CHEMICAL COMPOSITION AND BIOLOGICAL PROPERTIES OF *Etlingera elatior* Jack. (TORCH GINGER) INFLORESCENCE

By

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LIST OF ABBREVIATIONS / SYMBOLS

DPPH	2,2-diphenyl-1-picrylhydrazyl
FRAP	Ferric reducing/ antioxidant power assay
TPTZ	2,4,6-tris(2-pyridyl)- 5-triazine
MIC	Minimum inhibition concentration
MBC	Minimum bacterial concentration
ppm	Parts per million
rpm	Revolutions per minute
mg GAE/ 100 g DW	Milligram gallic acid equivalent per 100 g dry weight
mg QE/ 100 g DW	Milligram quercetin equivalent per 100 g dry weight
mg CE/ 100 g DW	Milligram catechin equivalent per 100 g dry weight
mg c-3-gE/ 100 g DW	Milligram cyanidin-3-glucoside equivalent per 100 g dry weight
TP	Total phenol content
TF	Total flavonoid content
MUFA	Monounsaturated Fatty Acids
PUFA	Polyunsaturated Fatty Acids
ADA	American Dietetic Association

CVD	Cardiovascular diseases
BC	Before Christ
USDA	United States Department of Agriculture
FDA	Food and Drug Administration

KOMPOSISI KIMIA DAN SIFAT BIOLOGI *Etlingera elatior* Jack. (BUNGA KANTAN)

ABSTRAK

Etlingera elatior Jack. (bunga kantan) dianalisis dari segi komposisi kimia dan ciri biologi (antioksidan dan antimikrob) bagi mengenalpasti potensinya sebagai sumber nutraseutikal. Penilaian dijalankan dengan menggunakan sistem pelarut yang berbeza [metanol, aseton (50%, 90% dan 100% v/v) dan air suling] untuk mengekstrak beberapa komponen antioksidan (jumlah fenol, tanin, flavonoid, dan antosianin) dan aktiviti antioksidan (peratus DPHH aktiviti perencatan radikal dan kuasa penurunan asei antioksidan ferik (FRAP)). Daripada semua pelarut yang digunakan, ekstrak aseton 50% menunjukkan jumlah fenol tertinggi (687.0 mg GAE/100g) dan jumlah flavonoid (1431 mg QE/100g) manakala 50% ekstrak metanol menunjukkan perolehan antosianin (5.9 mg c-3-gE/100 g). Pengekstrakan tanin didapati paling tinggi dengan 100% methanol (467.8 mg CE/100 g). Analisis dengan kromatografi gas-spektrometri massa (GC-MS) mengenalpasti konstituen kimia yang terkandung dalam minyak pati bunga yang diekstrak dengan menggunakan kaedah penyulingan hidro terdiri daripada 55 komponen iaitu 19 yang utama dan 37 adalah unsur surih. Minyak pati mengandungi terutamanya alkohol (44.25%) terdiri daripada 1-dodecanol (25.17%), hexadecen-1-ol dan trans-9 (12.73%), yang merupakan agen antimikrob yang diketahui. Asid laurik merupakan komponen antimikrob yang menyumbang kepada 20.4% asid dalam minyak pati. Dodekanal merupakan aldehid yang digunakan dalam industri wangian meliputi 17.5% dalam minyak ini. Didapati minyak pati dan ekstrak pelarut menunjukkan aktiviti antibakteria terhadap bakteria Gram-positif bakteria (*Bacillus cereus, B. subtilis, Staphylococcus aureus, Listeria*

monocytogenes). Daripada kumpulan bacteria Gram-negatif hanya *Klebsiella pneumonia* yang boleh terencat kepada minyak pati dan ekstrak pelarut. Namun demikian, minyak pati atau ekstrak tidak menunjukkan sebarang aktiviti terhadap fungi dan yis yang dikaji. Analisis komposisi peroksimat bunga kantan menunjukkan jumlah protein kasar yang banyak (12.6%), lemak (18.2%) dan serat (17.6%). Asid lemak tak tepu terdiri daripada asid palmitik (16.4%) dan asid linolenik (14.5%). Profil asid amino menunjukkan terdapat asid amino perlu iaitu lisin, leusin dan arginin. Bunga kantan juga mengandungi mineral penting seperti: K (1589 mg/100 g), Ca (775 mg/100 g), Mg (327 mg/100g), P (286 mg/100 g) dan S (167 mg/100g). Antinutrisi yang terdapat dalam bunga kantan adalah 3496 mg/100 g saponin dan 2851 mg/100g asid phytic. Logam berat yang dianalisis (Cd, As, Pb, Hg, Ni) adalah dibawah paras pengesanan. Penyelidikan ini dengan jelas menunjukkan potensi bunga *E.elatior*. sebagai sumber sebatian bioaktif yang boleh digunakan dalam industri makanan dan farmasi. Di samping itu, keputusan komposisi nutrisi menunjukkan potensi penggunaan bunga kantan dan ekstraknya digunakan dalam produk makanan dan formulasi.

CHEMICAL COMPOSITION AND BIOLOGICAL PROPERTIES OF *Etlingera elatior* Jack. (TORCH GINGER) INFLORESCENCE

ABSTRACT

Inflorescence of *Etlingera elatior* Jack. (torch ginger/ *kantan*) was evaluated for its chemical composition and biological properties (antioxidant and antimicrobial) to assess this plant material as a source of nutraceutical. Using different solvent systems [methanol, acetone (50%, 90% and 100% v/v) and distilled water] the extractability of some of the antioxidant compounds (total phenols, tannins, flavonoids, anthocyanins) and antioxidant activity (percent DPPH radical scavenging activity and ferric reducing antioxidant power (FRAP)) were evaluated. Of all the solvents employed, 50% acetone extract showed highest amount of total phenols (687.0 mg GAE/100 g) and total flavonoids (1431 mg QE/100 g), while 50% methanol extract showed maximum (5.9 mg c-3-gE/100 g) recovery for anthocyanins. Tannin extractability was found to be highest with 100% methanol (467.8 mg CE/100 g). The chemical constituents of the essential oils of inflorescence extracted using hydrodistillation method identified 55 chemical compounds (19 major and 37 in trace amounts) upon analysis using gas chromatography-mass spectrometry (GC-MS). The essential oil constitutes mainly, alcohols (44.25%), dominated by 1-dodecanol (25.17%) and hexadecen-1-ol, trance-9 (12.73%), which are all well established antimicrobial compounds. Lauric acid, an antimicrobial compound, contributed to 20.4% of the acids in essential oil. Dodecanal, an aldehyde used in perfumery industries, constituted 17.5% of the oil. Both the essential oils and solvent extracts showed antibacterial activities against Gram-positive bacteria (*Bacillus cereus, B. subtilis, Staphylococcus aureus, Listeria monocytogenes*). Of the screened Gram negative bacteria, only *Klebsiella pneumoniae*

was found to be inhibited for the essential oils and solvent extracts. However, neither the essential oil nor the extracts exhibited any activities against the screened fungi or yeasts. With regard to the proximate composition, the inflorescence had ample amount of crude protein (12.6%), fat (18.2%), and fiber content (17.6%). High amount of unsaturated fatty acids (Palmitoleic acid, 16.4% and linoleic acid, 14.5%) were present. The amino acids profile revealed the presence of essential amino acids (lysine, leucine and arginine). The inflorescence contained essential minerals like: K (1589 mg/100 g), Ca (775 mg/100 g), Mg (327 mg/100g), P (286 mg/100 g) and S (167 mg/100g). The levels of antinutrients analyzed were 3496 and 2851 mg/ 100g for saponin and phytic acid, respectively. The heavy metals analyzed (Cd, As, Pb, Hg, Ni) were below detection limits. This study clearly indicated the potencial of *E. elatior* inflorescence as a source of bioactive compounds to be used in food industries and pharmaceutical industries. Further, the results from nutrition composition suggest the potential of using this inflorescence or its extracts in new food products and formulations.

CHAPTER 1

INTRODUCTION

1.1. Background

During 460-370 BC, conception of the father of western medicine, Hippocrates was "*Let food be thy medicine and medicine be thy food*" (Bernal et al., 2010). This tenet is still true for today, since the community strongly believes that their health status is greatly subsist on their good dietary routine. Moreover American Dietetic Association (ADA) point outs that ''all food can be incorporated into a healthful eating plan, the key being moderation and variety'' (ADA, 2004). Epidemiological studies have consistently revealed the benefits of consumption of natural foods in delaying the burden of degenerative diseases including cardiovascular diseases (CVD), arteriosclerosis, different types of cancers, Alzheimer's disease and aging related disorders (Weichselbaum et al., 2010; Shukla et al., 2010; Prasain et al., 2010).

In fact, the increasing interest on studies pertaining to exploring the promising causatives agents in the food responsible for these defensive actions has come to the forefront of scientific research. The health promoting abilities of the plants is fundamentally due to the non-nutrient secondary metabolites (Masibo and He, 2009; Jan et al., 2010). Phytochemicals including phenols, alkaloids other nutrient and non-nutrient compounds (minerals, vitamins, dietary fiber, essential oils and carotenoids) are considered to be the most imperative groups of compounds attributing to a vast range of bioactivities (González-Molina et al., 2010). These biologically active

compounds are generated in the plant as a defensive mechanism against the pathogens and stress conditions (Espín et al., 2007). The resultant bioactive properties (antioxidant, antimicrobial, antiallergic, anti-inflammatory, hepato-protective, antithrombotic, antiviral, anticarcinogenic) of these phytochemicals are primarily due to their ability to scavenge free radicals and their antioxidant activity (Barros et al., 2008).

Tremendous developments of health promoting food and non food products comprising the bioactive compounds present in healthy foods is basically as a result increasing consumer awareness and interest on these products. Most of these types of products are marketed as varietal pharmaceutical products in the form of pills, gels, capsules, syrups, powder, liquors etc. (Kalra, 2003; Chen et al., 2009; Biesalski et al., 2009). These non food healthy products supposed to comprise food extracts or isolated phytochemicals responsible for the beneficial physiological function in human health.

1.2 Rationale of study

Since time immemorial, several aromatic plant species have been used to improve the healthy life style of the humans' world over. The health benefits provided is attributed to the presence of phytochemical with bioactivities. The increasing demand by the increasing health conscious society for healthy food supplements has lead to intensive research on both *in-vitro* and *in-vivo* to address the lack of scientific data with regard to bioactivity and toxicity.

Etlingera elatior Jack. (Torch ginger) is a well known plant species belong to family Zingiberaceae. The elegant inflorescence having characteristic aroma is extensively been used as a traditional food ingredient among Malaysians and is popular known as '*bunga kantan*' (Habsah et al., 2005; Wijekoon et al., 2010). For a long time, this plant is being used in the traditional Ayurvedic, Chinese and Unani-Tibb medicines for a range of ailments including indigestion, vomiting, treat earache, cleaning wounds (Mohamad et al., 2005; Chan et al., 2007).

Till date there is no any comprehensive scientific research is been carried out on this inflorescence. Hence, our study was performed to provide a sound scientific basis for the existing traditional knowledge. Also there is a lagging of information available about the chemical composition and the persuasive biological activities attributed to this torch ginger inflorescence. Figure 1.1 represents the conceptual framework of the research.

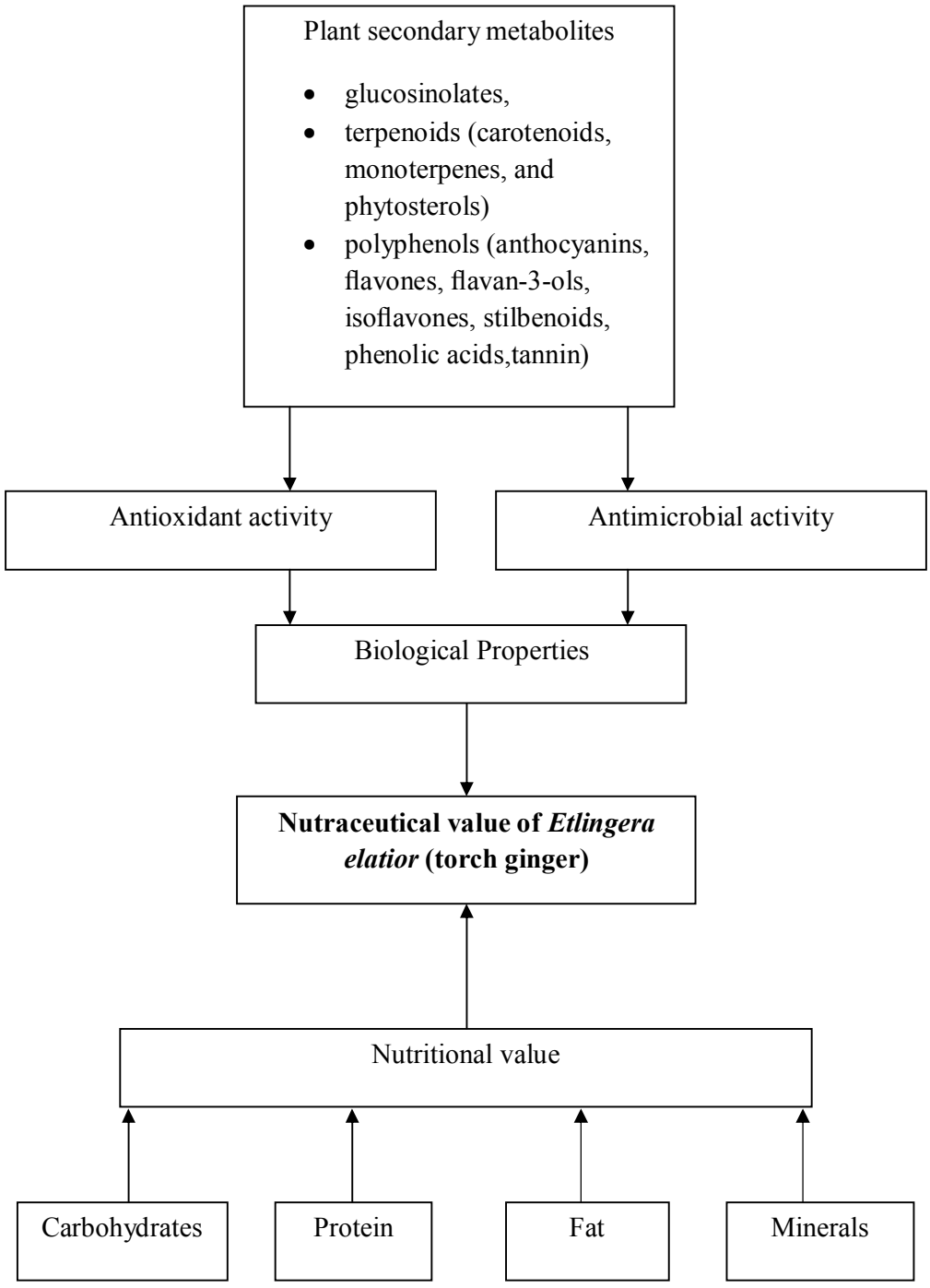

Figure 1.1 Conceptual framework of the research

1.3 Objectives

1.3.1 Main objective

To study the chemical composition and biological properties of *Etlingera elatior* Jack. (Torch ginger) inflorescence

1.3.2 Specific objectives

i) To analyse the nutrients and antinutrients present in the *E. elatior* inflorescence

ii) To analyse the bioactive compounds in the essential oil extracted from the inflorescence.

iii) To study the effect of different types of solvents on the extractability of phenolic compounds and the antioxidant activities of the *E. elatior* inflorescence.

iv) To evaluate the antimicrobial activity of the essential oil and the extracts of *E. elatior* inflorescence.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of the recent research on medicinal plants

Till today, 3500 plant species are being used in traditional medicines despite over 350,000 plant species that have been identified. From these medicinal plants less than 0.5% is analyzed for their chemical composition (Batugal et al., 2004). In 2003 the cost of the global market for nutraceuticals is around $60 billion and this amount annually grows at a rate of 6% with a major share from China and Korea (Pushpangadan, 2003).

From the drugs that are currently been used in market, at least 119 compounds originated from 90 plant species considered as important drugs. Out of this 77% of them are isolated from those plants used in traditional medicine world over. Similarly, more than half of the best selling pharmaceuticals in the year 1991 were originated from natural products. Naturally derived drugs can be divided into three groups namely, original natural products, semi synthetically derived natural products and products synthesized based on natural product molecules (Cragg et al, 1997).

All these reports emphasize the invaluable role of plant-derived natural products in the field of new drugs discovery particularly in prevention and curing neurodegenerative diseases. Another important fact is that phytochemicals exhibiting bioactivity or treatment of an ailment should be consumed in much higher dose than that the normal level of consumption. Therefore isolation, identification and quantification of these phytochemicals in foods and evaluation of their health benefits

have become the key step in the process of discovery of new natural products (Rowland, 1999). Table 2.1 lists some of the important drugs derived from natural medicinal plants.

Malaysia is known for its biodiversity and rich in natural resources, with more than 20,000 angiosperms species and around 600 ferns species. However, only about 15% of angiosperms and 13% of ferns species are reported to possess medicinal value and have been extensively used in folk medicines (Noor Rain et al., 2007). The heterogeneous Malaysian indigenous plants provide vast range of phytochemicals and therefore it is essential that a systematic chemical screening studies pertaining to their bioactive potency be carried out.

Table 2.1 Drugs discovered from medicinal plants (Taylor, 2000; Batugal et al., 2004)

Drug	Medicinal use	Plant source
Ajmaline	For heart arrhythmia	*Rauvolfia* spp.
Aspirin	Analgesic, anti-inflammatory	*Filipendula ulmaria*
Atropine	Pupil dilator	*Atropa belladonna*
Benzoin	Oral disinfectant	*Styrax tonkinensis*
Caffeine	Stimulant	*Camellia sinensis*
Camphor	For rheumatic pain	*Cinnamomum camphora*
Cascara	Purgative	*Rhamnus purshiana*
Rescinnamine	Antihypertensive	*R. serpentia*
Reserpine	Antihypertensive	*R. serpentia*
Quinine	For malaria prophylaxis	*Cinchona pubescens*
Psoralen	For vitiligo	*Psoralea corylifolia*
Hyoscyamine	Anticholinergic	*Hyoscyamus niger*
Quinidine	For cardiac arrhythmia	*C. pubescens*
Physostigimin	For glaucoma	*Physostigma venenosum*
Gitalin	Cardiotonic	*Digitalis purpurea*
Cissampeline	Skeletal muscle relaxant	*Cissampelos pareira*
Lapachol	Anticancer, antitumor	*Tabebuia* sp.
Morphine	Analgesic	*Papaver somniferum*
Palmatine	Antipyretic, detoxicant	*Coptis japonica*
Salicin	Analgesic	*Salix alba*
Taxol	Antitumor agent	*Taxus brevifolia*
Theophylline	Diuretic, brochodilator	*Theobroma cacao*
Tetrandrine	Antihypertensive	*Stephania tetrandra*
Topotecan	Antitumor, anticancer agent	*Camptotheca acuminata*

2.2 Functional foods and nutraceuticals

By definition bioactive compound includes essential and non essential compounds that occur naturally in foods at small amounts, and exhibit noticeable physiological effects on human health on long term consumption (Espín et al., 2007; Biesalski et al., 2009). According to Shahidi (2009), functional foods are defined as those foods which are consumed as part of a usual diet but known to demonstrate beneficial physiological function in regular consumption beyond their nutritional properties.

Nutraceuticals are those products derived from the foods, carrying a concentrated amount of a reputed bioactive agent of a food and used in the form of medicinal products (non-food matrix) such as pills, capsules, powders and solutions rendering physiological benefits in human health at higher dosage than that is obtained from normal foods (Shahidi, 2007; Shahidi, 2009; Bernal et al., 2010). The main aim of either functional foods or nutraceuticals is to improve health status through prevention from degenerative diseases. Nearly one third of these diseases is related to life-style of individuals and thereby tremendously reduces the burden cost of health care (Shahidi, 2007; Shahidi, 2009).

Although nutraceuticals products are not associated with foods, these are known to possess beneficial physiological effect or prevention against chronic diseases to expand the healthy life span. These are the plant secondary metabolites ingested into body as insignificant amounts in comparison to pharmaceutical products and their biological activity are effective in the long term as a physiological effect. These phytochemicals associated with foods are known for their biological activities include glucosinolates, terpenoids (carotenoids, monoterpenes, and phytosterols) and polyphenols (anthocyanins, flavones, flavan-3-ols, isoflavones, stilbenoids, phenolic acids etc.) (Espín et al., 2007).

2.3 Zingiberaceae family

The family Zingiberaceae is well known for aromatic plants, comprising over 1400 species in 47 genera. Plants belonging to this family have widely been used for the traditional medicines and in food ingredients in culinary applications all over the world (Pancharoen at al., 2000). Most of the herbs from the family Zingiberaceae belong to 12 genera; *Aframomum* Schum, *Alpinia* Roxb, *Amomum* Roxb,

Boesenbergia Kuntze, *Curcuma* L, *Elettaria* Maton, *Etlingera* Giseke, *Hedychium* J. Koenig, *Hitchenia* Wall, *Kaempferia* L, *Renealmia* L. f and *Zingiber* Mill. Species belonging to theses genera are stated in Table 2.2. Presence of characteristic volatile oils and oleoresins in the rhizomes and fruits increases the commercial value to these plants in export markets.

Seed extracts from *Aframomum melegueta* (Alligator pepper) is used in traditional medicine for relief from cough, stomachache and as a carminative. Different plant parts including decoction of the leaves (a tonic for rheumatism and as an anti-emetic agent) and fruits (used in medicines for dysenteric conditions) are also used in traditional medicines (Konning et al., 2004; Umukoro and Ashorobi, 2005). Previous reports have reviewed on the diterpenoids, sesquitepenoids, arylalkanoids and flavonoids compounds of this plant, known to be responsible for its bioactivity in antifungal, antibacterial, insect antifeedant activity, antiplasmodial, antihypercholesterolemic, antiviral activities, and cytotoxic activities (Tane et al., 2004; Umukoro and Ashorobi, 2008).

Table 2.2 Zingiberaceae species classification in different genera (USDA, 2010)

Scientific Name	Common Name	Scientific name of the species	Common name
Aframomum Schum	Aframomum	*Aframomum melegueta*	Melegueta pepper (Alligator pepper)
Alpinia Roxb.	Alpinia	*Alpinia galanga* (L.) Sw.	Greater galangal
		Alpinia mutica	Small shell ginger
		Alpinia officinarum	Lesser galangal
		Alpinia purpurata	Red ginger
		Alpinia zerumbet	Shellplant
Amomum Roxb.	Cardamom	*Amomum compactum*	Round cardamom (Chester cardamom)
		Amomum gracile	Serkkom
Boesenbergia Kuntze	Boesenbergia	*Boesenbergia rotunda*	Rotund Boesenbergia
Curcuma L.	Curcuma	*Curcuma amada* L.	Mango ginger
		Curcuma angustifolia L.	East Indian arrowroot
		Curcuma aromatica L.	Curcuma (wild turmeric)
		Curcuma australasica L.	Native turmeric
		Curcuma longa	Common turmeric
		Curcuma zedoaria	Zedoary
Elettaria Maton	Elettaria	*Elettaria cardamomum* (L.) Maton	Cardamom
Etlingera Giseke	Waxflower	*Etlingera cevuga*	Waxflower
		Etlingera elatior	Torch-ginger
Hedychium J. Koenig	Garland-lily	*Hedychium coronarium*	White garland-lily
		Hedychium flavescens	Cream garland-lily
		Hedychium gardnerianum	Kahila garland-lily
Hitchenia Wall.	Hitchenia	*Hitchenia caulina*	Chavar
Kaempferia L.	Kaempferia	*Kaempferia galanga*	Galangal
		Kaempferia rotunda	Kaempferia

Table 2.2 Continued

Scientific Name	Common Name	Scientific name of the species	Common name
Renealmia L. f	Renealmia	*Renealmia alpinia*	Jenjibre-de-jardin
		Renealmia jamaicensis	Narciso colorado
		Renealmia occidentalis	Bijao
Zingiber Mill.	Ginger	*Zingiber mioga*	Japanese ginger Cassumunar
		Zingiber montanum	Garden ginger
		Zingiber officinale	ginger
		Zingiber zerumbet	Bitter ginger

Rhizome powder from *Alpinia galanga* and young leaf paste of *Euphorbia neriifolia* together are applied as medicine for inflammation and allergy conditions occuring in the skin. In traditional medicines, galanagal is used as a stimulant and carminative inflatulence and used to treat laxative dyspepsia, vomiting and sickness at stomach (Tushar et al., 2010). Latest reports provide the evidence of hypoglycaemic activity of organic and aqueous extracts of galangal rhizomes (Akhtar et al., 2002). The pungent rhizome of *Alpinia officinarum* is a well-known plant material in Chinese medicine and its major biological activity is known for its diarylheptanoids, flavonoids and volatile oils (Zhao et al., 2010). Recently, Zhang et al. (2010) have analyzed the ethanolic extracts of the rhizomes and reported three novel diarylheptanoids having strong antibacterial activity and another ten reported compounds. Presence of some other constituents namely 1,8-cineole, methylcinnamate, α-cadinene, galangin, 3-O-methylgalangin, kaempferide, alpinin and galangol have been reported in earlier studies. Galangin and 3-O-methylgalangin is known to be the most important types of flavonol present in ample amounts with known anti-mutagenic, antioxidant, anti-clastogenic (Shin et al., 2003; Tao et al., 2006).

Various plant parts from species belonging to the genera *Amomum* are used in traditional Asian medicine (Salim et al., 2007; Yang et al., 2010). Combinations of the seeds from *Amomum aurantiacum* and *Amomum xanthiodes* are used for relief of stomachache in China, while fresh rhizome from *Amomum coccineum* is used to make vermifuge drinks for childrens in Indonesia. Also Indonesian community practices to chew the fruits from *Amomum gracile* for the relief from indigestion and nausea (Pancharoen et al., 2000). Most of the plants in genus *Boesenbergia* also have the potential use of its rhizomes, and till date there are two varieties belong to *Boesenbergia pandurata* have been screened for its phytochemicals constituents it has been known for its ability to dissolve kidney stones (Pancharoen et al., 2000).

Genera *Curcuma* includes very popular plants such as common turmeric (*Curcuma longa*), native turmeric (*Curcuma australasica*) and mango ginger (*Curcuma amada*). More than 80 species of rhizomatous herbs are included in genus *Curcuma* is said to be native to Indo-Malaya region and now these plants have been propagated in worldwide (Policegoudra et al, 2007b). Common turmeric is famous among Asians as a spice in domestic cooking. At the same time it is used as a dye for application in textile industries, cosmetic products and pharmaceuticals (Cousins et al., 2007). Beside these benefits, it is a popular plant in traditional medicine, used for treatment of stomachache, as a blood purifying compound, carminative agent, ingredient in appetizers and tonic agent (Singh et al., 2010b). Curcumin, the principal polyphenolic compound in turmeric and other turmeric extracts have been proven to be of antimicrobial activity (Apisariyakul et al., 1995), antioxidant activity (Singh et al., 2010a), anti-inflammatory (Jagetia and Rajanikant, 2004), anti-tumour activity (Surh, 2002) anti-venom activity (Ferreira et al., 1992; Jayaprakasha et al., 2005) and reduce blood glucose in animal models (Fujiwara et al., 2008). Hence in western medicine

compounds isolated from turmeric are also considered to be used in drugs for the treatment for cancer, dermatitis, AIDS and high blood cholesterol (Thomas-Eapen, 2009, Aggarwal and Harikumar, 2009).

Mango ginger (*Curcuma amada* Roxb.) carries the characteristic mango smell attributed to car-3-ene and cis-ocimene (Policegoudra et al., 2007a). A fresh rhizome from mango ginger is a source for appetizer, alexteric, antipyretic, aphrodisiac and used as an alaxative in ancient Indian Ayurveda (Policegoudra et al., 2007c). Resent researches have explored the potency of mango ginger rhizomes as antimicrobial activity agents and also the high amount of starch content (45.64% dry weight basis) for its application in development of food product providing health benefits (Policegoudra and Aradhya, 2007; Policegoudra and Aradhya, 2008).

Elettaria cardamomum (genus *Elettaria*) is a spice and a herb used in traditional medicine to treat eye inflammation and kidney and urinary disorders. Additionally they are used to treat infection of teeth, treat throat trouble, congestion of lung and pulmonary tuberculosis, asthma, heart disease, digestive disorder, snake bite and scorpion bite (Tushar et al., 2010). The pleasant aroma attributed to its essential oils makes the fruits applicable in foods as a spice and to be antifungal and anti-plasmodic, analgesic and anti-inflammatory activity (Hamdan et al, 2008; El Malti et al., 2007).

The genus *Hedychium* includes around 80 species baring attractive foliage and also aromatic flowers. Flower of some of the species are edible and some flowers are have industrial and medicinal value (Sakhanokho and Rajasekaran, 2010). In Brazil, *Hedychium coronarium* leaves extracted with hot water is used as a drink to treat hypertension or induce diuresis. Indians traditionally use the dried rhizome powders

of *H. coronarium* together with cup of milk as a treatment for diabetes (Pancharoen et al., 2000; Tushar et al., 2010). Recently identified compounds from different plant parts of family Zingiberaceae plants with their bioactive properties are been highlighted in the Table 2.3.

Table 2.3 Chemical compounds and their bioactivity of different Zingiberaceae plants

Chemical compound	Plant and part	Bioactivity	Reference
Three diarylheptanoids 7-(4″,5″-dihydroxy-3″-methoxyphenyl)-1-phenyl-4-heptene-3-one 1,7-diphenyl-5-heptene-3-one 4-phenethyl-1,7-diphenyl-1-heptene-3,5-dione	*Alpinia officinarum* Rhizomes	Antibacterial activity against *Helicobactor pylori*	Zhang et al. (2010)
Four diarylheptanoids 5-hydroxy-1,7-diphenyl-3-heptanone 7-(4”-hydroxy-3’methoxyphenyl)-1-phenylhept-4-en-3-one- 5-hydroxy-7-(4’-hydroxy-3”-methoxyphenyl)-1-phenyl-3-heptanone, 3,5-dihydroxy-1,7-diphenylheptane *Two Flavonols* Kaempferide Galangin	*Alpinia officinarum* Rhizomes	Melanogenesis inhibition in the ophylline-stimulated murine B16 melanoma 4A5 cells	Matsuda et al. (2009)
Essential oils 1,8-cineole (20.57%), terpinen-4-ol (19.39%), γ-terpinene (15.08%), sabinene (9.68%), *p*-cimene (8.54%), α-tujene (6.35), α-terpinene (3.88%), β-pinene (3.02%), limonene (2.64%), α-pinene (2.38%), terpinolene (1.93%), β-mircene (1.2%), trans-cariophilene (1.11%), α-terpineol (0.86%)	*Alpinia zerumbet* leaves	Active on rat sciatic nerve, on blocking compound action potential generation and conduction	Leal-Cardoso et al. (2004
1’-acetoxychavicolacetate	*Alpinia galanga* *Seed extracts*	Cytocoxicity against CORL 23 lung cancer cell line and MCF7 breast cancer cell line.	Lee and Houghton (2005)

Table 2.3 Continued

Chemical compound	Plant and part	Bioactivity	Reference
Cytotoxic compound Aculeatin D *Alkenone* 5-hydroxy-hexacos-1-en-3-one	*Amomum aculeatum* Rhizomes	Cytotoxicity against the KB and the L-6 cell line Anti-protozoal activity for *Plasmodium falciparum* strains, *Trypanosoma bruceir hodesiense* and *Trypanosoma cruzi*.	Heilmann et al. (2001)
Essential oils β-terpineol (13.4%), β-pinene (9.4%), α-pinene (6.9%)	*Amomum cannicarpum* Rhizomes	Antimicrobial activity	George et al. (2006)
Amadannulen	*Curcuma amada* Rhizomes	Antioxidany activity and antimicrobial activity	Policegoudra et al. (2007a)
Labdane diterpene dialdehyde	*Curcuma amada* Rhizome	Antitubercular activity against *Mycobacterium tuberculosis*	Singh et al. (2010b)
Curcuminoids	*Curcuma longa* L. Rhizome	Anti-arthritic activity in female rats with streptococcal cell wall-induced arthritis	Funk et al.(2010)
Gingerol	*Zingiber officinale* Roscoe Rhizome	Anti-arthritic activity in female rats with streptococcal cell wall-induced arthritis	Funk et al. (2009)

2.3.1 *Etlingera elatior*

2.3.1.1 Common notes and morphology of the plant *Etlingera elatior*

Etlingera elatior (Jack.) generally known as torch ginger is a plant that belongs to Zingiberaceae family. This plant is popularly known in Malaysia as '*kantan*' (Jaafar et al., 2007), and is commonly found in the South-Asian countries. Torch ginger plant is considered to be a native of Sumatra (Indonesia) and is referred to as '*kecombrang' or as 'kincung*.' Amoung Chinese communities this plant is popular as '*xiang bao jiang*' and Spanish people call it as '*antorcha rosada'*.

Torch ginger is an herbaceous perennial plant that individually grows in large clumps where the stalks can be as much as 6 m high with leaves as long as 85 cm. From the rhizomes (the underground stems), large and evergreen stalk of leaves grows up. The inflorescence is red with pinkish inner segments and red with yellow or white colour margins. Inflorescence grows directly from the rhizomes to a height up to one meter and thin cone shaped reddish inflorescence carries many small flowers appear in between the floral brackets (Figure 2.1). The mature fruits of *E. elatior* are green or reddish-green in colour, globe shape, 2-3 cm in diameter and contain small black seeds (Anonymous A, 2010).

Figure 2.1 Natural habitat of *Etlingera elatior* plant in Penang

2.3.1.2 Taxonomic classification of *Etlingera elatior* (Jack.) R.M. Smith (Anonymous, C.)

Kingdom	: **Plantae -** Plants
Subkingdom	: **Tracheobionta** - Vascular plants
Superdivision	: **Spermatophyta** - Seed plants
Division	: **Magnoliophyta** - Flowering plants
Class	: **Liliopsida** - Monocotyledons
Subclass	: **Zingiberidae**
Order	: **Zingiberales**
Family	: **Zingiberaceae** - (Ginger family)
Genus	: ***Etlingera*** Giseke - Wax flower
Species	: *Etlingera elatior* (Jack.) R.M. Smith - Torch ginger

2.3.1.3 Overview on nutraceutical value of *Etlingera elatior*

Torch ginger plant has extensive traditional uses wherein young inflorescence are consumed by indigenous communities either as a condiment, eaten raw or as cooked (Mohamad et al., 2005). Inflorescences of this plant are very popular as a spice for food flavouring and also as an ornamental. In some traditional Malaysian foods (like *laksa asam, nasi kerabu and nasi ulam*) the inflorescence forms a part of the key ingredient (Chan et al., 2007). Fruits of *E. elatior* are used to treat earache, while leaves are been used for cleaning wound and in the herbal mixture that used to bath *post-partum* women for removing body odour (Ibrahim and Setyowati, 1999).

Inflorescence of *E. elatior,* extracted with 50% methanol containing 1.2 M HCl were analyzed for the presence of quercetin, kaempferol, myricetin and flavones apigenin and luteolin with HPLC came up with the finding that extract is having high amount of quercetin accounting 1.18 mg/100g of sample. The rest of the flavonoids analyzed were observed to be below the detection limits (Andarwulan et al., 2010). Ethanolic extract of inflorescence have proven to have antimicrobial activity and cytotoxic activity against the HeLa (human cervical carcinoma) cell line (Mackeen et al., 1997). *In-vivo* studies also done in the rats on the effect of lead-induced changes in the oxidative biomarkers and histology of bone marrow of rats suggested that inflorescence extracts of *E .elatior* as a powerful source of antioxidant effect, and it also protects the lead acetate induced bone marrow oxidative damage in rats the (Haleagrahara et al., 2010).

Elingera elatior leaves were analyzed for the flavonoids by Williams and Harborne (1977) and reported the presence of four types of flavonoids namely kaempferol 3-glucuronide, quercetin 3-glucuronide, quercetin 3-glucoside and quercetin 3-rhamnoside. Similarly finding by Andarwulan et al. (2010) who had