
			Leaves	Hydro-ethanol	9.58±0.29mg GAE/g	2.3±0.09mg QE/g	610 µg/mL	DPPH	ND	Vats and Gupta[21]
			Flowers	Hydro-ethanol	24.21±1.55 mg GAE/g	ND	192.5±4.1 µM TEAC /g	DPPH	ND	Fakurazi et al.[23]
			Leaves	Hydro-ethanol	19.76 ± 0.26mg GAE/g	ND	158.8±5.3 µM TEAC /g	DPPH	ND	Fakurazi et al.[23]
3	*Mangifera indica*	Mango	Leaves	Methanol	298.38±5.99 mgGAE /g	77.62±1.03 mg QE/g	416.64±11.08 mg TEAC /g	DPPH	38.67	De Silva et al.[25]
							132.81±0.41 mg TEAC /g	FRAP		De Silva et al.[25]
							26.38±1.95 mg TEAC /g	ABTS		De Silva et al.[25]
							410.28±7.39 mg TEAC /g	ORAC		De Silva et al.[25]
			Leaves	Methanol	ND	ND	9 µg/mL	DPPH	ND	Itoh et al.[27]
					ND	ND	117 µg/mL	SOD	ND	Itoh et al.[27]
			Flower	Methanol	ND	ND	3 µg/mL	DPPH	ND	Itoh et al.[27]
					ND	ND	171 µg/mL	SOD	ND	Itoh et al.[27]
4	*Zanthoxylum rhetsa*	Batang berduri	Bark	Methanol (ethyl acetate fraction)	20.47±0.09 mg GAE/g	1.59±0.12 mg RE/g	140±1.20µg/mL	DPPH	13.36±0.12	Santhanam et al.[32]
							50 ±0.35 µg/mL	NO		
				Methanol (butanol fraction)	14.14±0.18 mg GAE/g	3.07±0.24 mg RE/g	168±0.76µg/mL	DPPH	8.62±0.08	Santhanam et al.[32]
							69±0.74 µg/mL	NO		
			Root Bark	Methanol (Aqueous Fraction)	ND	ND	55.25 ± 2.78 µg/mL	DPPH	ND	Zohora et al.[33]
			Fruits	Methanol	0.0392±0.011 mg/mL GAE	ND	96%	DPPH	ND	Kumar et al.[30]
			Seeds coat		0.033±0.005 mg/mL GAE	ND	95%	DPPH	ND	Kumar et al.[30]
			Bark	Methanol (ethyl acetate fraction)	ND	ND	ND	ND	6.90 ± 0.57	Santhanam *et al.*[34]
5	*Andrographis paniculata*	Hempedu Bumi	Leaves	Methanol	309±0.816 mg/g GAE	82.125±0.853 mg/g RE	398.31 µg/mL	DPPH	ND	Sinha and Raghuwanshi[37]
							377.074 µg/mL	H_2O_2	ND	
				Ethanol	290.5±1.290 mg/g GAE	61.375±1.108 mg/g RE	404 µg/mL	DPPH	ND	Sinha and Raghuwanshi[37]

							379.06 µg/mL	H_2O_2	ND	
				Aqueous	57 mg/g GAE	37.805±0.73 mg/g RE	483.29 µg/mL	DPPH	ND	Sinha and Raghuwanshi[37]
							467.65 µg/mL	H_2O_2		
			Fruits	Ethanol	181.00 ± 1.48 mg GAE/g	ND	88.13%	DPPH	ND	Rafat *et al.*[38]
			Leaves	Ethanol	ND	ND	ND		28.41 ± 0,05	Fardiyah *et al.*[36]
6	*Sonneratia caseolaris*	Pidada/ berembang/ perepat	Bark	Methanol	50.70±0.74 mg GAE/g	90.04±3.57 mg QE/g	21.19 µg/mL	DPPH	ND	Simlai *et al.*[45]
			Bark	Ethanol	60.25 mg GAE/g	ND	4.57 µg/mL	DPPH	ND	Munira *et al.*[42]
				Ethyl acetate	63.00 mg GAE/g	ND	13.09 µg/mL	DPPH	ND	Munira *et al.*[42]
			Leaves	Methanol	18.65±0.14 mg/g	79.95 ± 3.44 mg/g	ND		1.538±0.08	Ilmiah *et al.*[44]
			Leaves	Ethanol	ND	ND	68 µg/ml	DPPH	ND	Howlder *et al.*[41]
7	*Camellia sinensis*	Tea	Leaves	Aqueous	156.00 ± 0.62 mg GAE/g	53.16±1.95 µg RE/mg	48.32±1.53%	DPPH	ND	Hossain *et al.*[48]
			Leaves	Ethanol Crude	ND	ND	ND		17.40±0.30	Sopyan *et al.*[51]
				Ethanol Formulation					24.71	
8	*Nephelium lappaceum*	Rambutan	Peel	Ethanol	244.00±4.34 mg GAE/g	69.36±7.17 mg/g	24.99 ± 2.8 µg/mL	DPPH	ND	Yunusaa[53]
			Seeds	Ethanol	27.10±1.09 mg GAE/g	163.33±1.88 mg/g	ND			Yunussa[53]
			Peel	Ethanol	ND	ND	7.74±0.76 µg /mL	DPPH	ND	Muhtadi *et al.*[60]
			Peel	Ethanol	ND	ND	9.32±0.05 µg/mL	DPPH	13.12±0.001	Muhtadi *et al.*[58]
							51.09±0.99%	FTC		Muhtadi *et al.*[58]
			Peel	Ethanol					26.3	Mota *et al.*[56]
9	*Morinda citrifolia*	Mengkudu	Leaves	Methanol	5.30±0.011 µg GAE/mg	ND	95 µg/mL	DPPH	ND	Kolli *et al.*[63]
				Ethyl Acetate	3.19±0.035 µg GAE/mg	ND	80 µg/mL	DPPH	ND	Kolli *et al.*[63]
			Leaves	Ethanol	ND	ND	ND		29.916	Mugitasari and Rahmawati[66]
10	*Murraya koenigii*	Curry leaf	Leaves	Hydro alcoholic	58.32±3.79% GAE	19.92 ±0.05% QE	210 µg/mL	DPPH	ND	Aju *et al.*[69]
							1194 µg/mL	NO	ND	Aju *et al.*[69]
							525 µg/mL	H_2O_2	ND	Aju *et al.*[69]
							971 µg/mL	HR	ND	Aju *et al.*[69]
							155.45	SR	ND	Aju *et al.*[69]
			Leaves	Hot chloroform	ND	ND	16.06 µg/µL	DPPH	ND	Pande *et al.*[72]
				Cold chloroform		ND	17.46 µg/µL	DPPH	ND	Pande *et al.*[72]
			Leaves	Methanol	ND	ND	ND		10.74±0.32	Pradhan *et al.*[73]
			Leaves	Essential oil	ND	ND	ND		2.04±0.02	Patil *et al.*[74]

GAE (Gallic acid equivalent), QE (Quercetin equivalent), RE (Rutin equivalent), TEAC (Trolox equivalent antioxidant capacity), DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid), H_2O_2 (Hydrogen peroxide scavenging activity), FRAP (Ferric Reducing Antioxidant power assay), ORAC (Oxygen radical absorbance capacity), SOD (Superoxide dismutase), NO (Nitric Oxide), FTC (Ferric thiocyanate), HR (Hydroxyl radical scavenging activity), SR (superoxide radical scavenging activity assay) and ND (Not determined).

higher amount of phenolic contents in aqueous and hydroalcoholic extracts and demonstrated potential antioxidant activities compared of methanol extract in DPPH. In addition, ORAC and FRAP assay revealed a significant antioxidant potential of *M. oleifera* leave extracts.[20] According to Vats and Gupta[21] and Fakurazi *et al.*,[23] various part of hydroethanolic extracts of *M. oleifera* (leaves and flowers) exhibited a strong antioxidant property in DPPH scavenging activity as well as a high total phenolic and flavonoid content. Moreover, Atawodi *et al.*[22] first reported root and stem barks consist of procyanidin which was promoting strong antioxidant potential and similarly in other plants studies have shown that proanthocyanidins capable to protect the body from UV rays damage. Baldisserotto *et al.*[20] proves that formulation of sunscreen of the *M. oleifera* leaves has demonstrated great photostability, non-skin irritation, possessing broad-spectrum UV filter, and may enhanced UVA/UVB protection factor. The results revealed maximum SPF value was display in water followed by methanolic and hydroalcoholic leaves of *M. oleifera* extracts. However, this study concluded that hydroalcoholic formulation showed greatest

potential as a photoaging and photocarcinogenesis due to it only has promising anti-proliferative effect on melanoma COLO38 cells.

*MANGIFERA INDICA*L.

Botanical description

Mangifera indica (*M. indica*), also known as mango belong to genus *Mangifera* and family of *Anacardiaceae*, is a major fruit that is cultivated in tropical and sub-tropical regions. The genus of *Mangifera* originated from Borneo, Java, Sumatra and the Malay Peninsula. However, this plant is widely distributed and cultivated worldwide for commercial fruit production but the most-cultivated *Mangifera* species, *M. indica* (mango), has its origins in India and Myanmar. The tree is tall, height of plant may vary from 10 to 30m and it is evergreen trees can grow up more than 100 years, thick branch from strong trunk, dome shape, inflorescences flower, leaves usually linear- oblong, fruit with single seed, and long taproot.[24]

Traditional uses

Traditionally, *M. indica* has been used as medicinal treatment for hundreds of years due to the several beneficial pharmacological properties, such as antioxidant, anti-inflammatory, antimicrobial, anti-diabetic, lowering blood pressure, cardio tonic properties and hepatoprotective effects.[25,26]

Chemical constituents and biological activities

M.indica leaves presence of alkaloids, saponins, flavonoids, tannins, phenols, glycosides, carbohydrates and terpenoids.[25] In addition, Itoh *et al.*[27] report that there were active ingredients found in mango leaves extract including 3-C-β-D-glucosyl-2,4,4',6 tetrahydroxybenzophenone, mangiferin, chlorophyll and anthocyanins represented by cyanidin-3-O-glucoside work as antioxidant.[27]

Antioxidant activity and SPF

According to De Silva *et al.*[25] methanol extract of leaf *M. indica* was demonstrated strong antioxidant activities including in FRAP, DPPH, ABTS and ORAC assay as well as a high total phenolic and flavonoid contents. Besides, Itoh *et al.*[27] indicated high antioxidant activity of the methanolic extracts in flower and old dark green leaves extract compared to pericarp, seed and bark extract in DPPH and SOD method. De Silva *et al.*[25] reported the methanolic *M. indica* leaves extract had a photoprotection activity toward sun protection factor (SPF). Interestingly, based on their findings methanolic leaf extract of *M. indica* showed highest SPF value compared of standard agent Dermatone® as well as potent antioxidant activity.[25] Furthermore, Song *et al.*[28] found that *M. indica* leaves extract had an antioxidant effect in reducing inflammation in an *in vivo* model. After 0.1 mL of water containing 100 mg of mango extract was administrated orally daily, the treated group hairless mice was found effective UVB induced significant improvement in skin thickness, wrinkle formation and collagen fiber. These data imply that mango extract employed as a skin-care photoprotective agent.[28]

ZANTHOXYLUM RHETSA (ROXB.) DC.

Botanical description

Zanthoxylum rhetsa (*Z. rhetsa*) belongs to family *Rutaceae*, known as Indian prickly ash is a moderate sized aromatic deciduous tree or tree with cone-shaped spines on the stems and branches. It distributed in the tropical and sub-tropical regions, including India, Bangladesh, China, Indonesia and Malaysia.[29] The tree sometimes can grow up to 20-30m tall with pale corky bark at an altitude of 1800 m and spreading leafy branches and commonly found in tropical regions of India.[30]

Traditional uses

It is used in traditional medicinal systems for various illness such as cholera, toothache, microbial infection, antiseptic, rheumatism, inflammation, diabetes, snake bites, breast pain, enhance lactation production, astringent, and aromatic as well as.[29]

Chemical constituents and biological activities

Z. rhetsa bark consist of lignoids, alkaloids, amides, flavonoids, terpenes, sterols, coumarins, xanthyletin, sesamin, sabinene.[29,30] According to the Santhanam *et al.*,[29] there were thirty-nine bioactive compounds found in *Z. rhetsa* bark using GC–MS analysis. Interestingly, kobusin, yangambin, epi-eudesmin, eudesmin, 8-hydroxy-4′-methoxypinoresinol, hesperetin, magnolin reticuline, allocryptopine, usambanoline, dihydronitidine, N-methyl laurotetanine, chelerythrine[29] and hesperidin[31] were the first compounds reported present in the bark of *Z. rhetsa*.

Antioxidant activity and SPF

According to Santhanam *et al.*,[32] the ethyl acetate and butanol fraction of *Z. rhetsa* bark are potent in antioxidants. The ethyl acetate fraction of *Z. rhetsa* methanolic bark had a greater amount of total phenolic content and demonstrated stronger antioxidant activity in DPPH and nitric oxide (NO) method. Furthermore, butanol fractions of *Z. rhetsa* bark exhibited a significant quantity of flavonoid content with superior antioxidant activity.[32] In another experiment, Zohora *et al.*[33] reported that the aqueous fraction of *Z. rhetsa* methanolic root bark, possesses higher antioxidant potential (DPPH), cytotoxic, thrombolytic and antimicrobial activity against *Vibrio cholera* and *Klebsiella pneumonia*. According to Kumar *et al.*[30], methanol extract of *Z. rhetsa* (fruit and seed coat) showed antioxidant properties as well as a high total phenolic contents in whole fruit extract. Santhanam *et al.*[32] investigated the photoprotective potential of several solvent extracts of *Z. rhetsa* bark and the highest SPF values found in ethyl acetate fraction. As continuation to this work, Santhanam *et al.*[34] was formulated sunscreen comprising of ethyl acetate fraction *Z.rhetsa* bark extraction with promising sun protection potential. Overall, the formulation cream showed highest SPF value, good efficiency of UVB absorption and moderate UVA protection properties, no microorganism observed in microbiological test, present pseudo plastic behavior and the physiochemical evaluation were stable at 8 °C and 25 °C a except for samples kept at 40 °C.[34] Consequently, the ethyl acetate fraction and bioactive constituent, hesperidin was significant inhibits UVB induced damage in an *in vivo* study and the SPF value of hesperidin was found higher. Thus, it proves *Z. rhetsa* bark incorporated as a sunscreen agent and anti-ageing cosmetic.[31]

ANDROGRAPHIS PANICULATA (BURM. F.) NEES

Botanical description

In Malaysia, *Andrographis paniculata* Ness (*A. paniculata*) well known as Hempedu Bumi, which literally means 'bile of earth' since it is one of the most bitter plants that are used in traditional medicine and commonly known as 'King of Bitters'. It belongs to the family *Acanthaceae*, distributed in the open field. This plant widely used and cultivated in tropical and subtropical around the world such as Indonesia, Malaysia, Thailand, Philippines, Pakistan, Bangladesh, China, Hong Kong and India. The leaves appear bright in sun with green color physically, pinnate, acute apex, and entire margin in shape with size 2 to 12 cm in length and 1 to 3 cm diameter. The flower color is white with rose-purple spots on the petals and small in sized. The plant seeds are yellowish brown, 1.9 cm × 0.3 cm in size, capsules linear-oblong, acute at both ends and nearly square or numerous shapes. The plant can grow up from 30–110 cm height in moist, shady places, forest, farm, hill slopes and in garden.[35]

Traditional uses

A. paniculata considered as an important traditional folk medicine reported to be effective in treating diabetes and hypertension in Malaysia. Besides, it is widely applied in the treatment of various illness including diarrhea, fever, common cold, jaundice, malaria, sexual disorder, tonic water for heart and liver disease. Further, the plant used locally as a remedy for snake anti snake venom and for insect bites as well.[35]

Chemical constituents and biological activities

Previous studies showed the compounds present in *A. paniculata* had a good antioxidant, antimicrobial, antihypertensive, anti-inflammatory, anti-cancer, anti-malaria, and antidiabetic in various studies.[36] Additionally, the plant has several of phytochemical compounds such as alkaloids, tannin, triterpenoids, polyphenols, flavonoids, steroids, carbohydrate, cardiac glycosides, saponins and amino acids.[36,37] Besides, previous experiment on chemical composition showed this plant rich of 30 flavonoids, 8 quinic acid, more than 55 ent-labdane diterpenoids, 4 xanthones and 5 noriridoids which is and rographidoids A, B, C, D, and E.[35]

Antioxidant activity and SPF

According to Sinha and Raghuwanshi[37], methanol extract of *A. paniculata* leaves revealed a significant quantity of phenolic and flavonoid content with potential antioxidant activity in DPPH and Hydrogen peroxide (H_2O_2) method. In addition, among various parts (leaf, fruit and stem) of *A. paniculata*, the fruit extract showed high antioxidant potential in DPPH assay as well as maximum quantified of total phenolic.[38] According to Krithika *et al.*[39] isolated andrographolide from the aerial parts of this plant via silica column chromatography showed more potent antioxidant activity against cytoprotective effects in an *in-vivo* model. After induced of carbon tetrachloride (CCl4) toxicity in human hepatoma HepG2 cell line, the highest concentration of andrographolide (30 mmol/mL) found to be the most effective inhibitor of lipid peroxidation. Furthermore, both *A. paniculate* extract and andrographolide treatments along with CCl4 significantly proportional to its antioxidant activity. Fardiyah *et al.*[36] reported that the SPF values of ethanolic *A. paniculata* leaves extract demonstrated comparable in a concentration-dependent manner(12, 16 and 20 µL/mL) and the maximum SPF value was display at higher concentration. In addition, *A. paniculata* leaves extract exhibited two maximum peaks of ultraviolet absorption at 230nm and 362nm.[36] Besides, previous study done by Fardiyah *et al.*[40] was found that ethanolic extract of *A. paniculata* leaves had greater photoprotection potential toward fluorescence analysis at day 7 as an optimum intensity of fluorescence.

SONNERATIA CASEOLARIS(L.) ENGL.

Botanical description

Sonneratia caseolaris (*S. caseolaris*) is such a mangrove plant belonging to family *Sonneratiaceae*, commonly known as Mangrove apple or Crabapple mangrove. This species is widespread and found in tropical and subtropical in Indonesia, Malaysia, Myammar, the Philippines, Thailand, Bangladesh, Brunei Darussalam, Cambodia, China, India, northeast Australia, and Papua New Guinea.[41] It is an evergreen, medium in size normally grow up to 20 m tall, and elliptic-oblong leaves with 5-9.5 cm long.[42] *S. caseolaris*, which is also known "berembang" and "perepat" in peninsular Malaysia while it called as "Pidada" by Sabahan, Malaysian. *S. caseolaris* commonly grow in the mangrove forests on deep muddy soil, tidal areas with mud banks and sometimes found growing in fresh water. It flowering shoots bear dark red that are narrow petals with 10 cm in wide, nectar- rich which attract bats and moths, nocturnal and open at dusk and last only for one night. The fruits are a star shaped stem cap with six edges on the top, heavy seeds, and the size (12-20cm).[43]

Traditional uses

The plant is reported to be effective in traditional medicine like to stop bleeding, fever, smallpox, wound healing, cough, hematuria, sprains, helminth infection, hemorrhoids, antiseptic and astringent.[42,44]

Chemical constituents and biological activities

Phytochemical screening revealed that the plant consists of phenolic compounds, flavonoids, tannins, steroids, reducing sugars, alkaloid and saponins.[42,44,45] Interestingly, previous study found two isolated compounds of flavonoid from *S. caseolaris* that can be considered as photoprotection function which are luteolin and luteolin 7-O-β-glucoside.[46] One of luteolin function can absorb ultraviolet radiation from excessive exposure to the human skin.[44]

Antioxidant activity and sun protection factor

According to Simlai *et al.*[45] methanolic bark extract of *S. caseolaris* are high in antioxidants in DPPH method as well as showed strong antimicrobial activity. Other than that, ethanolic *S. caseolaris* bark extract had a high quantity of flavonoid content as well as revealed a significant quantity of phenolic, tannin, alkaloid and saponin content with potential antioxidant activity.[45] Similarly, another study done by Munira *et al.*[42] in DPPH method, the various fractions of *S. caseolaris* bark revealed significant antioxidant potential. The results found ethanolic fractions of *S. caseolaris* bark exhibited strong radical scavenging activity and the ethyl acetate fraction had a high quantity of phenolic content.[42] Ilmiah *et al.*[44] reported the different leaf tissues of *S. caseolaris* demonstrated antioxidant potential with epidermis part of *S. caseolaris* express of total phenolic, flavonoid and tannin content compared of mesophyll and whole leaf. In addition, Howlder *et al.*[41] found that ethanolic leaves extract of *S. caseolaris* possess of antioxidant effect in antinociceptive activity induced writhing in an *in-vivo* model. After treated with *S. caseolaris* ethanolic leaves extract, a dose of 500 mg/kg body weigh found to be the most effective in reducing power of writhing. Furthermore, in diclofenac induced white albino mice the concentration of *S. caseolaris* leaves extract administration was proportional to its antioxidant activity in DPPH method. Ilmiah *et al.*[44] compared the photoprotection potential in different leaf tissue parts(epidermis, mesophyll and whole leaf) of methanolic *S. caseolaris* leaves. Based on the finding, epidermis and mesophyll showed significantly photoprotection potential with the maximum SPF level and accumulation of compounds found in epidermis partin histochemical assay.

CAMELLIA SINENSIS (L.) KUNTZE

Botanical description

Tea is one of the most widely consumed beverages worldwide besides, and is available in various forms like green tea, black tea and oolong tea. The tea plant *Camellia sinensis* Kuntze (*C. sinensis*) belong to the family *Theaceae* grown in about 30 countries around the world. Common name includes tea plant, tea tree and tea shub. It is cultivated widely in tropical and sub-tropical regions with consistent moisture, well drainage, and slightly acidic soil. There are two botanical types of tea, which are *C. sinensis var. sinensis* (China tea) and *C. sinensis var. assamica* (Assam tea). *C. sinensis var. sinensis* widely growth in China, Japan, and Taiwan while *C. sinensis var. assamica* more commonly found in south and southeast Asia, including Malaysia and, more recently, Australia. Leaves and non- developed tea bud of tea plant used to produce tea. It usually planted in the highland area at a density of 5000 to 10,000 plants per hectare and as low shrubs of 1 to 1.5 m in height.[47]

Traditional uses

The chemical composition, therapeutic uses and pharmacological properties of these species reported. For thousand years in almost all countries worldwide, tea has been widely consumed in daily beverage was considered an effective medicine for treating different ailments in ancient folk medicine including diuretic effects and to reduce fever.[48]

Chemical constituents and biological activities

Tea mainly consists of polyphenols, caffeine, minerals, and trace amounts of vitamins (A, C, E, K and B), amino acids, lipid and carbohydrates.[49] In addition, tea has various pharmacological activities including as antioxidant, anti-cancer, anti-diabetic, anti-inflammatory, reduced cholesterol level and anti-mutagenic.[50] Catechin was the predominant group counting for 60–80% of tea natural occurring polyphenols with the present four major substances including epigallocatechin-3-O-gallate (EGCG), epigallocatechin (EGC), epicatechin-3-O-gallate (ECG) and epicatechin (EC). Zhang *et al.*[50] compared the active composition of catechins and theaflavins in different season tea, summer tea (STE) and autumn tea extract (ATE) found 15 of active compounds. EGC, EC, ECG, EGCG and GC was the major components of catechins in STE, while GC and EGCG was the main components of catechins in ATE. Furthermore, theafavins was slightly both in STE and ATE.[50]

Antioxidant activity and SPF

Hossain *et al.*[48] reported that among the various solvent extracts (water, ethanol and isopropanol), water extract of *C. sinensis* leaves demonstrated strong antioxidant properties in DPPH method as well as a high total phenolic flavonoid content. Previous study done by Chan *et al.*[47] found that, lowland leaves significantly quantify of phenolic content (TPC) as well as antioxidant activity (AOA) similarly to those of highland plants in three antioxidant methods (DPPH, FRAP and FIC). Besides, drying young green tea leaves was demonstrated rich TPC and AOA compared of four brands of commercial green and black teas in microwaved extraction method.[47] Zhang *et al.*[50] reported that the STE and ATE derived from the Jin Guanyin had an antioxidant effect in preventing the growth of human breast cancer cells MDA-MB-231in an *in-vivo* model. After intragastric administrated with STE at different concentrations for 14 days, the tumor volume was reduced from 722 mm^3 (control group) to 399 mm^3. Furthermore, STE found more effective to prevent tumor formation when the mice pre-treated with STE show no significant cytotoxic effects. Based on the finding, STE and ATE demonstrated strong antioxidant activity as well as promising prophylactic agent against cancers.[50]According to the Sopyan *et al.*,[51] ethanolic extract of *C. sinensis* has significant photoprotection potential. As continuation to this work, Sopyan *et al.*[51] was evaluated the sunscreen lotion comprising black tea leaf extract (*C. sinensis* Linnaeus) toward Sun Protection factor (SPF) at 4 °C and 40 °C for 28 days. The maximum SPF value found in formulation 2 (F2) consist of black tea leaves extract 0.04%. The finding suggests that both formulations meet the requirement of sunscreen preparation, good physical observation, safe and used as a sunscreen. In addition, Camouse *et al.*[52] report that topical application of green and white tea extracts had an antioxidant effect in induce oxidative DNA damage as well as prevent immune suppression in an *in-vivo* irradiation model. The finding recommends that, both of teas possess photoprotection agents that used as sun protection.

NEPHELIUM LAPPACEUM L.

Botanical description

Nephelium lappaceum (*N. lappaceum*) is a tropical plant most known as 'Rambutan' belongs to the family of *Sapindaceae* and are widely grow in Malaysia, Thailand and other southeast countries such as Indonesia, Thailand, Philippines, Vietnam, Sri Lanka and Combodia.[53,54] It also popular with the name of ''hairy fruit' because of presence of hairy and red spiny on the fruit.[54] Evergreen rambutan tree reaches 12 to 20m in height, grayish brown branches and the leaves look glossy green. Its fruit is an oval berry shape, green to red in color and elastic skin with soft hairy spines. The flesh is juicy, translucent whitish, sweet and has single seed. The flower small in sized, yellowish green to white in colour, petalless, can be male or female flower or hermaphroditic, mild sweet scent are highly attractive to bee, rich in nectar and rambutan trees can bear fruit twice annually.[55]

Traditional uses

Besides the delicious fruit, various parts of the plant are effective in traditional medicines; including diabetes mellitus, hypertension, antimicrobial infection, and diarrhea, enhance the digestion, astringent and headache. In Malaysia, *N. lappaceum* used as an astringent in treatment of tongue diseases.[55]

Chemical constituents and biological activities

Rambutan peel extracts contain of flavonoids, tannins, alkaloid, carbohydrate, and fixed oils.[54,56] In addition, it has been reported possess of various pharmacological activities including antibacterial, anti-hyperglycemic, antioxidant and anti-cholesterolemia.[57,58] Interestingly, this fruit peel has great antioxidants compound like ellagic acid, corilagin, and geraniin.[59] In another study, reported by Mutahdi *et al.*,[60] ethyl gallate found in Rambutan peel extract.

Antioxidant activity and SPF

A test done by Yunusaa[53] found that among the various solvent extracts, the ethanolic seeds and peel of *N. lappaceum* are high in antioxidant. The ethanolic peel extract of *N. lappaceum* had a high quantity phenolic content and showed potential antioxidant activity in the DPPH method. Besides, the maximum flavonoid content found in ethanolic extract of rambutan seed. According to Muhtadi *et al.*,[60] the ethanolic extract and their fractions of *N. lappaceum* peels showed more potent antioxidant activity compared of standard vitamin-E and other extracts (*Euphoria longan* Lour. Steud and *Durio zibethinus* Murr) in DPPH method. Apart from that, Muhtadi *et al.*[58] continued the research on gel nanoemulsion of the rambutan fruit peel extracts (RFPEs) revealed that the formulation had great antioxidant activity in DPPH and FTC method as well as photoprotective potential. The highest SPF level displayed in formulations. Based on the results, recommended that the gel nanoemulsion of RFPEs formulations showed good physical stability and photoprotection activity was proportional to its antioxidant activity. In addition, Sekar *et al.*[54] found that rambutan peel and flesh extracts demonstrated antioxidant activity could be potential as natural antioxidant substance in antiaging cosmetic formulation. According to Mota *et al.*[56] the formulation containing rambutan 1% of crude extract alone presence low SPF values compared of formulated 1% crude extract combined with 7.5 % of Ethylhexyl methoxycinnamate (EHMS) shows the highest SFP value. The above-mentioned study suggests that combined rambutan peel extract has significant efficiency of photoprotective activity in increasing the SPF values as well as decrease the concentration of the inorganic filter used as synthetic photoprotectors.[56]

MORINDA CITRIFOLIA L.

Botanical description

Morinda citrifolia (*M. citrifolia*) is a member of *Rubiaceae* family, generally known as noni that used by Polynesia for over 2000 years in food, folk medicine and dyeing of traditional clothes. It is an evergreen shrub or small sized tree, 3 to 10m height that grows widely in the

tropics that is native from Southeast Asia to Australia and is cultivated in Polynesia, India, the Caribbean region, and central and northern South America.[61] Locally in some countries, it namely as 'mengkudu' in Malaysia, 'Indian mulberry', 'nuna, or 'ach' in Indian, 'nhau' in Southeast Asia, 'painkiller bush' in the Caribbean, or 'cheese fruit' in Australia. The leaves are broadly elliptic (5-17cm x 10-40cm), petioles leave ring-like marks on the stalks and the corolla is greenish-white. The flower is small with tubular and peduncle together while the fruit is oval, fleshy, 3-10 cm x 3-6 cm width with an embossed appearance, slightly wrinkly, semitranslucent, and colour turn from green to yellow and the end to white as it ripens. The seeded fruit surrounded by little reddish-brown buds.[62]

Traditional uses

Traditionally it has been widely used for the treatment of various illness including enhance digestion, gout, as a tonic and febrifuge,[63] diabetes, hypertension, cancer, boils and skin ailment like skin disease, skin rash, pimples, bruises, wound, redness and sunburn.[64]

Chemical constituents and biological activities

According to the Serafini *et al.*[61] the leaves extract possesses of various phytochemicals constituents including flavonoids, tannins, saponins, steroids, triterpenoids, alkaloids and coumarins. In addition, this plant extracts rich of chemical compounds when performed the qualitative analysis such as quercetin-3-O-rutinoside or rutin and kaempferol glycosides,[61] cynarin and oleuropein.[63] Besides, in various studies, the compound has been confirmed possess of good antifungal, antibacterial, anticonvulsant, analgesic, anti-inflammatory, cytoprotective effect,[63] anti-oxidative, antidiabetic and anti-tumor activities.[65]

Antioxidant Activity and SPF

According to Kolli *et al.*,[63] *M. citrifolia* leaves extracts are high antioxidant in various solvent extracts (hexane, ethyl acetate, chloroform and methanolic). From the results, methanol extract of *M. citrifolia* leaves revealed high phenolic content and ethyl acetate extract found that more potent DPPH radical scavenging activity. Due the presence of antioxidant compound including cynarin and oleuropein, this present study concluded that *M. tinctoria* leaf extracts showed significantly antioxidant potential.[63] According to Serafini *et al.*,[61] aqueous extract of *M. citrifolia* leaves (AEMC) showed an antioxidant, antinociceptive, anti-inflammatory and antibacterial activity. After a toxic dose of morphine and acetylsalicylic acid administered orally 0.5 hour before acetic acid injection, a dose of AEMC at 400 mg/kg found to be the most effective in antinociceptive activity that was proportional to its antioxidant potential activity in an *in vivo* model. In addition, Li *et al.*[65] found that ultrasonic-assisted extraction (UAE) method was demonstrated more effective technique and strong antioxidant activity to extract polysaccharides from *M. citrifolia* (Noni). Mugitasari and Rahmawati[66] tested the photoprotective potential of ethanolic noni leaf extract and cream containing noni leaf extract in various concentration towards Sun Protecting Factor (SPF). The maximum SPF value found in the formulation cream comprising of 20% noni leaf extract. Furthermore, previous experiment done by Serafini *et al.*[67] revealed that gel formulation of *M. citrifolia* leaves extract (10% and 15%) was significantly exhibited good UVA -UVB photoprotective activity an in-*vitro* and *in-vivo* animal model. Based on the finding, the formulation comprising *M. citrifolia* leaves extract used to protect skin against UV damage in in reducing erythema, epidermal thickening, inflammation and regulating cell proliferation.[67]

MURRAYA KOENIGII (L.) SPRENG.

Botanical description

Murraya Koenigii, belongs to the family *Rutaceae*, popularly known as curry-leaf tree, is a native of India, Sri Lanka and Asian countries in Nepal, Pakistan, Thailand, Bhutan and Vietnam. It reached Malaysia, South Africa and Reunion Island, which is immigrants from South Indian. The curry leaf tree is small or shrub 4-6m height, 15-40 cm in diameter with trunk, dark grey bark and slender strong woody stem, closely crowded spreading dark green foliage. Well know aromatic leaves are pinnate, with 11-21 leaflets, which is each leaflet 2–4 cm long and 1-2cm broad. The flower white in funnel shape, bisexual, sweet aromatic, regular, actinomorphic, hypogynous, stalked and complete, fully opened flower being 1.12 cm in diameter. They produce shiny black berries (fruit) in small size and single or two seeds in green spinach colour but the seed not used in culinary dishes due to the poisonous factor.[68]

Traditional uses

M. koenigii, well known for its aromatics, consumed in many Asian as culinary dishes including Malaysia. It has a traditional used to treat diabetes, blood disorder, eruption, kidney pain, inflammation, leukoderma, piles, thirst, headaches, vomiting, influenza, insect bites, itching, rheumatism, dysentery, and diarrhea. It is acrid, bitter, analgesic, cooling, allay heat of body, alexiteric, anthelmintic, carminative, purgative and stimulant.[69,70]

Chemical constituents and biological activities

M. koenigii leaves extracts were found tannins, phenolic compounds, flavonoids, saponins, alkaloids, cardiac glycosides, phytosterols and triterpenoids.[69,71] Besides, *M. koenigii* leaves extract rich of vitamin including of vitamin A (β-carotene), vitamin C (ascorbic acid), thiamin, riboflavin, niacin, and vitamin E. Vitamins C and E are strong antioxidant. It also possesses of various pharmacological activities such as anti-diabetic, antioxidant, antimicrobial, anti-inflammatory, anticarcinogenic and hepato-protective properties.[71] In addition, Husna *et al.*[70] reported there were present of major phytochemical compound in ethanolic leaves extract including 1.8-cineol, β-caryophyllen, hexadecen-1-ol, α-matrine, benzo [a] naphtacene, 2H-3,5A-epoxynaphth [2,1-B] oxepin, 12-epilycodoline, γ-sitosterol, noruns12-ene and vitamin E when analysis using GC-MS has ability to mediate for antihyperglycemic effects.

Antioxidant activity and SPF

According to Aju *et al.*[69] the leaves of *M. koenigii*are rich in antioxidant. The hydro alcoholic extract of *M. koenigii* had high amount of phenolic flavonoid content and demonstrated potential antioxidant activity in DPPH, nitric oxide, hydrogen peroxide, Hydroxyl radical and superoxide radical assay. Furthermore, *M. koenigii* leaves revealed significant phenolic content was proportional to its antioxidant activity.[69] Besides, previous study done by Pande *et al.*,[72] the curry leaves in chloroform extract (hot and cold) shows an excellent antioxidant activity in DPPH radical scavenging assay. Husna *et al.*[70] found that, ethanolic *M. koenigii* leaves extract exhibited a powerful antioxidant activity in hyperglycemia in reducing malondialdehyde (MDA) level, enhancing GSH level, and reducing (HOMA)-insulin resistance index in an *in-vivo* model. After a toxic dose of streptozotocin and nicotinamide (STZNA)-induced, a dose of 200 mg/kg of ethanolic extract of *M. koenigii* found to be the most effective in antidiabetic and antioxidant activity. Furthermore, in streptozotocin and STZNA -induced mice, the concentration of *M. koenigii* leaves extract administration was proportional to its antioxidant activity. Pradhan *et al.*[73] compared photoprotective potential of five medicinal plants from Nepal throughout the course of a 21-day storage process in an *in vitro* UV spectrophotometry. From the results, methanolic *M. koenigii* shows sun protection activity toward Sun Protective Factor (SPF). According to Patil *et al.*,[74] found that less SPF level in a cream formulation consist of curry leaf oil. In addition, Pande *et al.* [72] revealed chloroform extract *of M. koenigii* leaves had photo-protective effect against UVB-induced

acute damage in an *in vivo* model. Based on the study, treatment of dermal damage with chloroform extract of *M. koenigii* leaves may reduce oxidative skin damage and significantly enhance enzyme SOD.[72]

CONCLUSION AND FUTURE PERSPECTIVES

This review article discussed ten commonly available medicinal plants in Malaysia that have demonstrated potential antioxidant properties and SPF values as mostly confirmed in *in vitro* studies. The results indicated that the medicinal plant extracts exhibit potent antioxidant activities due to most of these plant species rich of phenolic compounds and flavonoids. These compounds are beneficial in absorption of UV region and inhibit production of free radicals against harmful UV rays. Among the ten plant extracts reported in this review, the *M. indica* extracts has displayed a SPF value ≥30, which is considered high sun protective activity. The moderate photoprotection potential (SPF value ≥15) was found in extracts of *A. paniculata*, *M. citrifolia, C. sinensis* and *G. pictum*. *M. oleifera* and *S. caseolaris* exhibited low sun protective activity (SPF value ≤2). In the future, more *in-vitro* and *in-vivo* research will be needed to validate the safety and efficacy of all of these extracts for sun protection. Overall, this review recommends the possibilities in development of new innovative skin care cosmetic comprising these plant species such as sunscreen formulation that will be great important to the consumer demand, cosmetic industry and social economic. Nevertheless, further research needs to be discovered in development of cosmetics from these medicinal plants into formulations either alone or combination.

ACKNOWLEDGMENTS

The authors would like to thank Universiti Kuala Lumpur, Malaysia for the financial support provided *via* Short-Term Research Grant (STRG) Scheme (Ref: UniKL/CoRI/str18024). The authors also would like to thank Royal College of Medicine Perak, Universiti Kuala Lumpur, Ipoh, Perak, Malaysia for providing the necessary facilities and resources to complete the study. The figures in this manuscript were created with the support of https://biorender.com under a paid subscription

AUTHOR CONTRIBUTIONS

All the authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

FUNDING

The Universiti Kuala Lumpur, Malaysia, funded this study through the Short-Term Research Grant (STRG) Scheme (Ref: UniKL/CoRI/str18024).

DISCLOSURE

The authors have no conflicts of interest associated with the publication. There is also no significant financial support for this work.

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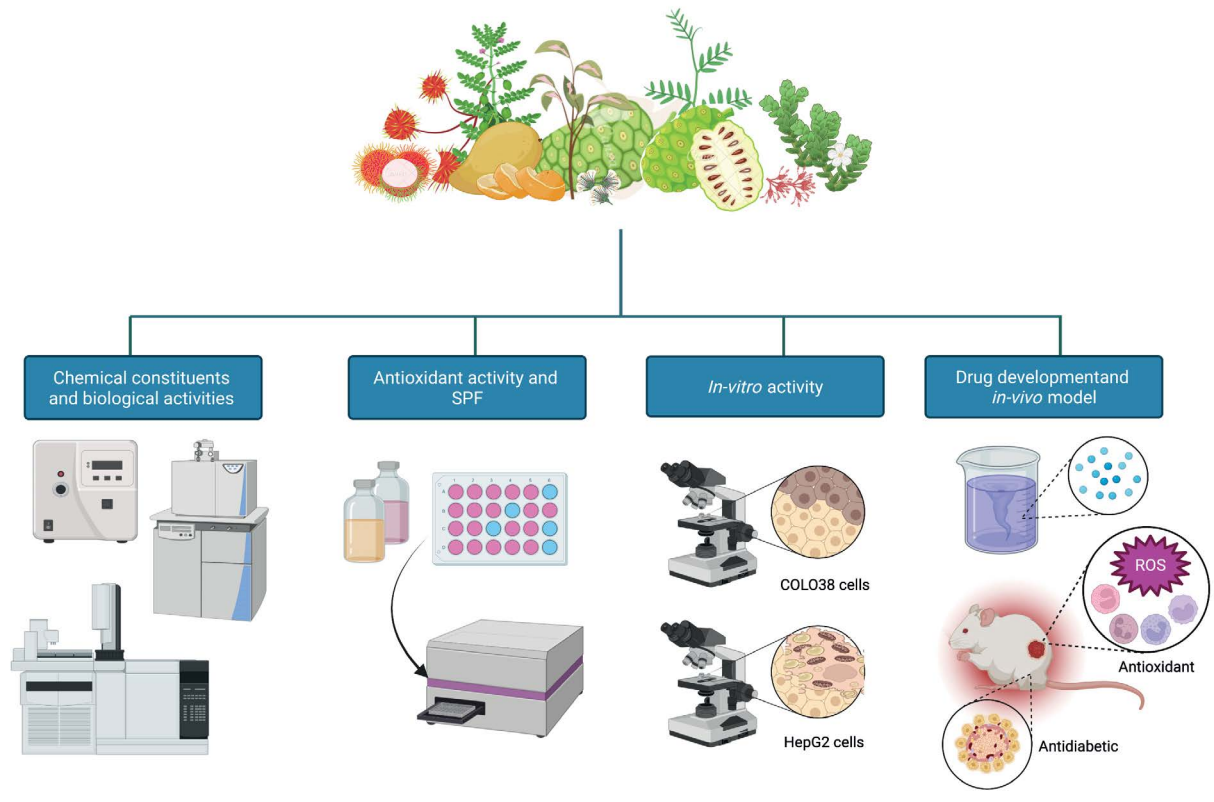
GRAPHICAL ABSTRACT



Cite this article: Ibrahim ND, Seow LJ, Sekar M, Rani NNIM, Lum PT. Ten Commonly Available Medicinal Plants in Malaysia with Potential Sun Protection Factor and Antioxidant Properties – A Review. Pharmacogn J. 2022;14(2): 444-455.