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A Review on Malaysian Plants Used for Screening of Antimicrobial Activity

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Authors' contributions

This work was carried out in collaboration between all authors. Author MA initiated the idea of writing this review article, supervised, made all the alignments, corrections and proof reading to the script, author PV studied and drafted most of article, Author KKC drafted the antimicrobial methods part and table, Author MMS helped in tabulating the entire data for table 1 and Author IHBAR helped in data collection and reference management. All authors read and approved the final manuscript.

Review Article

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ABSTRACT

Medicinal plants have very high potential as antimicrobial drugs for treating various human diseases. Although a number of plants have been screened, the search for antimicrobial substances from plants is continued as better and safer drugs to combat bacterial and fungal infections are still needed. Here, we attempted to summarize the antibacterial and antifungal properties of Malaysian medicinal plant extracts against a diverse range of organisms evaluated by disc diffusion and agar well diffusion techniques. Altogether, we provide information on a total of 93 medicinal plants used traditionally in Malaysia for antimicrobial screening during the last 4 years. We believe this combination of insights would provide information of medicinal plants (extracts) containing various secondary metabolites which are effective in controlling infectious diseases. This review also might be of great interest for researchers in isolation and separation of bioactive compounds existing in plant extracts by purification methods.

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1. INTRODUCTION

There is a long history of medicinal use of plants in South East Asian countries, some of which were marketed as semi-synthetic and synthetic drugs. This area is a most promising site for discovery of novel biologically active substances from its flora. In history, man has used these plants to treat common infectious diseases along with other maladies and especially certain plants had antimicrobial principles and were well accepted in daily use in both traditional medicine and modern medicine. Globally, infectious diseases are becoming a major health problem and also causing burden to individual and the nation. Especially microorganisms like bacteria, fungi and viruses are causing potential health problems and also affecting the economy of the country. According to World Health Organisation (WHO), 50,000 people per day are facing death due to these infectious diseases. This is becoming the major problem among developing countries as well as in developed countries. Most common pathogens for various infectious diseases are Vibrio cholerae, Salmonella species, Pseudomonas species and Klebsiella species.

A wide range of synthetic and semi-synthetic antimicrobial agents (AMA) are available in the market for the positive control of microorganisms. At the same time, resistance for the available AMAs is growing rapidly. Along with the resistance, these AMAs are also causing various adverse drug reactions like hypersensitivity, immunosuppression and depletion of beneficial gut and mucosal microorganisms [1]. Due to these unwanted effects of antibiotics, there is a continuous need in the development of newer antimicrobial agents which are most effective towards microorganisms and less harmful to the host. For centuries, plants are always the centre source in the treatment of many ailments. Throughout the globe, in every culture and tradition, plants are used as folklore medicine in treatment of several diseases. According to WHO in 1993 revealed that 80% of developed countries population use traditional medicine. The reason for the popularity of plants in traditional medicine is that they synthesize a vast range of organic compounds which are pharmacologically active. These organic compounds can be directly used as medicine or used as starting materials for the synthesis of new active compounds or as models for pharmacologically active compounds.

Malaysia is among the world's 12 mega biodiversity rich countries, especially in terms of its flora. More than 20,000 plants species are found in the wild having almost 2000 or more plants with medicinal properties which are being used in various traditional health care systems. Anti microbial compounds derived from plants are effective against microbes and have less side effects compared to synthetic antimicrobials [2]. The present review article focus on the various plants screened for their antimicrobial activities in Malaysia.

2. METHODS USED FOR SCREENING PLANTS

2.1 Preparation of Crude Plant Extracts

Plant extraction is carried out with different polar solvents with increasing polarity in order to separate the active moieties. The most commonly used solvent for the extraction were Distilled water, deionised water, hot water, Methanol, Ethyl acetate, Hexane, Chloroform, Dichloro methane, Acetone, ethanol, crude petrol and mixture of Chloroform and Methanol

(3:1) (Table 1). Finally the extracts are filtered and concentrated under reduced pressure using rotary flash evaporator. Collected residues were assayed for screening by taking different concentrations of extracts.

2.2 Antimicrobial Screening Methods

2.2.1 Disk diffusion

Disk diffusion method is most commonly used screening method for the screening of antimicrobial property among Malaysian plants. Susceptibility of test organism to the plant extract was determined by employing the standard disc diffusion technique. Whatman No.1 filter paper discs of 6 mm diameter, placed in dry petridish were autoclaved. Stock solutions (µl) of desired concentrations were applied to each sterilized filter paper disc (6 mm diameter) with the help of micro pipette. Later, the filter paper discs were dried on the laminar air flow bench and carefully placed over the spread cultures and incubated at 37℃ for 24 h for bacteria and 48 h for fungi. Antimicrobial standards such as nystatin (for fungi) and ciproflaxacin (for bacteria) alone served as standard. After incubation, the plates are observed for any zones of inhibition surrounding the disc. The observed marked zone of growth inhibition of bacteria and fungi were measured with the help of a scale and recorded. A zone of inhibition (a clear area) around the disc indicates that the compound, which diffused into the agar from the disc, inhibited the growth of the organism. The low cost and simple technique of disc diffusion bioassay is advantageous in the determination of the antimicrobial activity of crude drugs [3].

2.2.2 Agar well diffusion assay

This technique depends on the diffusion of the test solution (crude extracts) from a cavity through the solidified agar layer to an extent such that growth of the added microorganism is inhibited entirely in a circular area or zone around the cavity. Twenty millilitres of sterile molten agar medium (Luria broth for bacteria, Czapek Dox for fungi) was poured into a sterile Petri dish under aseptic conditions and was allowed to solidify. Likewise a series of agar plates were prepared. Then, each plate was inoculated with 100 µl of (18 h old bacterial and 48 h old fungal) axenic culture of 10^{-6} CFU/ml separately and was evenly spread with a sterile bent glass rod. The five agar wells (8 mm, diameter) were made equidistantly by cutting out the media using sterile broad end (7.5 mm) of micropipette tip, in order to load test solutions and are filled with different dilutions of an extract. Of these, the middle well was loaded with 100 µl of DMSO for each test organism was included as a control with the help of a micropipette. Whereas, the remaining four peripheral wells were loaded with the desired extract. Plates were incubated after 30 min in BOD digital incubator at 37℃ for a period of 24 h for bacteria and 48 h for fungi. After incubation, the plates were observed for the zones of inhibition surrounding each well. The observed marked zones of growth inhibition of bacteria and fungi were measured with the help of a scale (Hi-Media antibiotic zone scale) and the results were recorded. A zone of inhibition (a clear area) around the well indicates that the organism was inhibited by the extract, which diffused into the agar from the well.

However, these are not the perfect test to conclude the antimicrobial activity and correlate how the drug will act in vivo. Many other factors like first pass metabolism, drug resistance, microbial defence and patient's pathological conditions will also affect the sensitivity of the test. Other major screening methods used were minimum inhibitory concentration (MIC) 2-fold method in microtiter plate, hole plate diffusion method, MIC by Versa Max Tunable

microplate reader, MIC by using flat bottom tissue culture plate (96 well) and screening by agar well diffusion method. Only one group of researchers used very specific methods like MIC by tetrazolium microplate assay, MIC by serial dilution method, MIC by liquid dilution method and MIC by micro dilution method (Table 1).

Table 1. List of medicinal plants and their extracts used for the screening of antimicrobial activity against different microbes

S. No	Plant name	Extract	Method Used	Microbes used	Activity	Ref. No
1	*Abutilon indicum*	Ethanol	Screening by disc diffusion method	*Bacillus cereus* *Staphylococcus aureus* *Escherichia coli* *Pseudomonas aeruginosa* *Candida albicans*	+ + + + +	[4]
2	*Ajuga reptans*	Ethyl acetate Hexane Methanol Distilled water	Screening by disc diffusion method	*Bacillus subtilis* *Escherichia coli*	+ -	[5,6]
3	*Alpinia conchigera*	Dichloromethane	MIC by microtitre-plates method	*Methicillin resistant Staphylococcus aureus* *Methicillin sensitive Staphylococcus aureus* *Vancomycin intermediate resistant Staphylococcus aureus* *MRSA with intermediate resistance to vancomycin* *MRSA with complete resistance to vancomycin* *Candida albicans* *Microsporum canis* *Trichophyton rubrum*	+ + + + + + +	[7]
4	*Amaranthus tricolor*	Ethanol	Screening by disk diffusion method. MIC by flat bottom tissue culture	*Bacillus cereus* *Listeria monocytogenes* *Staphylococcus aureus*	+ - -	[8]

			plates (96 well)	*Vibrio para*	-	
				Escherichia coli	-	
5	*Andrographis paniculata*	Methanol water Chloroform	Screening by disk diffusion method. MIC by agar dilution method	*Staphylococcus aureus* Methicillin resistant	+	[9]
				Staphylococcus aureus	+	
				Staphylococcus saprophyticus	+	
				Staphylococcus epidermis	+	
				Bacillus anthracis	+	
				Micrococcus luteus	+	
				Streptococcus pyogenes	+	
				Enterococcus faecalis	+	
				Proteus mirabilis	+	
				Proteus vulgaris	+	
				Neisseria meningitis	+	
				Escherichia coli	-	
				Pseudomonas aeruginosa	+	
				Klebsiella pneumonia	+	
6	*Arytera littoralis*	Ethyl acetate Hexane Methanol Distilled water	Screening by disk diffusion method	*Bacillus subtilis*	+	[5,6]
				Escherichia coli	-	
7	*Bauhinia kockiana*	Ethyl acetate Hexane Methanol Distilled water	Screening by disk diffusion method	*Bacillus subtilis*	+	[5,6]
				Escherichia coli	-	
8	*Blechnum orientale*	Methanol	Screening by disk diffusion method	*Bacillus cereus*	+	[10]
				Micrococcus luteus Methicillin suceptable	+	
				Staphylococcus aureus Methicillin resistant	+	
				Staphylococcus aureus	+	
				Staphylococcus epidermis	+	
				Escherichia coli	-	
				Pseudomonas aeruginosa	-	

				Enterobacter aerogenes	-	
				Klebsiella pneumonia	-	
				Salmonella choleraesius	-	
9	*Brassica oleracea*	Methanol	Screening by disk diffusion method	*Staphylococcus aureus*	+	[11]
				Methicillin resistant *Staphylococcus aureus*	+	
				Escherichia coli	+	
				Pseudomonas aeruginosa	+	
				Bacillus subtilis	+	
				Klebsiella pneumonia	+	
				Salmonella typhi	+	
10	*Bruguiera gymnorrhiza*	Ethanol Methanol Chloroform	Screening by disk diffusion method	*Bacillus cereus*	+	[12]
				Staphylococcus aureus	+	
				Escherichia coli	+	
				Pseudomonas aeruginosa	+	
11	*Callistemon viminalis*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis*	+	[5,6]
				Escherichia coli	-	
12	*Calophyllum canum*	Hexane Dichloro methane Methanol	Screening by disk diffusion method, MIC by Versa Max™ Tunable micro plate reader.	*Bacillus cereus*	+	[13, 14]
				Staphylococcus aureus	+	
				Escherichia coli	-	
				Pseudomonas aerginosa	-	
				Candida albicans	-	
				Candida neoformans	-	
13	*Calophyllum depressinervosum*	Hexane	Screening by disk diffusion method, MIC by Versa Max™ Tunable micro plate reader.	*Bacillus cereus*	+	[13]
				Staphylococcus aureus	+	
				Escherichia coli	-	
				Pseudomonas aerginosa	-	
14	*Calophyllum rubiginosum*	Hexane Dichloro methane Methanol	Screening by disk diffusion method, MIC by Versa Max™ Tunable micro plate reader.	*Staphylococcus aureus*	+	[15]
				Escherichia coli	-	
				Bacillus cereus	+	
				Pseudomonas aeruginosa	-	
				Candida albicans	-	

				Candida neoformans	-	
15	*Calophyllum symingtonianum*	Hexane	Screening by disk diffusion method, MIC by Versa Max™ Tunable micro plate reader.	*Bacillus cereus*	+	[13]
				Staphylococcus aureus	+	
				Escherichia coli	-	
				Pseudomonas aerginosa	-	
16	*Calophyllum teysmanii*	Hexane	Screening by disk diffusion method, MIC by Versa Max™ Tunable micro plate reader.	*Bacillus cereus*	+	[13]
				Staphylococcus aureus	+	
				Escherichia coli	-	
				Pseudomonas aerginosa	-	
17	*Canna indica*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis*	+	[5,6]
				Escherichia coli	-	
18	*Cassia spectabilis*	Methanol Hexane Dichloro methane ethanol	Screening by disk diffusion method	*Staphylococcus aureus*	+	[16]
				Bacillus subtilis	+	
				Escherichia coli	+	
				Salmonella typhi	+	
				Pseudomonas aeruginosa	+	
				Candida albicans	+	
19	*Centella asiatica*	Methanol Water	Screening by hole-plate diffusion method, MIC by two fold dilution method in microtiter plate	*Bacillus subtilis*	+	[17]
				Escherichia coli	-	
				Aeromonas hydrophila	-	
				Citrobacter freundii	-	
20	*Cinnamomum iners*	Ethanol	Screening by disk diffusion method MIC by broth dilution method	*Bacillus* subtilis	+	[18, 19]
				Bacillus cereus	+	
				Salmonella typhi	+	
				Methicillin resistant Staphylococcus aureus	+	
				Escherichia coli	+	
				Pseudomonas aeruginosa	+	
				Shigella sonnei	+	
				Candida albicans	+	
				Saccharomyces cerevisiae	+	
21	*Cinnamomun*	Ethanol	Screening by	*Bacillus cereus*	-	[20]

	verum		disk diffusion method MIC by using sterile flat bottom tissue culture plates (96 well)	*Listeria monocytogenes* *Staphylococcus aureus* *Vibrio para* *Escherichia coli*	- - - -	
22	*Citrullus lanatus*	ethanol Hexane Chloroform	Screening by using cup-plate agar diffusion method	*Escherichia coli* *Staphylococcus aureus* *Pseudomonas aeruginosa* *Bacillus subtilis* *Proteus valgaris*	+ + + + +	[20]
23	*Clerodendrum paniculatum*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis* *Escherichia coli*	+ -	[5,6]
24	*Costus spicatus*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis* *Escherichia coli*	+ -	[5,6]
25	*Couroupita guianensis*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis* *Escherichia coli*	+ -	[5,6]
26	*Curcuma longa*	ethanol	Screening by hole-plate diffusion method, MIC by two fold dilution method in microtiter plate	*Bacillus cereus* *Listeria monocytogenes* *Staphylococcus aureus* *Vibrio para* *Escherichia coli*	- - - - -	[8]
27	*Cymbopogon citrate*	Essential oil	Screening by hole-plate diffusion method, MIC by two fold dilution method in microtiter plate	*Escherichia coli* *Salmonella* sp *Klebsiella pneumonia* *Staphylococcus aureus* *Streptococcus* sp *Bacillus subtilis* *Asperigillus niger* *Penicillum* sp. *Candida albicans*	- - - - - - - - +	[21]
28	*Dioscorea daemona*	Ethanol	Screening by disk diffusion method	*Bacillus cereus* *Staphylococcus aureus* *Escherichia coli* *Pseudomonas aerginosa*	+ + + -	[4]

				Candida albicans	+	
29	*Diospyros wallichii*	Ethanol Hexane Chloroform	Screening by disk diffusion method	*Bacillus cereus* *Staphylococcus aureus* *Pseudomonas aeruginosa* *Escherichia coli*	+ + - +	[22]
30	*Durio zibethinus*	Ethanol	Screening by disk diffusion method MIC by using sterile flat bottom tissue culture plates (96 well)	*Bacillus cereus* *Listeria monocytogenes* *Staphylococcus aureus* *Vibrio para* *Escherichia coli*	- - - - -	[8]
31	*Epipremnum* sp.	Methanol	Screening by disk diffusion method	*Staphylococcus aureus* *Bacillus subtilis* *Escherichia coli* *Pseudomonas aeruginosa* *Salmonella paratyphi*	- - - + -	[23]
32	*Erythrina glauca*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis* *Escherichia coli*	+ -	[5,6]
33	*Etlingera brevilabrum*	Methanol Ethyl acetate Hexane Distilled water Acetone ethanol	Screening by disk diffusion method	*Methicillin resistant Staphylococcus aureus* *Staphylococcus aureus* *Staphylococcus epidermidis* *Bacillus thuringiensis* *Vibrio parahaemolyticus*	+ + + + +	[24]
34	*Etlingera elatior*	Deionised water	Screening by disk diffusion method	*Pseudomonas aeruginosa* *Escherichia coli* *Salmonella chleraesuis* *Staphylococcus aureus* *Micrococcus luteus* *Bacillus cereus*	- - - + + +	[25]
35	*Etlingera fulgens*	Deionised water	Screening by disk diffusion method	*Pseudomonas aeruginosa* *Escherichia coli* *Salmonella*	- -	[25]

				chleraesuis	-	
				Staphylococcus aureus	+	
				Micrococcus luteus	+	
				Bacillus cereus	+	
36	*Etlingera maingayi*	Deionised water	Screening by disk diffusion method	*Pseudomonas aeruginosa*	-	[25]
				Escherichia coli	-	
				Salmonella chleraesuis	-	
				Staphylococcus aureus	+	
				Micrococcus luteus	+	
				Bacillus cereus	+	
37	*Etlingera rubrostriata*	Deionised water	Screening by disk diffusion method	*Pseudomonas aeruginosa*	-	[25]
				Escherichia coli	-	
				Salmonella chleraesuis	-	
				Staphylococcus aureus	+	
				Micrococcus luteus	+	
				Bacillus cereus	+	
38	*Euginia caryopyllis*	Essential oil	Screening by disk diffusion method	*Escherichia coli*	+	[26]
				Salmonella sp	+	
				Klebsiella pneumonia	+	
				Staphylococcus aureus	+	
				Streptococcus sp	+	
				Bacillus subtilis	+	
39	*Euphorbia hirta*	Methanol	MIC by tetrazolium microplate assay	*Escherichia coli*	+	[27]
				Klebsiella pneumniae	+	
				Enterobacter aerogens	+	
				Proteus mirablis	+	
				Proteus vulgaris	+	
				Proteus aeurginosa	+	
				Salmonella typhi	+	
				Shigella dysenteriae	+	
				Staphylococcus aureus	+	
				Bacillus subtilis	+	
				Asperigillus niger	+	
				Candida albicans	+	
				Candida		

				glabrata	+	
40	*Eurycoma longifolia*	Water	MIC by serial dilution method	Methicillin Resistant *Staphylococcus aureus*	-	[28]
				Enterococcus faecium	-	
				Klebsiella pneumoniae	-	
				Pseudomonas aeruginosa	-	
				Salmonella typhi	-	
				Asperigillus baumanii	-	
				Candida albicans	-	
				Candida glabrata	-	
				Candida krusei	-	
41	*Ficus deltoidea*	Methanol Water Chloroform	Screening by disk diffusion method	*Staphylococcus aureus*	+	[113]
				Bacillus subtilis	+	
				Escherichia coli	+	
				Pseudomonas aeruginosa	+	
				Candida albicans	+	
42	*Garcinia griffithii*	Methanol Hexane Dichloromethane	Screening by disk diffusion method, MIC by Versa Max™ Tunable micro plate reader.	*Staphylococcus aureus*	-	[109]
				Bacillus cereus	-	
				Escherichia coli	-	
				Pseudomonas aeruginosa	-	
43	*Garcinia prainiana*	Methanol Hexane Dichloromethane	Screening by disk diffusion method, MIC by Versa Max™ Tunable micro plate reader.	*Staphylococcus aureus*	-	[109]
				Bacillus cereus	-	
				Escherichia coli	-	
				Pseudomonas aeruginosa	-	
44	*Garcinia malaccensis*	Methanol Hexane Dichloromethane	Screening by disk diffusion method, MIC by Versa Max™ Tunable micro plate reader.	*Staphylococcus aureus*	-	[109]
				Bacillus cereus	-	
				Escherichia coli	-	
				Pseudomonas aeruginosa	-	
45	*Gynura procumbens*	Ethanol Water	Screening by agar well diffusion method	*Escherichia coli*	-	[29]
				Bacillus cereus	-	
				Salmonella typhi	-	
				Pseudomonas aeruginosa	-	
				Staphylococcus		

				aureus	-	
46	*Heliconia rostrata*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis* *Escherichia coli*	+ -	[5,6]
47	*Hymenocallis littoralis*	Methanol Ethyl acetate Hexane Distilled Water	Screening by disk diffusion method, MIC by broth dilution method	*Bacillus subtilis* *Escherichia coli* *Micrococcus*sp *Escherichia coli* *Bacillus subtilis* *Pseudomonas aeruginosa* *Salmonella* sp *Bacillus thuringiensis* *Proteus mirabillase* *Staphylococcus aureus* *Klebsiella pneumonia* *Candida albicans* *Asperigillus nigrer*	+ - + + + + + + + + + +	[5,6] [30]
		Chloroform : Methanol (3:1)				
48	*Ixora chinensis*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis* *Escherichia coli*	+ -	[5,6]
49	*Jatropha curcas*	Methanol Hot water	Screening by disk diffusion method	*Enterobacter aerogenes* *Micrococcus luteus* *Klebsiella pneuomoniae* *Escherichia coli* *Pseudomonas aeruginosa* *Bacillus cereus* *Bacillus subtilis* *Staphylococcus aureus*	+ + + + + + + +	[31]
50	*Lactuca sativa* var *capitata*	Ethanol Dichloromethane	Screening by disk diffusion method	*Escherichia coli* *Staphylococcus aureus* *Pseudomonas aeruginosa* *Streptococcus pyogenes* *Candida albicans*	- + - - -	[32]
51	*Lagerstomia loudonii*	Methanol Ethyl acetate	Screening by disk diffusion	*Bacillus subtilis* *Escherichia coli*	+ -	[5,6]

		Hexane Distilled water	method			
52	*Leucas aspera*	Methanol	Screening by disk diffusion method	*Escherichia coli*	+	[18]
				Staphylococcus aureus	+	
				Salmonella typhimurium	+	
				Salmonella choleraesuis	+	
				Shigella flexneri	+	
				Pseudomonas aeruginosa	+	
53	*Limnocharis flava*	Ethanol Dichloro Methane	Screening by disk diffusion method	*Escherichia coli*	-	[32]
				Staphylococcus aureus	+	
				Pseudomonas aeruginosa	+	
				Streptococcus pyogenes	+	
				Candida albicans	-	
54	*Ludwigia octavalvis*	Methanol Ethyl acetate Hexane Chloroform	Screening by disk diffusion method MIC by broth micro dilution bioassay in 96-well plates	*Bacillus cereus*	+	[33]
				Bacillus spizizenn	+	
				Bacillus licheniformis	+	
				Staphylococcus aureus	+	
				Staphylococcus epidermis	+	
				Streptococcus mutans	+	
				Shigella boydii	+	
				Escherichia coli	+	
				Klebsiella pneumniae	+	
				Pseudomonas aeruginosa	+	
				Pseudomonas stutzeri	+	
55	*Mangifera indica*	Ethanol Deionised water	Screening by hole-plate diffusion method, MIC by two fold serial agar dilution method	*Staphylococcus aureus*	+	[34]
				Escherichia coli	+	
				Bacillus cereus	+	
				Bacillus subtilis	+	
				Pseudomonas aeruginosa	+	
				Salmonella typhi	+	
				Streptococcus thermophiles	+	
				Lactobacillus acidophilus	+	
56	*Manihot esculenta*	Ethanol	Screening by disk diffusion	*Bacillus cereus*	-	[8]
				Escherichia coli	-	

			method MIC by using sterile flat bottom tissue culture plates (96 well)	*Listeria monocytogenes* *Staphylococcus aureus* *Vibrio para*	- - -	
57	*Melaleuca cajaputi*	Essential oil	Screening by disk diffusion method	*Escherichia coli* *Salmonella* sp *Klebsiella pneumonia* *Staphylococcus aureus* *Streptococcus* sp *Bacillus subtilis*	+ + - - - +	[21]
58	*Melastoma malabathricum*	Ethanol	Screening by disk diffusion method	*Staphylococcus aureus* *Escherichia coli* *Bacillus cereus* *Pseudomonas aeruginosa* *Candida albicans*	+ + + + +	[4]
59	*Mentha arvensis*	Ethanol Dichloro methane	Screening by disk diffusion method	*Escherichia coli* *Staphylococcus aureus* *Pseudomonas aeruginosa* *Streptococcus pyogenes* *Candida albicans*	- - + - -	[32]
60	*Mentha piperita*	Methanol	Screening by disk diffusion method	*Escherichia coli* *Acinatobacter* sp. *Staphylococcus* sp. *Candida albicans* *Candida glabrata*	+ + + + +	[35]
61	*Mesua grandis*	Methanol Dichloromethane Hexane	Screening by disk diffusion method, MIC by Versa Max™ Tunable micro plate reader.	*Staphylococcus aureus* *Bacillus cereus* *Escherichia coli* *Pseudomonas aeruginosa*	+ + - -	[13]
62	*Michelia champaca*	Methanol	MIC by two fold micro dilution method	*Aeromonas hydrophila* *Edwardsiella tarda* *Escherichia coli* *Flavobacterium* sp. *Klebsiella* sp.	+ + + + +	[36]

				Pseudomonas aeruginosa	+	
				Salmonella sp.	+	
				Vibrio alginolyticus	+	
				Vibrio cholerae	+	
				Vibrio parahaemolyticus	+	
63	*Molineria latifolia*	Ethanol	Screening by disk diffusion method	*Staphylococcus aureus*	+	[4]
				Escherichia coli	+	
				Bacillus cereus	-	
				Pseudomonas aeruginosa	+	
				Candida albicans	+	
64	*Muntingia calabura*	Chloroform, Methanol Water	MIC by liquid micro dilution method	*Methicillin suceptable Staphylococcus aureus*	+	[37]
				Methicillin resistant Staphylococcus aureus	+	
				Escherichia coli	+	
				Pseudomonas aeruginosa	+	
				Candida albicans	+	
				Microsporum canis	+	
65	*Mussaenda philippica*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis*	+	[5,6]
				Escherichia coli	-	
66	*Mussaenda flava*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis*	+	[5,6]
				Escherichia coli	-	
67	*Myristica fragrans*	Essential oil	Screening by disk diffusion method	*Escherichia coli*	+	[26]
				Salmonella sp	+	
			MIC by broth micro dilution bioassay in 96-well plates	*Klebsiella pneumonia*	+	
				Staphylococcus aureus	-	
				Streptococcus sp	-	
		Ethanol Ethylacetate		*Bacillus subtilis*	-	[38]
				Streptococcus mutans	+	
				Streptococcus mitis	+	

				Streptococcus salivarius	+	
				Aggregatibacter actinomycetemcomitans	+	
				Porphyromonas gingivalis	+	
				Fusobacterium nucleatum	-	
68	*Nephelium lappaceum*	Ethanol	Screening by disk diffusion method	*Listeria monocytogenes*	+	[8]
				Staphylococcus aureus	+	
			MIC by using sterile flat bottom tissue culture plates (96 well)	*Vibrio para*	+	
				Bacillus cereus	-	
				Escherichia coli	-	
69	*Orthosiphon aristatus*	Ethanol Methanol Water	Screening by agar well diffusion method	*Escherichia coli*	-	[17]
				Bacillus subtilis	+	
70	*Orthosiphon stamineus*	Ethanol Methanol Water	Screening by disk diffusion method	*Staphylococcus aureus*	+	[39]
				Streptococcus agalactiae	+	
				Escherichia coli	+	
				Klebsiella pneumonia	-	
71	*Phaleria macrocarpa*	Methanol	Screening by disk diffusion method	*Bacillus cereus*	+	[40]
				Bacillus subtilis	+	
				Micrococcus luteus	+	
				Staphylococcus aureus	+	
				Enterobacter aerogenes	+	
				Escherichia coli	+	
				Klebsiella pnuomoniae	+	
				Mucor indicus	-	
				Pseudomonas aeruginosa	+	
				Aspergillus niger	+	
				*Fusarium oxy*sporum	-	
				Ganoderma lucidum	-	
72	*Phyllanthus amarus*	Methanol Water	Screening by agar well diffusion method	*Salmonella typhimorium*	-	[41]
				Klebsiella oxytoca	-	
				Aeromonas hydrophila	-	
				Escherichia coli	-	
				Salmonella		

				paratyphi	-	
				Staphylococcus aureus	+	
				Yersinia enterocolitica	-	
				Bacillus cereus	+	
				Serratia marcescens	-	
				Bacillus niacini	-	
				Listeria monocytogenes	+	
				Bacillus arvi	-	
				Bacillus anthracis	+	
				Methylobacterium hispanicum	+	
73	*Phyllanthus niruri*	Methanol Water	Screening by agar well diffusion method	*Salmonella typhimorium*	-	[41]
				Klebsiella oxytoca	-	
				Aeromonas hydrophila	-	
				Escherichia coli	-	
				Salmonella paratyphi	-	
				Staphylococcus aureus	+	
				Yesinia enterocolitica	-	
				Bacillus cereus	+	
				Serratia marcescens	-	
				Bacillus niacini	-	
				Listeria monocytogenes	+	
				Bacillus arvi	-	
				Bacillus anthracis	+	
				Methylobacterium hispanicum	+	
74	*Phyllanthus urinaria*	Methanol Water	Screening by agar well diffusion method	*Salmonella typhimorium*	-	[41]
				Klebsiella oxytoca	-	
				Aeromonas hydrophila	-	
				Escherichia coli	-	
				Salmonella paratyphi	-	
				Staphylococcus aureus	+	
				Yersinia enterocolitica	-	
				Bacillus cereus	+	
				Serratia marcescens	-	

				Bacillus niacini	-	
				Listeria monocytogenes	+	
				Bacillus arvi	-	
				Bacillus anthracis	+	
				Methylobacterium hispanicum	+	
75	*Piper betel*	Ethanol	Screening by disk diffusion method	*Bacillus cereus*	+	[4]
				Staphylococcus aureus	+	
				Escherichia coli	+	
				Pseudomonas aerginosa	+	
				Candida albicans	+	
76	*Piper sarmentosum*	Ethanol	Screening by disk diffusion method	*Bacillus cereus*	-	[4]
				Staphylococcus aureus	+	
				Escherichia coli	-	
				Pseudomonas aerginosa	-	
				Candida albicans	+	
77	*Pithecellobium jiringa*	Methanol	Screening by disk diffusion method	*Pseudomonas aeruginosa*	+	[42]
				Salmonella typhi	+	
			MIC by liquid dilution method	*Staphylococcus aureus*	+	
				Bacillus subtilis	+	
				Klebsiella pneumoniae	+	
				Microsporum canis	-	
				Staphylococcus epidermidis	+	
				Microsporum gypsum	+	
				Trichophyton rubum	-	
				Candida albicans	+	
78	*Polygonum minus*	Methanol Ethanol Water	Screening by well diffusion method	*Escherichia coli*	-	[17]
				Bacillus subtilis	+	
79	*Premna cordifolia*	Ethanol Dichloro Methane	Screening by disk diffusion method	*Escherichia coli*	-	[32]
				Staphylococcus aureus	-	
				Pseudomonas aeruginosa	+	
				Streptococcus pyogenes	-	
				Candida albicans	-	
80	*Psidium*	Ethanol	Screening by	*Listeria*		

	guajava		hole-plate diffusion method, MIC by two fold dilution method in microtiter plate	*monocytogenes* *Staphylococcus aureus* *Vibrio para* *Bacillus cereus* *Escherichia coli*	- - - - -	[8]
81	*Psophocarpus tetragonolobus*	Ethanol Dichloro Methane	Screening by disk diffusion method	*Escherichia coli* *Staphylococcus aureus* *Pseudomonas aeruginosa* *Streptococcus pyogenes* *Candida albicans*	- - - - -	[32]
82	*Pluchea indica*	Ethanol Dichloro Methane	Screening by disk diffusion method	*Escherichia coli* *Staphylococcus aureus* *Pseudomonas aeruginosa* *Streptococcus pyogenes* *Candida albicans*	- - - - -	[32]
83	*Quercus infectoria*	Methanol Acetone	Screening by well diffusion method MIC by twofold serial micro dilution in 96-well microtiter plate	*Streptococcus mutans* *Streptococcus salivarius* *Porphyromonas gingivalis* *Fusobacterium nucleatum*	+ + + +	[43]
84	*Spathiphyllum cannifolium*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis* *Escherichia coli*	+ -	[5,6]
85	*Shorea acuminate*	Methanol	Screening by disk diffusion method	*Streptococcus pyogenes* *Staphylococcus aureus* *Bacillus subtilis* *Escherichia coli* *Candida albicans* *Aspergillus niger*	+ + - - - -	[44]
86	*Shorea macroptera*	Methanol	Screening by disk diffusion method	*Streptococcus pyogenes* *Staphylococcus aureus* *Bacillus subtilis* *Escherichia coli* *Candida albicans*	+ + + - -	[44]

				Aspergillus niger	-	
87	*Smilax* sp.	Methanol	Screening by disk diffusion method	*Staphylococcus aureus*	+	[23]
				Bacillus subtilis	+	
				Escherichia coli	+	
				Pseudomonas aeruginosa	+	
				Salmonella paratyphi	+	
88	*Solanum lycopersicum*	Ethanol Methanol Water	Screening by agar well diffusion method	*Escherichia coli*	-	[17]
				Bacillus subtilis	+	
89	*Sonneratia alba*	Methanol Ethyl acetate Hexane	Screening by disk diffusion method MIC by microdilution method	*Staphylococcus aureus*	+	[45]
				Bacillus cereus	+	
				Escherichia coli	+	
				Pseudomonas aeruginosa	-	
				Candida albicans	-	
				Candida neoformans	+	
90	*Syngramma alysmifolia*	Methanol	Screening by disk diffusion method	*Staphylococcus aureus*	-	[23]
				Bacillus subtilis,	-	
				Escherichia coli	-	
				Pseudomonas aeruginosa	-	
				Salmonella paratyphi	-	
91	*Syzygium samarangense*	Ethanol	Screening by disk diffusion method MIC by using sterile flat bottom tissue culture plates (96 well)	*Bacillus cereus*	-	[8]
				Escherichia coli	+	
				Listeria monocytogenes	-	
				Staphylococcus aureus	-	
				Vibrio para	+	
92	*Torenia fournieri*	Methanol Ethyl acetate Hexane Distilled water	Screening by disk diffusion method	*Bacillus subtilis*	+	[5,6]
				Escherichia coli	-	
93	*Vitex trifolia*	Ethanol	Screening by disk diffusion method MIC by using sterile flat bottom tissue culture plates (96 well)	*Bacillus cereus*	+	[8]
				Staphylococcus aureus	+	
				Listeria monocytogenes	+	
				Vibrio para	-	
				Escherichia coli	+	

3. PATHOGENIC ORGANISMS USED FOR THE SCREENING

The pure axenic cultures of bacteria and fungi screened for AMA of the plants (Table 2). Specifically, Gram positive organisms from *Bacillus*, *Staphylococcus* and *Streptococcus* were most commonly used. Most of these microorganisms are associated with inflammatory, skin infection, bowel disorders, meningitis, osteomyelitis and endocarditits. Gram negative organisms like E. coli, Klebsiella, Neisseria, Proteus, Pseudomonas, Salmonella and Shigella are used to screen the antimicrobial activity of Malaysian plants. These microorganisms were primarily associated with bowel disorders, meningitis, urinary tract infections, and respiratory tract infections. These organisms are further maintained on nutrient agar slants at 4℃ until further use.

Table 2. List of bacteria and fungi used against number of plants

Gram positive		Gram negative		Fungus and yeast	
Name of bacteria	**Number of plants used**	**Name of bacteria**	**Number of plants used**	**Name of fungi and yeast**	**Number of plants used**
Bacillus subtilis	21	*Escherichia coli*	91	*Asperigillus niger*	2
Bacillus cereus	41	*Klebsiella pneumonia*	13	*Asperigillus*	
Bacillus anthracis	4	*Klebsiella oxytoca*	3	*baumanii*	1
Bacillus		*Klebsiella* sp.	2	*Candida albicans*	28
thuringiensis	1	*Pseudomonas*		*Candida*	
Bacillus spizizenn	1	*aeruginosa*	42	*neoformans*	3
Bacillus		*Salmonella typhi*	12	*Candida glabrata*	3
licheniformis	1	*Salmonella paratyphi*	6	*Candida krusei*	1
Bacillus niacini	3	*Salmonella*		*Ganoderma*	
Bacillus arvi	3	*choleraesius*	1	*lucidum*	1
Staphylococcus		*Salmonella* sp	6	*Fusarium*	
aureus	51	*Vibrio para*	9	*oxy*sporum	1
Methicillin		*Vibrio parahaemolyticus*	2	*Microsporum*	
resistant		*Neisseria meningitis*	1	*canis*	3
Staphylococcus	8	*Shigella sonnei*	1	*Micro*sporum	
aureus		*Shigella flexneri*	1	*gypsum*	1
Methicillin		*Shigella boydii*	1	*Mucor indicus*	1
suceptable		*Aggregatibacter*		*Penicillum* sp	1
Staphylococcus	3	*actinomycetemcomitans*	1	*Saccharomyces*	
aureus		*Fusobacterium*		*cerevisiae*	1
Staphylococcus	4	*nucleatum*	2	*Trichophyton*	
epidermis		*Methylobacterium*		*rubum*	2
Vancomycin		*hispanicum*	3		
intermediate		*Enterobacter*			
resistant		*aerogenes*	3		
Staphylococcus	1	*Aeromonas hydrophila*	5		
aureus		*Citrobacter freundii*	1		
MRSA with		*Porphyromonas*			
intermediate	1		2		
resistance to		*gingivalis*	1		
vancomycin		*Proteus mirabilis*	2		
MRSA with	1	*Proteus vulgaris*	1		
complete		*Acinatobacter* sp	1		
resistance to	1	*Flavobacterium* sp	3		
vancomycin	1	*Yersinia enterocolitica*	3		
Staphylococcus		*Serratia marcescens*	5		

saprophyticus	9	*Aeromonas hydrophila*	1
Staphylococcus sp	3	*Pseudomonas stutzeri*	1
Streptococcus pyogenes	1	*Edwardsiella tarda*	
Streptococcus mutans	2		
Streptococcus thermophiles	5		
Streptococcus salivarius	1		
Streptococcus sp	1		
Streptococcus agalactiae	1		
Enterococcus faecalis	2		
Enterococcus faecium	1		
Micrococcus luteus	1		
Micrococcus sp	1		
Lactobacillus acidophilus	1		

4. MEDICINAL PLANTS USED FOR THE SCREENING OF ANTIMICROBIAL ACTIVITY

Abutilon indicum Linn. (Malvaceae) also known as *Sida indica* is called as country mallow or chinese bell flowers in English and kembang lohor/ sugudai in Malay. It is a shrub which can grow up to 2 m tall, which is native to California. It is rich in amino acids, contains gallic acid, caffeic acid, fumaric acid, β-sitosterone. The roots and seeds of the plants are used in treatment of many diseases like gastro intestinal diseases, respiratory diseases, genito-urinary diseases, skin diseases, leprosy, pulmonary tuberculosis, anuria and carbuncle. It has antidiabetic activity, hepatoprotective activity, anti-inflammatoryactivity, antimalarial activity, analgesic activity, immunomodulatory activity, antimicrobial activity and antioxidant activity [46]. In Malaysia it is used to treat fever, ulcers, dysuria and snake bite. In some areas in Terengganu, *A. indicum* is used by local residents to treat swollen skin and pre-stage cancers. The flowers are used to increase semen in men [47].

Ajuga reptans Linn. (Lamiaceae) is commonly known as bugle, blue bugle and carpenters weed. It is a perennial herb growing up to 0.3 m high, and is grown throughout the world as an ornamental plant mainly. It contains ferulic acid, *p*-coumaric acid, malonic acid, delphinidin, verbascoside and teupolioside. It is widely used as wound herb in early days; it has property of arresting haemorrhage, used in treatment of diseases like cough, throat infections and mouth ulcers. It has digitalis like action and hence can be used as cardio tonic. The plant is used in preparations of aromatic medicated oils. It has vasoconstrictor effect, antioxidant /oxygen scavenging activity, anti-inflammatory and wound healing property [48].

Alpinia conchigera Griff. (Zingiberaceae) commonly known as mussel galangal in English and lengkuas ranting, lengkuas kecil, lengkuas padang, lengkuas genting or chengkenam in Malay. It is a perennial herb grows to 0.7-1.7 m in height, found in India, Bangladesh, Myanmar, Thailand, Peninsular Malaysia and Sumatera. The rhizome is used as a

condiment and the young shoots are prepared into a vegetable dish. In folk medicine it is used to treat digestive problems, jaundice, fungal infections, stomach ache and as a post-partum medicine [49]. Chemical constituents of *A. conchigera* are β-sitosterol, stigmasterol, 1, 8-cineole, β-caryophyllene and flavonoids like cardamomin, alpinetinandnaringenin, 3, 5, 7-trihydroxyflavoneand 3, 5, 7-trihydroxy-40-methoxyflavone. It has gastro protective, antinociceptive, anti-inflammatory and anticancer activity [50].

Amaranthus tricolor Linn. (Amaranthaceae) commonly known as josephs coat in English is an annual and perennial herb native to South America and grown widely in South Eastern Asia. It is an ornamental plant generally reaching a height of 1m; the leaves of the plant are used in preparation of salads and used as vegetable. It contains carotene, thiamine, ascorbic acid, methionin and riboflavin. It is generally used in cases of constipation, urinary retention, anaemia, oedema, reduced eye sight, diuretic, menorrhagia, haemorrhage and hepatoprotective agent [51]. It has antioxidant, antimicrobial and antiproliferative property [52].

Andrographis paniculata (Burm.f.) Wall. ex Nees (Acanthaceae) is commonly known as king of bitters in English and hempudu bhumi in Malay. It is an annual erect herb growing up to a height of 0.3-1.1 m, found in tropical Asia. It contains terpenoids like andrographolide, neoandrographolide and many more like andrographine, panicoline and paniculide-A, B, C. The plant is used for many medicinal uses, as it has antityphoid, antibacterial, antifungal, hepatoprotective, antioxidant, antibiotic, antimalarial [53], anti inflammatory, anti snake venom, anti cancer [54] and anti pyretic properties. In Malaysia the plant has been extensively used as traditional medicine as that help against fever, dysentery, diarrhea, inflammation, and snake bite.

Arytera littoralis Blume. (Sapindaceae) is a small evergreen tree or rarely shrub growing to 3-10 m tall, usually found in Malaysia and Singapore. In Malaysia it is locally used for making rough baskets and grown as shade trees in parks. It is also used for medicinal purpose as it has the anti bacterial activity.

Bauhinia kockiana Korth. (Fabaceae) commonly known as kock's bauhinia is a flowering climber. These are perennial trees which typically grow to a height of 6-12 m, native of peninsular Malaysia. The chemical constituents are bauhinin, bauhinilide and dehydrodicatechin A. It is used in the treatment of dysentery, vuneral disease, and leprosy. It also has anti-oxidant and anti bacterial activities [55].

Blechnum orientale Linn. (Blechnaceae) is commonly known as centipede fern in English and paku lipan in Malay. It is perrenial herb and may be tree fern reaching 0.3-0.5 m tall. It is found in India, Nepal, South China, South East Asia, Australia and Polynesia. The fronds of the plants are used as vegetable and rhizome is grounded and used in making a kind of unleavened bread. It contains flavones like luteolin, apigenin, acacetin and flavonols quercetin, kaempferol and isorhamnetin. It has immunomodulatory, anthelmentic, antioxidant, anticancer, antibacterial and wound healing properties [56]. It is used for various skin diseases, stomach pain and urinary bladder problems.

Brassica oleracea Linn. (Brassicaceae) commonly known as wild cabbage in its non cultivated form and cultivated forms are called as cabbage, broccoli and cauliflower in English and kubis in Malay. It is a perinneal herb and often annual, biennial plant growing upto a height of 1-2 m and grown as a vegetable in many countries. It consists of β-

carotene, vitamin C, allyl isothiocyanate and norisoprenoids. It has clinical benefits, which has cancer preventive properties [57], anti-inflammatory and antidiabetic activity.

Bruguiera gymnorrhiza (Linn) Lam. (Rubiaceae) is called black mangrove in English. It is a small tree growing up to 10 m high native to many countries of Asia, Southern and Eastern Africa. It contains oleanolic acid, septadecanoic acid, daucosterol, triacontanol and stigmasterol. It usually has astringent property and also used in the treatment of malaria, diarrhea and fever [58]. It has antioxidant and antimicrobial properties.

Callistemon viminalis (Gaertn) G. Don. (Myrtaceae) is commonly known as weeping bottle brush in English. It is a perennial shrub or small tree usually growing to a height of 8 m native to Australia and grown in many countries as an ornamental tree. It contains 1, 8-cineole, α-pinene, α-phellandrene and α-terpineol. It has anti microbial, antifungal activity and used to treat diarrhea, gastro-enteritis, haemorrhoids and skin infections [59]. In Malaysia, it is used as a traditional medicine used to cure worm infections.

Calophyllum canum Hook.f. ex T.Anderson. (Guttiferae) is called as santa maria in English. It is an evergreen tree growing from 7.5 - 36 m tall and native to Madagascar, Eastern Africa, South and Southeast Asia, Pacific islands. It contains amentoflavone, quercetin, gallic acid, protocatechuic acid and calophynic acid. It has antioxidant, antibacterial and anticancer properties [60].

Calophyllum depressinervosum M. R. Hend. & Wyatt-Sm. (Guttiferae) is a medium to large tree reaching up to 25 m tall and native to Madagascar, Eastern Africa, South and Southeast Asia from Pakistan East to Vietnam and also found growing throughout Malaysia. It contains xanthones, coumarins, biflavonoids, chalcones, benzofurans and triterpenes. It has quasi-medicinal uses which are found to possess anti human immunodeficiency virus property. In Malaysia, it is traditionally used as it has free radical scavenging and antibacterial activities.

*Calophyllum macrocarpum*Hook.F. (Guttiferae) is commonly called as bintangor rimba, bentangur batu, bunut and buru in Malay. It is emergent tree growing up to 60 m tall and native to Madagascar, Eastern Africa, South and Southeast Asia and widely grown in many countries. It contains xanthones, coumarins, biflavonoids, chalcones, benzofurans and triterpenes. The latex of *C. macrocarpum* is said to have medicinal uses, and the ethanol extract has the antimicrobial activity and is used as a local medicine in Malaysia.

Calophyllum rubiginosum M. R. Hend. & Wyatt-Sm. (Guttiferae) is known as bintangor duan karat in Malay. It is a medium sized tree growing up to a height of 40m and is distributed from Southern Malay Peninsula to Sumatra and Borneo. The wood of the tree is used for construction purposes and latex is used to kill vermin's because of its poisonous nature. It contains xanthones, coumarins, biflavonoids, chalcones, benzofurans and triterpenes. It has antioxidant, cytotoxic [61] and antimicrobial activities.

Calophyllum symingtonianum M.R.Hend. & Wyatt-Sm. (Guttiferae) commonly known as bitangor bukit in Malay, and is present in Tropical Asia and in Peninsular Malaysia. It is an evergreen broad-leaved growing 12 - 39 m tall distributed in the Malay Peninsula. It contains xanthones, coumarins, biflavonoids, chalcones, benzofurans and triterpenes. It have antioxidant, anti fungal [62] and anti human immunodeficiency virus activities.

Calophyllum teysmanii Miq. (Guttiferae) a small to big tree growing up to 33 m in height; present from Malay Peninsula to Borneo. The wood is used for construction purposes. It

contains xanthones, coumarins, biflavonoids, chalcones, benzofurans and triterpenes. It has antiviral and anti HIV properties [63].

Canna indica Linn. (Cannaceae) is commonly known as indian shot in English. It is a perennial plant native to tropical America and Caribbean grows up to a height of 1.5 m and it is grown as garden plant mostly. The roots of the plants are cooked to produce canna starch; the plant is used medicinally as demulcent, diaphoretic, diuretic, antidiabetic and also used as insecticide. It contains β-eudesmol, δ-cadinol, α-selinene, luciferin and palmitic acid. It has hepatoprotective, antioxidant, antinociceptive, antihelmentic [64], antimicrobial and HIV reverse transcriptase inhibiting properties.

Cassia spectabilis DC. Irwin et Barn. (Leguminoseae) commonly known as calceolaria shower, Cassia in English and kasia kuning in Malay. It is a medium to large deciduous tree with 7-10 m in height, is native to Tropical America grown as an ornamental plant. The plant is mainly used as shading and ornamental plant. The plant contains 3-*O*-acetylspectaline, spectaline, iso-6-spectaline and 7-hydroxyspectaline. It has laxative, antiinflammatory, analgesic, antimicrobial, antifungal, antioxidant [65] and antiulcerogenic property.

Centella asiatica (L.) Urban. (Apiaceae) is commonly known as centella, asiatic pennywort in English and pegaga in Malay. It is an annual small herbaceous plant creeping on the soil, is a native to India, Sri Lanka, Malaysia, Indonesia, Northern Australia and other parts of Asia. The plants have culinary uses like preparation of salad, juice and medicinal uses in healing wounds; along with this it has mild adaptogen, antibacterial, antiviral, antinociceptive, anti-inflammatory [66], anxiolytic [67], antidepressant, diuretic and sedative properties. The important chemical constituents in *C. asiatica* are centic acid, cenellic acid, brahmoside, brahmic acid, brahminoside, asiatic acid and asiaticoside.

Cinnamomum iners Reinw. ex Blume. (Lauraceae) commonly known as wild cinnamon in English and Kayu manis in Malay is an evergreen tree growing to a height of 20-30m distributed in India, Southeast Asian countries like Cambodia, Indonesia, Malaysia, Philippines, Thailand, Vietnam and Laos. The bark and leaves are used for preparation cinnamon oil which is used as flavouring agent. Various parts of the plant are used for various medicinal uses like fever, rheumatic poultice intestinal and urinary complications and flatulence. It contains β-saponins, terpenes, caryophyllene, cinnamic aldehyde and eugenol. It has antidiarrheal, analgesic, antipyretic [68], anticancer, antioxidant and antimicrobial activities.

Cinnamomun verum J. Presl. (Lauraceae) also known as ceylon cinnamon in English. It is evergreen tree 10-15 m tall, native to India, Bangladesh and Sri Lanka, seen in Colombia, Dominica, Fiji, Haiti, Indonesia, Malaysia and Philippines. Oil from the bark is used in meat and fast food seasoning. It contains cinnamaldehyde, cinnamyl acetate, eugenol and anethole. The medicinal uses of cinnamon bark oil include apetite stimulation, treatment of arthritis, inflammation and dyspepsia. It has nematocidal, antioxidant [69], immunomodulatory and anti microbial properties.

Citrullus lanatus (Thunb.) Matsum. & Nakai. (Cucurbitaceae) is most commonly known as water melon in English and tembikai in Malay. It is a perennial creeper native to Africa and cultivated throughout the world. The pulp of the fruit contains 6% sugars and 92% water, the pulp contains lycopene, β carotene, citrulline and vitamin C. The rind is used as vegetable in some areas and used in alcoholic poisoning and diabetes [70]. The juice has mildly diuretic

and antihypertensive action. The seed is demulcent, diuretic, vermifuge and tonic. The plant also has antibacterial, antifungal, antacid and carminative properties [71].

Clerodendrum paniculatum Linn. (Verbenaceae) is known as pagoda flower in English and pangil-pangil or panggil-panggil in Malay. It is a shrub growing to height of 0.9-1.5 m found throughout tropical parts of Southeast Asia and largely grown as an ornamental plant in many countries. It contains clerodermic acid, cleroinermin, friedelin, oleanolic acid, gramisterol and obtusifoliol. It has many medicinal properties like anti pyretic, antioxidant, anti inflammatory [72] and antiviral activity. It is used to treat sore eyes, urinary tract, gonorrhea and kidney problems. In traditional Malay medicine it is used as purgative and applied to stomach externally.

Costus spicatus Jacq. (Costaceae) is known as indian head ginger or spiked spirlaflag ginger in English. It is an herbaceous plant growing to height of 2 m native to South America and Caribbean. It contains costunolide, costic acid, kaempferide 3-*O*-neohesperidoside and quercetin 3-*O*-neohesperidoside. It has medicinal properties like antinociceptive, anti inflammatory action, it is used to treat diabetes. In folk medicine it is used to treat cold, dysentery, diarrhea, sore throats, urethra and kidney complaints [73].

Couroupita guianensis Aubl. (Lecythidaceae) is commonly called as ayahuma or cannon ball tree in English. It is an evergreen tree grows up to 25m in height, is a native to South America and India. It contains α-amirin, β-amirin, β-sitosterol, eugenol, linalool, (E, E)-farnesol and nerol. The tree is used to treat common cold, stomach pain, skin diseases, tooth ache, hypertension, malaria and tumours. It has antifungal, antimicrobial, antiseptic analgesic, antinociceptive, immunomodulatory and wound healing activites [74].

Curcuma longa Linn. (Zingiberaceae) is commonly called as turmeric in English and kunyit in Malay. It is herbaceous perennial plant growing to a height of 1 m native to tropical parts of South Asia. The leaves of the plants are used in preparation of curries and sweets. The powder of rhizome is widely used as a spice, food additive and colouring agent. It contains curcumin, α-turmerone, β-turmerone, β-ocimene, α-phellantrene, terpinolene and 1,8-cinceole. It is used as cosmetic in many countries in skin tanning and in removal of facial hair. It is used in dying of robes and saris. It has many medicinal properties and used in treatment of cancer, arthritis, diabetes and pancreatitis. It has antiinflammatory, anticoagulant, antiferility and antitumor activities [75].

Cymbopogon citrates (DC.) Stapf. (Gramineae) is commonly known as lemon grass in English and sakumau in Malay. It is evergreen herb growing to a height of 1 m, native to Southeast Asia. It is used in curries as a flavouring agent. The Essential oil of lemon grass contains citronellol, citral, geranilol and citronellal. It has antihypertensive, anxiolytic, hypnotic, anticonvulsant, anti malarial and antimutagenicity properties [76].

Dioscorea daemona Roxb. (Dioscoreaceae) is commonly known as ubi gadong in Malay. It is a perennial herb which is widely distributed in South America, Africa, Australia, Southeast US and Mandalay. It contains dioscorine and 4-epidioscorine. Its tuber is useful to treat ulcer, to kill worms in wounds. It is found to have antimicrobial activity. In Malaysia it is used to stop nose bleeds and treat pimples [77].

Diospyros wallichii King & Gamble (Ebenaceae) is a mid-canopy tree that grows at a height of 32 m at annual temperature of 27C. In secondary forests it is usually present as a pre disturbance remnant plant, distributed in India, Burma, Thailand, Peninsular Malaysia,

Sumatra and Borneo. It contains gallic acid, methylgallate, ellagic acid, kaempferol and quercetin. It has cytotoxicity, antimicrobial and antioxidant activity [78].

Durio zibethinus Murray. (Bombacaceae) is commonly called as civet fruit in English and durian in Malay. It is a tree which grows to a height of 27-40 m in the wild. It is native to Southeast Asian countries like Thailand, Malaysia, and Indonesia and cultivated in Sri Lanka, South East India, and some parts of Australia and Africa. It contains palmitic acid, palmitoleic acid, stearic acid and linoleic acid. In Malaysia it is used to prescribe as an antipyretic and poultice [79]. It is found to have anti oxidant property and as it has the property of inhibition of aldehyde dehydrogenase enzyme; it has potential use in disease preventive diets.

Epipremnum sp (Araceae) is commonly called as golden pothos, golden pothos vine and pothos in English. It is an annual herb which is widely grown in the areas of Australia, Spain and Singapore. It contains alkaloids, flavonoids, tannins and sterols. It is used in rheumatism, fractures, dentistry, piles, mixed with honey and applied to wounds and abscesses. It has medicinal properties like anti-inflammatory, analgesic, anti- lipid peroxidative, antimicrobial and anticancer properties [80].

Erythrina glauca Willd. (Fabaceae) is commonly called as sunshine tree, purple coral tree and dedap in Malay. It is a large spreading tree of height 10-15 m which grows at the annual temperature of 16-24℃ distributed in North America , South America, South east Eurasia, South east Africa and Asia. It contains erysodine, erysovine, erysonine, erythratine, erythramine and N-norprotosinomenine. It has anti HIV antiviral, antibacterial, antimalarial and estrogenic activity. It is used to treat head ache, kidney problems and inflammation [81].

Etlingera brevilabrum (Valeton) R.M.Sm. (Zingiberaceae) is an annual herb which is commonly found in the areas of Thailand, Malaysia and Indonesia and distributed from India to Pacific islands. In Malaysia it is used in various herbal coffees and in local dishes. The aerial parts of the stolons, stems and leaves are said to have different medicinal uses. It contains eucalyptol. β-pinene, caryophyllene oxide, α-thujene, limonene and β-pinene. In Malaysia it is used to treat sore eyes, stomach pain and applied to diseased skin [82].

Etlingera elatior (Jack) R. M. Sm. (Zingiberaceae) is commonly called as torch ginger, pink spider in English and bunga kantan in Malay. It is a perennial herb that grows up to 6 m tall. It is native to the pluvial forests of Borneo. Its flower is often used in Malaysian salads. It contains β-pinene, 1-dodecene, 1, 6-octadien-3-ol and 3, 7-dimethyl cinnamaldehyde. It is used to treat ear ache and cleaning wounds. It has several pharmacological properties such as antimicrobial, antioxidant and cytotoxic activity [83].

Etlingera fulgens (Ridl.) C.K.Lim. (Zingiberaceae) is an annual to perennial herb growing to a height of 4-5 m native to Tropical South Asia. It has various traditional and commercial uses as food. It contains cyclododecane, dodecanol and cyclotetradecane. It has anti oxidant and tyrosinase inhibition properties. It is used as ornamental plant. In Malaysia, it is used as spice for local fish dishes. It has antioxidant and antibacterial property [84].

Etlingera maingayi (Baker) R.M.Sm. (Zingiberaceae) commonly called as Malay rose. It is an herbaceous perennial plant growing to 2 m tall originated from Central Asia, Southern Thailand and Peninsular Malaysia. It is used as ingredient in the local Malaysian dishes. It contains lauric acid, hexadecanol, dodecanol and decanoic acid. It has antioxidant, anti fungal and antibacterial properties [84].

Etlingera rubrostriata (Holttum) C.K.Lim (Zingiberaceae) is a perennial herb that exists at variable height and size. It is found in Thailand and Peninsular Malaysia and used in the local dishes. It contains terpene-4-ol, α-terpineol and dodecanoid acid. The leaves have the antimicrobial and antioxidant activity [85].

Euginia caryophyllus (Spreng.) Bullock & S. G. Harrison. (Myrtaceae) is commonly called as clove, tropical myrtle in English. It is an evergreen tree growing to 8-12 m tall, native to Indonesia and widely spread in Asia, Africa and Europe to Mediterranean mountainous region. It is used traditionally in the treatment of infections in Malaysia. It contains acetyl eugenol, beta-caryophyllene, methyl salicylate, eugenin and campesterol. It has medicinal use such as anti stress property, antioxidant, antibacterial, antipyretic, anticandidal, local anaesthetic, antiviral [86] and aphrodisiac property [87].

Euphorbia hirta Linn. (Euphorbiaceae) is commonly called as asthma plant, hairy spurge, garden spurge in English and ara tanah, gelang susu in Malay. It is usually annual or perennial herb which has low spreading stems and leaves grows up to 0.3 m found in Java, Sumatra, Peninsular Malaysia and Philippines. It contains afzelin, quercitin, myricitin, kaempferol, camphol, rhamnose and chtolphenolic acid. It has anxiolytic, antioxidant, anticancer, anti microbial, antifungal, antimalarial, antihelmentic, antihypertensive, analgesic, antipyretic and anti-inflammatory properties [88]. It is used traditionally for female disorders, respiratory ailments such as cough, asthma, bronchitis. In Malaysia it is used to treat skin disorders, gastrointestinal disorders, particularly intestinal parasitosis, amoebic dysentery, diarrhoea and ulcer.

Eurycoma longifolia Jack. (Simaroubaceae) is commonly called as tongkat ali, dong quai in Malay. It is a perennial unbranched tree or shrub that grows up to about 10 m tall native to Indonesia and Malaysia, usually found in Southeast Asia. It contains eurycomanone, eurycomanol, eurycomalactone and canthine-6-one alkaloid. It has been used as a medicinal herb in Southeast Asia mainly to increase libido and to a lesser extent to improve general health. It is found to possess anti cancer, anti malarial and antimicrobial property. It is used traditionally to treat various diseases such as urinary tract infection, cancer, hypertension, indigestion, fever and itchiness. It is used as food and drink additive, in Malaysia it is used to increase male virility [89].

Ficus deltoidea Jack. (Moraceae) is commonly called as mistletoe fig in English and mas codec in Malay. It is small perennial herb, growing up to about 2 m tall which is native to Malaysia. It contains mortenol, vitexin, isovitexin, phthalicacid, carbonic acid and butanoic acid. It has antidiabetic [90] and antinociceptive property. Malays used it traditionally to treat ailments such as wounds, sores, joint pains, piles pain and rheumatism. It is used for regulating blood pressure, reducing cholesterol, treatment of migraine and improving blood circulation.

Garcinia griffithii T. Anderson. (Guttiferae) is commonly called as apple kandis or kandis gajah in Malay. It is a medium sized tree growing to a height of 12-18 m which is found in Asia, India, Sri Lanka, Malaysia, Myanmar and Thailand. It contains guttiferone I, cambogin, 1, 7-dihydroxyxanthone and isoxanthochymol. It has antimicrobial activity, antimalarial, antiplatelet, cytotoxic and cardio protective properties [91].

Garcinia malaccensis Hook. f. (Guttiferae) commonly called as forest mangosteen, saptrees in English and manggis burung, manggis hutan in Malay. It is evergreen tree growing to a

height of 24 m native to peninsular Malaysia, Sumatra and Borneo. It contains α- and β-mangostin and cycloart-24-en-3β-ol. It has antioxidant, antimicrobial, anticancer, apoptotic [92] and antiplatelet aggregation properties.

Garcinia prainiana King. (Guttiferae) commonly called as button mangosteen in English and kecupu in Malay. The tree grows for about 2-10 m tall, found in Thailand and Borneo and native to Malaysia. It contains friedelin, euphanol, prainianonide, stigmasterol, taraxerone and taraxerol. It is locally used as anti inflammatory agent in Malaysia. The seeds are used in food colouring and in cosmetics. It has antimicrobial activity, antiplatelet, antioxidant and cardio protective properties [91].

Gynura procumbens (Lour.) Merr. (Asteraceae) is commonly called as leaves of the gods, googoolipid in English and sambung nyawa in Malay. It is an annual evergreen shrub which is found in Southeast Asia especially Malaysia, Indonesia and Thailand, that may grow to 1 m high. It contains alkaloids, glycosides, and flavonoids like quercetin, kaempferol and kaempferol-3-O-β-D-glucopyranoside. It is said to have antihyperlipidimic, anti-inflammatory [93], antioxidative, anti-ulcerogenic, anticancer, anti-diabetic and hypoglycaemic activity. It is used to treat eruptive fevers, migraine, constipation, dysentery, rheumatism, cardiovascular diseases, hyperlipidemia, kidney disease, cancer and leukaemia.

Heliconia rostrata Ruiz & Pavon (Heliconiaceae) is commonly called as lobster claw, hanging helicon, false bird of paradise in English. It is an herbaceous perennial shrub reaching 1-3 m tall which is native to the north western region of South America. In Malaysia it is used in local dishes and also used as ornamental. It is used as traditional medicine against fever and dysentery.

Hymenocallis littoralis (L.f. ex Salisb.) Salisb. (Amaryllidaceae) is commonly called as beach spider lily in English. It is a perennial herb which ranges in height from 0.6-0.7 m, native to coastal regions of Southern Mexico and Central America; this is used as ornamental as well as medicinal plant. The bulb is used in wound healing. It contains lycorine, hippeastrine, 11-hydroxyvittatine, quercetin 3'-O-glucoside and rutin. It has antimicrobial, antioxidant [94], antitumor and anticancer properties [95].

Ixora chinensis Lam. (Rubiacea) is commonly referred to as Jungle Flame, Needle Flower in English and pechah priok in Malay. It is a woody perennial shrub growing to 2m tall which is native to China and usually found in South Carolina, Malaysia, Burma, Vietnam, Borneo, Philippines and northern Australia. It contains α–cyperone, linalool, α–pinene, β-pinene, α–copaene, oleanolic acid, ursolic acid, ixoric acid, ixoside and sitosterol. It has ethno medical uses also used to treat sores, ulcers, tuberculosis, bronchial disorders, headache, hypertension and diarrhoea [96]. In Malaysia decoction of root is used after child birth and is also used for ornamental purpose.

Jatropha curcas Linn. (Euphorbiaceae) is commonly called as physic nut tree, purging nut tree and barbados nut in English. It is semi-evergreen shrub or small tree, growing to a height of 6 m and a native of Central America. It contains nobiletin, β-sitosterol, taraxerol, jatropholone-A, B and caniojane. The oil of the plant is used as biodiesel, the oil possess medicinal properties and used as purgative, skin diseases, rheumatism and paralysis. The seeds have abortificient property and used as contraceptive. In Malaysia the leaves are cooked and eaten, it is also used as ornamental, and as bio diesel for energy. The fruit of this plant has been widely used in holistic medicine. It has analgesic, anticancer,

anticoagulant, antidiabetic, antifertility, antihelmentic, anti-inflammatory, antimicrobial, antiviral, cytotoxic and wound healing properties [97].

Lactuca sativa L. var *capitata* (Asteraceae) commonly referred as garden lettuce, letisi, head lettuce, cabbage lettuce and butter-head lettuce in English. It is a leafy annual or perennial herb native to Mediterranean region, cultivated around the world as leafy vegetable. It contains vitamin A, lutein and β-carotene. It is used exclusively as a fresh, raw salad vegetable in Malaysia. It is used to treat pain, rheumatism, tension, nervousness, coughs and insanity. Extracts of the plant are used as skin creams. It has antimicrobial and antioxidant property [98].

Lagerstroemia loudonii Teijsm. & Bin (Lythraceae) is commonly known as thai bungor. It is small to medium multiple-trunked tree growing up to a height of 10-20 m, native of Burma and Thailand. Its bark and leaves are used as a tonic, especially for debility after child birth. Its roots are used for stomach problems.

Leucas aspera (Willd.) Linn. (Labiateae) commonly referred as White Dead Nettle in English, which is usually found throughout India. It is a small erect, much branched annual herb that grows up to 0.6 m tall. It contains an alkaloid called margosin in its leaf and barks which is a well known blood purifier along with maslinic acid, macelignan, acacetin. This herb is also used in food to provide fragrance to food. It has antipyretic, antifungal, antimicrobial, antioxidant and antinociceptive [99] properties. It is used as stimulant, expectorant, diaphoretic and anti-helmenthic. In Malaysia the leaves are usually applied locally in snake bites.

Limnocharis flava (L.) Buchenau (Limnocharitaceae) commonly known as yellow sawah lettuce, yellow burr head or yellow velvetleaf in English and paku rawan in Malay. It is a perennial aquatic herb roughly growing to 0.5 m tall seen in Cambodia, Vietnam, Brunei, Singapore, Thailand, Indonesia and Malaysia. It contains phenols and flavanoids. It has antioxidant properties [100] and it also has the capability to increase nutrient availability in body to maintain our health.

Ludwigia octavalvis (Jacq.) PH Raven (Onagraceae) commonly called as mexican primrose willow in English and buyang samalam, lakom ayer in Malay. It is annual or perennial herbs that grow up to 2-4 m tall found throughout the world. It contains beta-sitosterol, oleanolic acid, luteolin, quercetin, apigenin, gallic acid and ellagic acid. In Malaysia it is used to treat boils, dermatitis, ulcers, pimples [101] and it is also said to have herbicidal and other medicinal properties like antimicrobial and antioxidant activity. Decoction of the plant is used to treat diarrhea and flatulence.

Mangifera indica Linn. (Anacardiaceae) commonly referred to as mango in English and mangga in Malay. It is an evergreen tree which has a height of 10-40 m, native to South Asia and now cultivated in tropical parts around the globe. It contains mangiferin, alanine, glycine, γ-aminobutyric acid, kinic acid and shikimic acid. It possesses antidiabetic [102], antioxidant, antibacterial, antifungal, antihelmintic, antitumor, antiviral, cardio tonic, hypertensive, anti-inflammatory properties. Its bark is used in treatment of dysmenorrhea, menorrhagea, and other menstrual disorders and eczema. This is an herb that is commonly used in the ayurvedic medicine. Its leaves and fruits are ritually used for floral decorations.

Manihot esculenta Crantz. (Euphorbiaceae) commonly called as uca, tapioca, mandioca in English. It is a tall semi-woody perennial shrub or tree that grows up to 7 m high native to

South America and found throughout the tropics. In Malaysia it is used as a food and medicinal plant. It contains alkaloids, anthocyanosides, flavonoids, tannins, reducing sugars and anthraquinone. It is used to treat diseases like treat hypertension, headache, irritable bowel syndrome, cancer, diarhhea and loss of appetite. It has analgesic, antiinflammatory [103], antimicrobial and antioxidant properties.

Melaleuca cajaputi Adans. (Myrtaceae) is commonly called as five-veined paperback, broad-leaved tea-tree, melaleuca, cajeput-tree, white bottlebrush in English and kampong gelam or kayu putih in Malay. It is a perennial tree which grows for about 8-12 m, found in Malaysia, India, Jamaica, Martinique, Montserrat, Netherlands Antilles, Philippines, etc. leaves are used to prepare cajeputi oil or tea tree oil which has medicinal and antiseptic uses. In Malaysia it is used locally for minor wounds, muscle ache and massage. It is also used to treat cold, headaches, in relieving pain, rheumatism, this oil improves mood and it increases the resistance to infections. It contains 2-pyridone, nerolidol, limonene, terpineol and valeric acid. It has insect repellent, fumigant and contact toxicity properties [104] and antimicrobial, antioxidant, hepatoprotective and anticancer activity.

Melastoma malabathricum Linn. (Melastomataceae) is commonly known as bank's melastoma, malabar melastome in English and senduduk in Malay. It is annual, biennial, perennial shrub or tree that grows upto 1.5 to 5 m tall, found in India, Malaysia, Indonesia, and Southeast Asia. It contains asiatic acid, ursolic acid, kaempferol, quercetin and ellagic acid. In Malaysia it is used traditionally to treat wounds, post-natal care, stomach ulcers, dysentery and diarrhoea, its roots are used as mouthwash to relieve from toothache or to treat leprosy. It possesses antinociceptive, anti-inflammatory, antipyretic [105], anti-ulcerogenic, antihelmintic, antispasmodic, antibacterial and hypertensive effects.

Mentha arvensis Linn. (Lamiaceae) commonly called as field mint, corn mint, and japanese mint in English. It is an annual or perennial herb growing to 0.5 m long seen in Europe, Western Asia. It contains limonene, cadinene, dimethyl sulphide, sabinebe and terpinoline. It has anaesthetic, antispasmodic, antiseptic, aromatic, anticandidial, antiulcer [106] and anti-inflammatory property. In Malaysia it is used for anti viral property and to treat stomach pain, thirst, swellings, headaches, diarrhoea, cold and fevers.

Mentha piperita Linn. Emend. Huds. (Lamiaceae) commonly called as watermint or peppermint in English. It is a perennial plant which grows to a height of 0.3-0.9 m native to Europe. It is widely used in the manufacturing of toothpaste, chewing gum, and other pharmaceuticals as a flavouring agent. It contains menthone, menthyl acetate, menthofuran, 1,8-cineol, limonene, pulegone and eucalyptol. It also has several medicinal uses such as analgesic, used to treat nausea, vomiting, abdominal pain, indigestion and irritable bowel syndrome. The oil extracted from the leaves is used in aroma therapy. It has antiviral, antibacterial, antibiofilm, antifungal, antiodema, analgesic and antioxidant activities [107].

Mesua grandis (King) Kosterm (Guttiferae) is commonly referred to as ceylon ironwood in English and penaga bayan, penaga sabut in Malay. The tree grows up to 33 m tall, seen in wet zone of Sri Lanka, Borneo and Malaysia. In Malaysia its seeds are used for poulticing wounds and were also tested to have free radical scavenging property. It contains cudraxanthone G, ananixanthone and euxanthone. It has anti diarrhoeal, antimicrobial and antioxidant property and also used in ayurvedic medicine for arresting bleeding.

Michelia champaca Linn. (Magnoliaceae) commonly called as fragrant champaca, golden champa, orange chempaka, yellow champa in English and chempaka, cempaka

merah, cempaka kuning and jampaka in Malay. The tree is an evergreen or semi deciduous grows up to 30 m height native to India and found in Indo-China, Malaysia, Sumatra, Java, and south-western China. It contains anonaine, asimilobine, nuciferine, anolobine, vanillin, vanillic acid, syringic acid and romerine. The oil produced is used as a perfume, and medicinally it has antidiabetic, antimicrobial, anti tumour, antipyretic, anti inflammatory and wound healing [108] properties. It is used for its astringent, disinfectant, diuretic and cooling properties and in parasitic infections, dysuria and diseases due to vitiated blood.

Molineria latifolia (Dryand. ex W.T.Aiton) Herb. ex Kurz. (Hypocedaceae) commonly called as palm grass in English and lemba in Malay. It is annual or perennial shrub or tree that grows to a height of 3-3.5 m. It is a native of Native of Indo-China, Myanmar and Malaysia. In Malaysia they are used for traditional purposes and to treat cough, stomach ache, wounds. It is also used in the treatment of kidney disorders, headaches, ulcers and swellings. It has antimicrobial and antioxidant properties [109].

Muntingia calabura Linn. (Elaeocarpaceae) is commonly called as jamaican cherry, panama berry in English and ceri kampung in Malay. It is a small flowering tree growing to a height of 7-12 m native to Mexico, Central America, Carebbean islands and Southern America. The fruits are used in preparation of jams and eaten. It contains vitamin C, vitamin E, carotenoids, glutathione, flavonoids and phenolic acids. It has antiplatelet aggregation [110], antihypertensive [111], antinociceptive, cytotoxic antiseptic, antidiarrhoeal and also antidiabetic property. In Malaysia it is traditionally used to relieve various pain related ailments.

Mussaenda philippica A. Rich (Rubiaceae) is commonly known as white mussaenda, musaenda aurora, tropical dogwood and virgin tree in English. It is an evergreen shrub that grows to a height of 3-5 m. It has several medicinal uses and also used for several ailments like stomach ache, influenza and bleeding gums [112].

Mussaenda flava (Rubiaceae) is commonly known as dwarf yellow mussaenda, white wings in English. It is a perennial shrub that grows for about 0.7 – 1.5 m, usually found in Tropical Africa, Asia and Malaysia. In Malaysia it is used for commercial propagation and ornamental. It contains mussaenoside, shanzhiside methyl ester, melilotoside and dihydromelilotoside. It has several medicinal properties like astringent, expectorant, and used in the treatment of jaundice, gastric ulcers, etc.

Myristica fragrans Houtt. (Myristicaceae) commonly called as nutmeg, mace in English and bah pale in Malay. It is an ever green tree growing to around 5-13 m high indigenous to Indonesia and cultivated in Malaysia, India and Caribbean Islands. It contains asinine, α-pinene, α-phellandrene and terpinen-4-ol. It is used as stomachic, stimulant, carminative as well as for intestinal catarrh and colic, headaches, diarrhea, vomiting, nausea, fever, bad breath, to stimulate appetites and to control flatulence. It is used to treat rheumatism and stomach complaints in Malaysia and Indonesia. It has properties such as hypolipidemic, hypocholesterolemic, antimicrobial, antifungal, antioxidant, anti inflammatory, anticonvulsant, disease preventing properties, anticancer [113] and aphrodisiac properties [87]. Nutmeg is used as spice, in bakery and confectionery items. Nutmeg oil stimulates the heart and circulation and activates the mind.

Nephelium lappaceum Linn. (Sapindaceae) is commonly known as rambutan in both English and Malay is a tropical evergreen tree growing to a height of 12-20 m native to Indonesia and Malaysia and seen in Southeast Asia. The trees are cultivated in many places to

produce fruits. The fruits are consumed whole after removing the cover, the seeds are bitter in taste. The fruit wall is rich in tannins and used for dying silk. The seed kernel is used in production of oil and rambutan tallow used for making soaps and candles. It contains ellagic acid, corilagin and geraniin. The fruit have medicinal properties like astringent, stomachic, febrifuge, antihelmintic, antioxidant and antibacterial activities. It is taken in conditions of diarrhoea and dysentery. In Malaysia the roots of the plant are used as decoction in treating fever and as febrifuge, bark is used as an astringent [114].

Orthosiphon aristatus (Blume) Miq. (Lamiaceae) is commonly known as cat whiskers or java tea in English and miasi kucing in Malay. It is a perennial herb growing to a height of 0.45-0.6 m native to Indonesia, grown throughout Southeast Asia and Australia. It contains orthosiphol A and B, orthosiphonone A and B, cirsimaritin, myoinositol, flavanoids, lipoproteins, saponins and terpinoids. The leaves and roots of the plant are used for treating cough, syphilis, arteriosclerosis, diabetes, hypertension, albuminuria, kidney stones and inflammation of the kidney. It has anti allergic, antihypertensive [115], anti-inflammatory & diuretic properties.

Orthosiphon stamineus Benth. (Lamiaceae) is commonly known as cat whiskers or java tea in English and miasi kucing in Malay. It is a shrub growing to a height of 1.5 m native to Southeast Asia. It contains sinensetin, eupatorin, caffeic acid and rosmarinic acid. It is used for treating kidney disorders and urinary disorders, to treat gout, diabetes, hypertension and rheumatism. It has anti-inflammatory, analgesic, antipyretic [116], antimicrobial and antioxidant activities.

Phaleria macrocarpa (Boerl.) Scheff. (Thymelaceae) is commonly known as gods crown in English and mahkota dewa in Malay. The trees can grow to height of 5 m native to Indonesia. It contains phalerin, mangiferin, kaempferol, myricetin, naringin and quercetin. It is used to control cancer, impotency, haemorrhoids, skin diseases, and it has anticancer, antidiabetic, antihypertensive, antihyperlipidimic and vasorelaxative properties [117].

Phyllanthus amarus Schum. & Thonn. (Euphorbiaceae) is commonly known as dukung anak in Malay. It is an annual herb growing to a height of 0.15-0.6 m widely in tropical parts of the world except in Australia. It contains phyllanthine, hypophyllanthine, quercetin, quercertrin, isoquercitrin and astragalin. The plant is used as astringent, diuretic, in treatment of skin diseases, jaundice, dysentery and liver diseases. It is traditionally used to treat kidney and gall bladder diseases, liver related diseases and viral infection. It has antiviral, antibacterial, antiplasmodial, anti-inflammatory, antimalarial, antimicrobial, anticancer, antidiabetic, hypolipidemic, antioxidant, hepatoprotective, and diurectic properties [118].

Phyllanthus niruri Linn. (Euphorbiaceae) is commonly known as stonebreaker or seed-under-leaf in English. It is herb growing to height of 0.5-0.7m native to Asia and found in tropical parts of the world. It contains phyltetralin, cymene, hypophyllanthin and ricinoleic acid. It has antilithic, antihypertensive, anti-HIV, antioxidant and hepatoprotective property [119]. The plant is used in treatment for diseases of stomach, genitourinary system, liver, kidney and spleen. It is useful in treating asthma, bronchitis, hiccups, leprosy and in snake bite.

Phyllanthus urinaria Linn. (Euphorbiaceae) is commonly known as chamber bitter, gripe weed or stone breaker in English and dukung anak in Malay. It is an herb reaching to a height of 0.6 m native to Asia and found in tropical parts of USA. It contains isostrictiniin, geraniin, gallic acid and ellagic acid. It stimulates excretory system, used to treat diabetes,

hypertension and hepatitis. It has anticancer [120], antiaging, antimicrobial and hepatoprotective properties.

Piper betel Linn. (Piperaceae) is commonly known as betel in English and daun sirih in Malay. It is an evergreen perennial vine native to Southeast Asia. The leaf is consumed as paan in Southeast Asian countries; it is used medicinally to cure worms, as stimulant, carminative, aphrodisiac, and antiseptic. It contains caryophyllene, cadinene, γ-lactone, allyl catechol, *p*-cymene and eugenol methyl ether. Betel juice is taken to treat cough and night blindness. It has anticancer, antibacterial, gastroprotective, antioxidative, hepatoprotective and immunomodulatory property [121].

Piper sarmentosum Roxb. (Piperaceae) is commonly called as wild betel leaf in English and pokok kadok, daun kadok in Malay. It is an herb growing to a height of 0.3-0.8 m native to Southeast Asian countries and China. It contains beta-sitosterol, stigmasterol, sarmentine, sarmentosine and pellitorine. It has antidiabetic, antioxidant, antibacterial, antiprotozoal, antimalarial activity. It is used to treat diarrhoea, dysentery, ulcers, cough, asthma, rheumatism, malaria and fungoid dermatitis. The leaves are used as digestive tonic, carminative and expectorant. It has antituberculosis, antiplasmodial and antidiabetic [122] effect.

Pithecellobium jiringa (Jack) Prain. (Leguminoseae) is commonly known as soaking tree in English and jering in Malay. It is native tree of Malaysia and Thailand growing to a height of 25 m. It contains flavonoids, terpenoids, alkaloids, vitamin E, allyl sulphur and some fatty acids. In Malaysia it is traditionally used to induce urination, chest pains, skin ailments, wounds and cuts. It has hypoglycemic, antiulcer, antioxidant and antianginal [123] activity.

Polygonum minus Huds. (Polygonaceae) is commonly known as knotweed in English and kesum in Malay. It is an herb growing to a height of 1-1.5 m native to Southeast Asian countries like Malaysia, Thailand, Vietnam and Indonesia. It contains dodecanal, undecanal, tetradecanal, 1-undecanol, nonanal, 1-nonanol, and β-caryophyllene. It increases digestion and decreases dandruff. It is used in preparation of aromatic oils used in aroma therapy. In Malaysia it is used to treat gastric disorders and dandruff. It has antioxidant, antiviral, antifungal, antibacterial and antiulcer activity [124].

Premna cordifolia Roxb. (Lamiaceae) is commonly called as wild beast in English and bebuas in Malay is a shrub growing to a height of 2-4 m is distributed in India, china, Burma, Thailand, Malaysia. It is used to treat fever and asthma. It contains isorhamnetin, methylquercetin and apigenin- 7- O- rutinoside. In Malaysia it is used in cooking and in medicinal uses like increasing breast milk and expulsion of worms in children. It has antioxidant [125], hypoglycemic and anti inflammatory property.

Psidium guajava Linn. (Myrtaceae) is commonly known as guava in English and jambu burung, jambu padang in Malay. It is small evergreen tree growing up to 5-10 m in height, native to Mexico, Caribbean and South America is grown in many parts of the world as a fruiting tree. It contains guaijavarin, quercetin, hexenal, β-caryophyllene, nerolidol and limonene. It is used to treat diabetes, gout, kidney problems and skin diseases. It has astringent, anticough, antimicrobial, antidiarrhoeal, anti inflammatory, antispasmodic, antimalarial, hypoglycemic and antioxidant activity [126].

Psophocarpus tetragonolobus (Linn.) DC. (Fabaceae) is commonly known as winged bean or Goa bean or four angled bean in English and kacang botol in Malay. It is an herbaceous

perennial vine growing to a height of 3-4 m native to Southeast Asian countries. It is commonly used as vegetable, the young leaves, tubers and pods are edible and used in various preparations. It contains lysine, aspartic acid, glutamic acid and leucine. It has antifungal, antimicrobial, antidiabetic and antihypertensive property [127].

Pluchea indica Less. (Asteraceae) is commonly called as indian camphor weed in English and beluntas in Malay. It is a small shrub growing to 2 m in height wide spread to Asia. The leaves and roots are used medicinally in bad breath, fever, increase of appetite, gastro intestinal disorders, tuberculosis and arthritis. It contains quercetin-3-*0*-sulphate, 3-O-caffeoylquinic acid 3, 4-0-dicaffeoylquinic acid, *β*-sitosterol and stigmasterol. In Malay traditional medicine the plant is considered to have astringent, febrifuge, stomachic, antipyretic and tonic like actions. It is used to treat gynaecological diseases. It has antioxidant, anticancer, antiinflamatory, antisnakevenom [128], antituberculosis, antiulcer and antiviral activity.

Quercus infectoria Olivier. (Fagaceae) commonly called as nut gall or gall in English and biji manjakani in Malay. It is an evergreen shrub growing to a height of 1.8 m found in Southern Europe and East Mediterranean regions. The seeds of the plant are edible and used in many preparations like bread, stews. It contains gallotanic acid, gallic acid ellagic acid, starch and sugar. The bark is used as astringent in treatment of impetigo and eczema. The galls are rich in tannins and have antidiabetic, antibacterial, antifungal, anti inflammatory, antiviral and antiseptic actions. They are used in treatment of haemorrhages, diarrhoea, dysentery, gonorrhoea and pharangytis. In Malay traditional medicine the galls are used to treat wound infections [129] after child birth, to restore postpartum uterine elasticity and also stimulate the contraction of vaginal muscles.

Shorea acuminata Dyer. (Dipterocarpaceae) is commonly known as light red meranti in English and meranti rambai duan in Malay. It is endemic tree growing up to a height of 45-60 m native to Malaysia. It contains oligostilbinoids, acuminatol, mangiferonic, 2α-hydroxyursolic and asiatic acids. Essential oils extracted from the tree posses antioxidant [130] and antimicrobial activities.

Shorea macroptera Dyer. (Dipterocarpaceae) is commonly known as meranti melantai in Malay. It is a tall tree widely distributed in Southeast Asia. It contains oligostilbinoids, hopeaphenol, isohopeaphenol and hemsleyanol. The plant has anti bacterial anti oxidant and cytotoxic properties [131].

Smilax sp (Liliaceae) is commonly known as greenbriar, catbriar in English. It is woody vine native to Jamaica, Honduras, Costa Rica and Mexico. The plant roots are used for its medicinal activities. It has anti-inflammatory, antirheumatic, antifungal [132], carminative and diaphoretic action. It is used to treat chronic rheumatism, gout, chronic inflammatory disease, colds, fever, ring worm and psoriasis.

Solanum lycopersicum Linn. (Solanaceae) is commonly known as tomato in English and Malay. It is a perennial herbaceous plant reaching to a height of 1-3 m native to America grown throughout the world as a vegetable plant. The fruit of the plant is used in preparations of various food items around the world, in some places it is eaten raw as other normal fruits. It contains carotenoids, vitaminC, quercetin glycosides, naringenin chalcone and chlorogenic acid. The fruit is rich in lycopene which is a powerful antioxidant decreases the risk of cancers. Using of tomatoes decreases the risk of breast cancer, head and neck

cancers [133], heart disorders, diabetes and difficulties in urination. The fruit pulp is used as face pack and face wash for oily skin.

Sonneratia alba J. Smith. (Sonneratiaceae) is commonly known as mangrove apple in English and perapat in Malay. It is mangrove tree growing to height of 20 m native to east Africa, China, India, Sri Lanka, South East Asia and South East Australia. The leaves and fruits of *S. alba* are edible, it has medicinal uses and used to treat cuts, bruises, sprains, swellings and cough. It contains flavonoids, tannins, triterpenes, anthraquinones, alkaloids and saponins. It has antimicrobial, antidiabetic, antioxidant and cytotoxic [134] activity.

Spathiphyllum cannifolium (Dryand.) Schott. (Araceae) is commonly known as spathe flower or peace lilly in English and keladi wangi, bendera putih in Malay. It is a perennial herb growing to height of 0.4 - 0.7m native to South America and Caribbean islands. It is grown as ornamental plant in many parts of the world. It contains flavonoids, lipids like stigmasterol. *Syngramma alysmifolia* (Polypodiaceae) is commonly known as panah arjuna in Malay. It is a perennial herb growing to height of native to Malaysia. Roots are boiled and water after boiling is taken for spiritual energy.

Syzygium samarangense (Blume) Merr. & Perry. (Myrtaceae) is commonly known as love apple, java apple, royal apple or bell fruit in English and Jambu air in Malay. It is a tropical tree growing to height of 12 m native to peninsular Malaysia and Andaman and Nicobar islands, now widely grown in the tropical areas. It contains stercurensin, cardamonin, reynoutrin, hyperin, myricitrin, quercitrin, quercetin and guaijaverin. It has immunomodulatory, antidiabetic [135], antioxidant and anti inflammatory activities.

Torenia fournieri Lind. (Scrophulariaceae) is commonly known as wishbone flower or torenia in English. It is a perennial herb growing to height of 0.3-0.5 m native to Asia. It contains acteoside, luteolin-7-O- β -glucoside and apigetrin. It has antimicrobial property and antioxidant property [136].

Vitex trifolia Linn. (Labiatae) is commonly known as simple leaf chaste tree in English and lemuni in Malay. It is a large shrub growing to height of 5m native to east Africa and Asia. It contains β-sitosterol, β-sitosterol-3-O-glucoside casticin and, 3, 6, 7-trimethylquercetagetin. It is used to treat fever. It has larvicidal, antioxidant, antimicrobial, anti inflammatory [137], cytotoxic, hepatoprotective and wound healing activities.

4. DISCUSSION

Malaysia is rich in its biodiversity and has hundreds of flora in which around 100 plants are used as traditional medicinal plants and many more are used in general folklore medicine. In this article we provided information on a total of 93 plants listed which were used for antimicrobial screening in the last 4 years in Malaysia. The plants were reviewed to produce additional information like their traditional uses, phytochemical constituents and pharmacological properties. Majority of the plants screened for antimicrobial properties have been used in either traditional medicine or as food. Most of the plants have shown antimicrobial activity except *Cinnamomun verum, Curcuma longa, Durio zibethinus, Eurycoma longifolia, Garcinia griffithii, Garcinia prainiana, Garcinia malaccensis, Psidium guajava, Psophocarpus tetragonolobus, Pluchea indica* and *Syngramma alysmifolia* as per the used extracts and microbes. The critical analysis of research data shows that most of the screening was carried out using *Escherichia coli* (against 91 plants), *Bacillus cereus* (41 plants) *Pseudomonas aeruginosa* (42 plants) and *Staphylococcus aureus* (51 plants), but

there was no notable research on dreadful microbes like *Salmonella typhi* (12 plants), *S. paratyphi* (6 plants) and *Mycobacterium tuberculosis* (no plants) (Table 2) while only few plants were screened on bacteria causing skin diseases like *Andrographis paniculata, Alpinia conchigera* and *Myristica fragrans* and *Quercus infectoria* for oral disorders.

So far majority of the researchers focused only on preliminary screening and determination of Minimum inhibitory concentration (MIC) of plant extracts which is not so importantly useful to mankind in treating and controlling the diseases to a major extent. As these extracts contain many compounds along with the active compounds may cause side or toxic effects. Hence future research should be focused on the isolation and identification of active compounds with antimicrobial activity rather than simply screening the plant crude extracts. In addition researches should take indepth studies to know the mechanism of action of drug so that it is beneficial for drug discovery and development. Novel methods also have to be adopted that would help to enhance the biosynthesis of secondary products, so that the prevention of further loss of plants can be augmented with yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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