HOSTED BY
ELSEVIER

Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Biomedicine

journal homepage: www.elsevier.com/locate/apjtb

Review article http://dx.doi.org/10.1016/j.apjtb.2016.11.026

Ethnobotanical review and pharmacological properties of selected medicinal plants in Brunei Darussalam: *Litsea elliptica*, *Dillenia suffruticosa*, *Dillenia excelsa*, *Aidia racemosa*, *Vitex pinnata* and *Senna alata*

May Poh Yik Goh[1], Aida Maryam Basri[2], Hartini Yasin[3], Hussein Taha[1], Norhayati Ahmad[1*]

[1]*Environmental and Life Sciences, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE1410, Brunei Darussalam*

[2]*Herbal Drug Discovery Laboratory, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE1410, Brunei Darussalam*

[3]*Chemical Sciences, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE1410, Brunei Darussalam*

ARTICLE INFO

Article history:
Received 18 Sep 2016
Received in revised form 5 Oct 2016
Accepted 1 Nov 2016
Available online 25 Nov 2016

Keywords:
Litsea elliptica
Dillenia suffruticosa
Dillenia excelsa
Aidia racemosa
Vitex pinnata
Senna alata

ABSTRACT

The aim of the current study is to review the medicinal properties of the plants found in Brunei Darussalam namely *Litsea elliptica*, *Dillenia suffruticosa*, *Dillenia excelsa*, *Aidia racemosa*, *Vitex pinnata* and *Senna alata*. The known phytochemical constituents of these plants and their ability to bring about a range of biological activities are included in this review. These plants have been used traditionally for a multitude of diseases and illnesses. There is a lot of untapped potential in these medicinal plants which could cure multiple diseases.

1. Introduction

Brunei Darussalam, also known as the Kingdom of Unexpected Treasures, is a country that is prosperous, not only in oil and natural gas, but also in many other resources. Located in the Island of Borneo, the country is also rich in natural flora that covers a large portion of its land. This natural flora is well-preserved as a good proportion which is still left untouched. Needless to say, the floral species that make up this abundant vegetation can be exceptionally wide-ranging. Many of these species are of great medical importance as they could potentially treat many modern day diseases following proper identification and extensive research work. Nevertheless, there are several species that have already been identified for their use in local traditional remedies. They are either taken raw, cooked, or taken in the form of decoction, poultices, infusions or pounded pastes that are then consumed orally, applied topically or used in herbal baths. Today, some of these practices are still considerably active within the local community where they are used to treat known and unknown diseases as an alternative to modern medicine.

With the trend in emerging diseases, there is an increased interest to revert back to knowledge of traditional medicine, with hopes to discover novel biological activities within these plants. Thus, this article reviews the traditional uses and scientific findings of some of the species used in traditional remedies in Brunei Darussalam, including *Litsea elliptica* Blume (*L. elliptica*), *Dillenia suffruticosa* (Griff.) Mart. (*D. suffruticosa*), *Dillenia excelsa* (Jack) Martelli (*D. excelsa*), *Aidia racemosa* (Cav.) Tirveng. (*A. racemosa*), *Vitex pinnata* L. (*V. pinnata*) and *Senna alata* (L.) Roxb. (*S. alata*).

*Corresponding author: Norhayati Ahmad, Environmental and Life Sciences, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE1410, Brunei Darussalam.
Tel: +673 2463001, ext. 1385
E-mail: norhayati.ahmad@ubd.edu.bn

Foundation Project: Supported by Universiti Brunei Darussalam and the Brunei Research Council (Grant No. JPKE/UBD/BRC6).

Peer review under responsibility of Hainan Medical University. The journal implements double-blind peer review practiced by specially invited international editorial board members.

2. *L. elliptica*

L. elliptica, found widely in the forests of South East Asia, is a tropical tree from the Lauraceae family [1] (Figure 1). It is locally known as "Pawas" in Brunei Darussalam. The leaf extract of this plant species have been used to treat different illnesses such as stomach ulcers, fevers and headaches [1,2]. The methanolic extract of its leaf was shown to inhibit the growth of *Helicobacter pylori* (*H. pylori*), a bacterium that is responsible for the multiple forms of gastric complications such as gastritis, dyspepsia, peptic ulcer disease and gastric cancer [3]. This demonstrates their potential chemo-preventive properties [3]. The leaf of *L. elliptica*, similar to the leaves of *Pouzolzia pentandra*, *Cycas siamensis* and *Melaleuca quinquenervia*, was found to have a minimum inhibitory concentration (MIC) of 100 mg/mL against *H. pylori* [3]. This inhibitory activity was lower when compared to the extracts of other plant species in the study, such as the aril of *Myristica fragrans* that had a MIC of 12.5 mg/mL, the leaf of *Barringtonia acutangula* and rhizome of *Kaempferia galanga*, that exhibited an MIC of 25 mg/mL, and the leaves of *Cassia grandis*, *Cleome viscosa*, *Myristica fragrans* and *Syzygium aromaticum* with an MIC of 50 mg/mL [3]. Nonetheless, the apparent inhibitory activity against *H. pylori* justifies how *L. elliptica* was a useful traditional remedial plant for the treatment of stomach ulcer.

Figure 1. Leaves of *L. elliptica*.

In more recent studies, the methanolic extracts from the stems, roots and leaves of *L. elliptica* showed significant antioxidant activities that were higher than those of synthetic antioxidant, butylated hydroxytoluene, and antioxidant standards, vitamin C and trolox [4,5]. Wong *et al*. has also shown that the stems of the plant have significantly higher inhibition against bacterial growth, as compared to its roots and inner bark [5]. This is especially shown by dichloromethane and chloroform extracted stems that showed reactivity against skin pathogen *Pseudomonas aeruginosa* (*P. aeruginosa*) and food-borne pathogens *Escherichia coli* (*E. coli*) and *Bacillus subtilis* (*B. subtilis*) [5]. Additionally, the essential oils extracted from the roots have also displayed antifungal properties, where they were able to inhibit about 67% of mycelial growth of *Fusarium oxysporum* [5].

Previous reports also have indicated that *L. elliptica* possesses remarkable insecticidal properties especially towards mosquitoes [6–10]. Its median lethal concentration (LC_{50}) against adult *Aedes aegypti* was found to be < 20 mg/cm^2 (*i.e.* 0.11 mg/cm^2) which is more effective than the well-known insecticidal plant *Azadirachta indica* and *Asimina triloba* [8]. It was also found that a high concentration of 12.42 mg/cm^2 was able to cause 50% mortality in the *Aedes aegypti* population within 10 min [8]. This is a relatively short period of time when compared to the other plant species studied which required more than 20 min to achieve the same percentage mortality [8]. Moreover, the essential oil of the leaf also displayed 100% repellency against the same species of mosquito at 0.003 79 mg/cm^2 [9]. Due to this profound property, several studies were carried out to determine its potential safety/health hazard on red blood cells and other parts of the body. These studies focused on acute and subacute toxicities, morphological, hematological and biochemical parameters of mice that were administered orally with the essential oils. They have demonstrated that the essential oil of this plant species is likely to be non-toxic in all aspects under normal usage following the World Health Organization guidelines [1,10].

3. *D. suffruticosa*

Locally known as "Simpor bini", *D. suffruticosa* is a medium sized tree characterized by its large bright flowers with five thin yellow petals around its white stamen, and dark-pink star-shaped fruits all of which are surrounded by large oval leaves (Figure 2). This plant species typically grows in wastelands, swamps, poor soil, white sands, secondary forests, along roadsides or the edge of forests [11–13]. Its leaves have been traditionally used for different treatments such as to promote wound healing, relieve rheumatism and treat fever while the fruit was claimed to be able to treat cancerous growths [12–16].

Figure 2. Flowers and leaves of *D. suffruticosa*.

The methanolic extract of the roots of this plant have displayed significant antioxidant and cytotoxic activities particularly towards the HeLa cervical cancer cell line [17]. Studies conducted by Armania *et al*. have indicated that the phenolic content was an important contributor to the high antioxidant activity observed in the methanolic root extract of this plant species [17,18]. Although this extract showed the highest antioxidant and cytotoxic activities in the HeLa cell line, it was found that the dichloromethane and ethyl acetate extracts exhibited higher cytotoxicity in the breast cancer cell lines, MCF7, MDA-MB-231, the A549 lung cancer cell line and the HT29 colon cancer cell line [17]. Further mechanistic investigation demonstrated that the plant extract inhibited the proliferation of the HeLa cervical cancer cell line as well as

the MCF7 and MDA-MD-231 breast cancer cell lines via the induction of apoptosis and the G2/M cell cycle arrest [17,18]. An *in vivo* study conducted by Yazan *et al*. showed that oral intake of aqueous root extracts have successfully reduced breast cancer induced in rats and also inhibited metastasis of the cancer to the heart [19]. The study further demonstrated that the extract was not toxic at the acute toxicity level up to a high dose of 500 mg/kg, however, mild focal hemorrhage was observed when a dose of 1 000 mg/kg of the extract was used for treatment [19]. The cytotoxic activities of this plant species could be attributed to the presence of phytochemicals such as saponins, triterpenes, sterols, and polyphenolic compounds [17,20–26].

Saponins is a collective term for triterpenoid and steroidal glycosides [27], which consists of at least 150 kinds of natural saponins that have displayed significant anti-cancer properties [28]. Moreover, they have been recognized for their ability to reduce cholesterol level in the blood [29]. Dietary and endogenous cholesterols pass through the bile or desquamated-intestinal cells and reach the intestine before they are absorbed into the blood stream [29]. Saponins, being poorly absorbable from the intestine into the blood stream, interact with cholesterols and other sterols, and thus interfere and prevent them from being absorbed into the blood stream [29]. Additionally, saponins have the ability to stimulate the immune system and enhance antibody production [30]. Interestingly, multiple studies have reported reduction in bone loss with diets that are high in saponins [31,32]. One of the many saponins in particular, called asperosaponin VI, was able to induce the differentiation and maturation of osteoblasts and thus increase bone formation via the bone morphogenetic protein-2/p38 synthesis, and activation of the extracellular signal-regulated kinase 1/2 pathway [32].

On the other hand, polyphenols, which include phenolic acids, flavonoids, stilbenes and lignans, have been recognized for their multiple health-benefiting properties [33]. Polyphenols such as resveratrol and quercetin were found to exhibit significant cardio-protective effects by preventing platelet aggregation, disrupting atherosclerotic plaques and inhibiting protein expressions [33]. Other than that, anti-cancer, anti-viral, anti-diabetic, anti-aging and neuro-protective effects were also noted for the phytochemicals in the polyphenol group. They also showed beneficial effects towards asthma, osteoporosis, bone loss, skin damage and mineral absorption in intestines [33].

The phytochemical contents within *D. suffruticosa* play a significant role in relieving and alleviating illnesses. Perhaps it is a combination of their effects that promote wound healing, relieve rheumatism, and treat fever and cancerous growth traditionally. However, more studies should be performed to fully validate their traditional uses for such diseases.

4. *D. excelsa*

Another species in the *Dillenia* genus is *D. excelsa*, which is also known as “Simpor laki” by locals in Brunei (Figure 3). This particular species of *Dillenia* is well represented by its distinct purple stamen in the middle of its flower with five pale yellow petals and white star-shaped fruits [12]. It has been noted to grow in dry to swampy soils, often along streams within forests [34].

Figure 3. Flower of *D. excelsa*.

Not much has been reported on the remedial use of this plant, except that its bark and fruits may possess medicinal values, one of which is to treat diarrhoea [12]. Similarly, scientific studies of this species also seem to be lacking, possibly due to its rare occurrence.

5. *A. racemosa*

A. racemosa or locally referred to as “Sambal/Sambah Bagangan”, is a plant that belongs to the Rubiaceae family [13]. It is a small tree with pinkish-red young leaves, and mature green leaves [13]. The leaves are glossy on the upper surface (Figure 4). This plant was brought into light recently due to the ability of its roots and leaves to relieve body aches and tiredness. It is now being marketed locally as a tea or tonic for energy and overall body strength [35]. In addition to this, it was also traditionally known to be able to cure gastric pains [13,35].

Although having a good marketable value, the scientific investigations and information on this plant are still very limited. The medicinal property of this plant remains understudied.

Figure 4. Young plant of *A. racemosa*.

6. *V. pinnata*

V. pinnata is a small tree from the Lamiaceae family (Figure 5), and is commonly known as "Kulimpapa" in Brunei [13]. It has whitish blue flowers with purplish black berries [13]. Traditionally, the whole plant has been used to treat jaundice [36] while the bark has been used in post-natal herbal baths and for the treatment of stomachaches [13]. Along with the leaves, the bark has also been used for treating wounds, dysentery and stomach diseases [13,37] while the leaves alone were used to treat fever and hypertension [13,38]. Additionally, the roots of the plant species have also been taken as a tea for relieving tiredness, body aches and backaches [13,38].

With an IC_{50} value of 17.38 mg/mL, the methanolic extract of this plant species was found to be a less potent anti-proliferation agent when compared to that of *Syzygium polyanthum* and *Barringtonia racemosa*, with IC_{50} values of 5.50 mg/mL and 3.47 mg/mL respectively [39]. However, it was found to be more potent compared to *Oroxylum indicum* which did not show any IC_{50} value [39]. Moreover, since the IC_{50} value of the extract of this plant species was less than 20 mg/mL, it can thus be considered as being an active anti-proliferative agent [39–41].

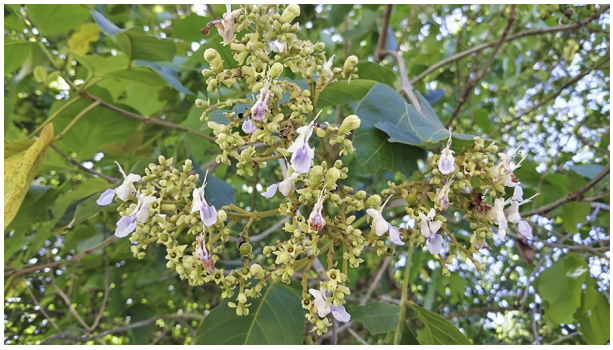

Figure 5. Calyx and flowers of *V. pinnata*.

A study by Ramesh *et al*. has indicated that the petroleum ether, ethyl acetate, methanol and aqueous leaf extracts of *V. pinnata* contain varying amounts of the alkaloid, anthocyanidins, aucubins, coumarins, flavonoids, flavanols, gallic tannins, iridoids, proteins, reducing compounds, steroids, triterpenoids and glycoside compounds where flavonoids appeared to have the highest frequency in all the four different extracts [42]. Additionally, a new compound, pinnatoside iridoid glucoside, along with other known flavonoids, namely viscioside, apigenin and luteolin were isolated by Ata *et al*. from the bark of this plant species and their structures were determined by nuclear magnetic resonance spectroscopy [36]. Interestingly, the pinnatoside iridoid glucoside compound was found to have modest inhibition against the fungus *Candida albicans* [36].

The identification of the phytochemical compounds from the most commonly used parts of this plant species can definitely provide clues for further scientific investigations.

7. *S. alata*

S. alata, locally known as "Daun Kurap", or commonly known as "Candlestick", is a perennial shrub with only few branches (Figure 6) [13]. It is recognizable by its bright orange-yellow flowers that are arranged spirally on its rachides [13]. This plant species was found to have abortifacient properties [43]. *S. alata* has been considered of high value due to its ethnomedicinal uses in multiple health disorders traditionally. These disorders include gastroenteritis, asthma, hypertensions, sickle-cell anemia, diabetes, hepatitis, skin diseases, jaundice, eczema and ringworm, constipation and food poisoning, burns, wounds, skin infection, diarrhea and upper respiratory tract infection [16,44,45].

Consequently, there has been a considerable amount of literature reporting on this plant species. Some of these studies revealed that the plant species displayed significant cytotoxic activities, apoptotic induction and proliferation inhibition in selected breast cancer cell lines and leukemia cells [46–48]. A study carried out by Essien *et al*. revealed that the essential oils of the Nigerian origin of this plant species contained mainly ar-turmerone (13.5%), β-caryophyllene (7.3%), (E)-phytol (7.0%) and 6,10,14-trimethyl-2-pentadecanone (6.8%) [46]. In addition, the essential oils of *S. alata* were found to be cytotoxic against the Hs 578T human tumor breast cell line [46]. Jaabir *et al*. has also showed that the methanolic extracts of the leaves of this plant species were cytotoxic towards

Figure 6. Plant of *S. alata*.

MCF-7 breast cancer cell line at 1 mg/mL [47]. Further investigation indicated that the extract caused cell death in the selected cell line via apoptosis [47]. On the other hand, it was found that, the inhibition of proliferation of the L1210 leukemia cells after 72 h increased with the concentration of ethanolic extract of the *S. alata* leaves [48]. The plant extract was also able to significantly decrease protein synthesis of leukemia cells [48]. Moreover, the study showed that, the addition of α-difluoromethylornithine to the plant extract decreased the production of polyamines that were produced from the proliferation of leukemia cells, such as putrescine, spermidine and spermine [48]. This signifies that more effective inhibition of leukemia cell proliferation is achieved via the α-difluoromethylornithine plant extract complex [48].

Apart from that, the crude methanolic extract of the leaves of this plant species also displayed more effective anti-diabetic property when compared to the standard clinical drug, acarbose, via the inhibition of α-glucosidase [49]. Subsequently, the crude plant extract was fractionated in different solvents, namely petroleum ether, chloroform, ethyl acetate, *n*-butanol and water, in order to further determine the chemical constituents responsible for the finding [49]. The results showed that the ethyl acetate and *n*-butanol fractions exhibit the highest inhibitory effect against α-glucosidase [49]. Following that, these two fractions were found to contain mainly kaempferol and kaempferol 3-O-gentiobioside [49]. Thus, these suggest that these two compounds found in the *S. alata* leaves could be the major contributors to the anti-diabetic effect observed [49]. This also allows justification for the traditional use of this plant species to treat diabetes [45].

Antibacterial and antifungal properties have also been reported for this plant species [46,50]. According to Essien *et al*., the volatile oil from this plant species demonstrated antimicrobial activities when tested against standard strains of *Bacillus cereus*, *P. aeruginosa*, *E. coli*, *Staphylococcus aureus* (*S. aureus*), *Candida albicans* and *Aspergillus niger* although only moderately [46]. Contrastingly, Alalor *et al*. found that the crude methanolic and aqueous extracts of the leaves and barks were able to inhibit *S. aureus* and *B. subtilis* in a concentration-dependent manner, however, no activity was shown on the Gram-negative bacteria, *E. coli* and *P. aeruginosa* [50]. The aqueous extracts had higher inhibitory activity against the two susceptible bacteria when compared to the methanolic extracts [50]. Additionally, *B. subtilis* was found to be more susceptible to the extract than *S. aureus* [50]. Another study has shown that the crude ethanolic extract of the stem bark of *S. alata* inhibits the growth of clinical dermatophytes in a concentration-dependant manner [51]. The strain with the lowest susceptibility was the *Microsporum canslaslomyces*, followed by *Trichophyton mentagrophytes*, *Epidermophyton floccosum* and *Trichophyton verrucosum* [51]. Furthermore, it was also demonstrated that the MIC and minimum fungicidal concentration of the extract were 5.0 mg/mL against all four of the dermatophytes except for *Epidermophyton floccosum* (as it appears to be only fungistatic at that concentration) [51]. Nonetheless, these findings provide justification for its traditional use in treating many diseases such as skin diseases, gastroenteritis, ringworm, food poisoning, skin infection and upper respiratory tract infection.

According to Singh *et al*., the leaves of *S. alata* also possess anti-allergenic properties [44]. In this study, the hydroalcoholic extract of the leaves and two of its constituents, rhein and kaempferol were evaluated for its anti-mast cell degranulation activity [44]. Additionally, *in vitro* studies were also carried out to evaluate the inhibitory effects they have on the lipoxygenase (LOX) enzyme as the increased expressions of the enzyme have been linked with increased allergic reactions [44,52]. It was found that both the extract and the active constituents were able to significantly inhibit the mast cell degranulation at doses of 200 mg/kg and 5 mg/kg respectively [44]. However, only the extract and rhein was able to inhibit the LOX enzyme, while kaempferol appeared inactive against the enzyme [44]. According to Morris, rhein was also noted to have anti-carcinomic, anti-tumor and antiseptic properties [53]. Nevertheless, Singh *et al*. suggested that the anti-allergic properties of the leaves of this plant species were via the stabilization of mast cells and inhibition of the LOX enzyme [44]. These findings justify the traditional uses of the plant species for treating complications such as asthma and eczema.

Antioxidant compounds and activities of this plant species have also been reported in several other studies [54,55]. In a study by Panichayupakaranant and Kaewsuwan, the methanolic extract of the leaves of *S. alata* was determined to have the highest antioxidant activity when compared to the methanolic extracts of its flowers and pods [54]. It was also found that methanolic extract of the leaves has stronger antioxidant

activity when compared to the *n*-hexane extract and therefore, the methanolic extract of the leaves was subsequently purified to determine which compound contributed to the highest antioxidant activity [54]. The compound that produced the highest activity was determined to be kaempferol [54]. The antioxidant activity of the flavanol compound was found to be six times more active than that of butylated hydroxytoluene, and 58 times more active than that of emodin suggesting that kaempferols are the significantly active antioxidant compound in *S. alata* leaves [54]. Emodin is a major compound in the active fraction of the *Cassia tora* extract, however it was noted that since the pure isolated emodin did not exhibit a strong antioxidant activity as in the active fraction, the significant antioxidant activity could possibly be a minor component in the active fraction of *Cassia tora* [54]. Nevertheless, emodin was also noted to be one of the phytochemicals in *S. alata* and it was noted to have antiaggregant, anti-inflammatory, antimutagenic, antiseptic, antitumor (breast), antiulcer and spasmolytic properties [53]. In another study by Chatterjee *et al*., it was suggested that the good amount of phenols, vitamin C, vitamin A, flavonoids, carotenoids and anthraquinone in the extract also contributes to the strong antioxidant activity noted for the alcoholic extracts of the leaves of this plant species [55]. In addition to this, the study also showed that rabbits that have been administered with the extract displayed significant increase in blood hemoglobin and red blood cell count, leukocytes, peritoneal macrophages and the granulocyte/agranulocyte ratio [55]. This showed the strong immune-modulating or immune-stimulating potency of the aqueous leaf extract of the plant species, which can also be attributed to the phenols, vitamins, carotenoids and anthraquinone found in the plant [55]. In summary, this study also demonstrated apparent antioxidant activities and additional immune system stimulating properties of the *S. alata* leaves.

Additionally, Morris suggested that this plant species possesses anti-leukemic, antiseptic, anti-tubercular and anti-tumor properties as it contains the phytochemical, aloe-emodin that is known for these activities [53]. In addition, the plant species is also said to contain chrysophanol that is known to be antiseptic and haemostatic [53]. Moreover, the flavonoids, quercetin and kaempferols, found in the plant species have exhibited anti-pancreatic cancer properties [56]. Therefore, it is likely that the activity of this species is attributed to the presence of the combination of the phytochemicals of the plant species.

Scientific links to the treatments of the other notable complications by *S. alata* such as in sickle-cell anemia, hypertension and constipation are yet to be discovered. Nevertheless, it seems that these wide-ranging properties have contributed significantly to its effectiveness in treating the complications such as diabetes, hepatitis, skin diseases, gastroenteritis, eczema, ringworm, food poisoning, skin infection and upper respiratory tract infection traditionally.

8. Conclusion

This review summarizes the known literature in relation to some of the medicinal plant species found in Brunei Darussalam. All six plant species have been used varyingly for treatments and reliefs of different illnesses traditionally. It is evident that these plants possess great potential to become useful natural treatments for many modern day diseases. However, it is inevitable that further scientific exploration is required. Certain species such as *S. alata* have been reputed to have wide medicinal applications. However, their exact mechanisms are still uncertain. Thus, much more comprehensive studies need to be carried out to reveal the full potential of these plants for novel drug discovery.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

We wish to acknowledge the support from Universiti Brunei Darussalam and the Brunei Research Council (Grant No. JPKE/UBD/BRC6).

References

[1] Taib IS, Budin SB, Siti Nor Ain SM, Mohamed J, Louis SR, Das R, et al. Toxic effects of *Litsea elliptica* Blume essential oil on red blood cells of Sprague-Dawley rats. *J Zhejiang Univ Sci B* 2009; **10**(11): 813-9.

[2] Grosvenor PW, Gothard PK, McWilliam NC, Supriono A, Gray DO. Medicinal plants from Riau Province, Sumatra, Indonesia. Part 1: uses. *J Ethnopharmacol* 1995; **45**(2): 75-95.

[3] Bhamarapravati S, Pendland SL, Mahady GB. Extracts of spice and food plants from Thai traditional medicine inhibit the growth of the human carcinogen *Helicobacter pylori*. *In Vivo* 2003; **17**(6): 541-4.

[4] Suksamerkun W, Thongsomchitt S, Wongkrajang Y, Temsiririrkkul R, Kitphati W, Thongpraditchote S. Screening of antioxidant activity of vegetables in Thailand. *J Asian Assoc Sch Pharm* 2013; **2**: 254-61.

[5] Wong MH, Lim LF, Ahmad FB, Assim ZB. Antioxidant and antimicrobial properties of *Litsea elliptica* Blume and *Litsea resinosa* Blume (Lauraceae). *Asian Pac J Trop Biomed* 2014; **4**(5): 386-92.

[6] Rohani A, Nazni WA, Ngo LV, Ibrahim J, Lee HL. Adulticidal properties of the essential extracts of some Malaysian plants on vector mosquitoes. *Trop Biomed* 1997; **14**: 5-9.

[7] Hidayatulfathi O, Sallehudin S, Ibrahim J, Azizol AK. Evaluation of methanol extracts of some Malaysian plants for larvicidal activities. *Trop Biomed* 2003; **20**(2): 153-7.

[8] Hidayatulfathi O, Sallehuddin S, Ibrahim J. Adulticidal activity of some Malaysian plant extracts against *Aedes aegypti* Linnaeus. *Trop Biomed* 2004; **21**(2): 61-7.

[9] Jantan I, Zaki ZM. Development of evironment-friendly insect repellents from the leaf oil of selected Malaysian plants. ASEAN Review of Biodiversity and Environmental Conservation (ARBEC); November–December 1999. Available from: https://www.researchgate.net/publication/265321515_Development_of_environment-friendly_insect_repellents_from_the_leaf_oils_of_selected_Malaysian_plants [Accessed on 3rd July, 2015]

[10] Budin SB, Siti Nor Ain SM, Omar B, Taib IS, Hidayatulfathi O. Acute and subacute oral toxicity of *Litsea elliptica* Blume essential oil in rats. *J Zhejiang Univ Sci B* 2012; **13**(10): 783-90.

[11] Corners EJH. *Wayside trees of Malaya*. 4th ed. Kuala Lumpur: Malayan Nature Society; 1997.

[12] The simpur story. 2011. [Online] Available from: https://ictscience.files.wordpress.com/2011/09/the-simpur-story1.pdf [Accessed 8th August, 2016]

[13] Department of Agriculture. *Medicinal plants of Brunei Darussalam*. Revised ed. Brunei: Ministry of Industry and Primary Resources; 2000.

[14] Mat Salleh K, Latiff A. *Tumbuhan ubatan Malaysia*. Kuala Lumpur: Universiti Kebangsaan Malaysia; 2002.

[15] Ibrahim FH, Hamzah N. The use of medicinal plant species by the Temuan Tribe of Ayer Hitam Forest, Selangor, Peninsular Malaysia. *Pertanika J Trop Agric Sci* 1999; **22**: 85-94.
[16] Ahmad FB, Holdsworth DK. Traditional medicinal plants of Sabah, Malaysia Part III. The Rungus people of Kudat. *Int J Pharm* 1995; **33**: 262-4.
[17] Armania N, Yazan LS, Ismail IS, Foo JB, Tor YS, Ishak N, et al. *Dillenia suffruticosa* extract inhibits proliferation of human breast cancer cell lines (MCF-7 and MDA-MB-231) via induction of G2/M arrest and apoptosis. *Molecules* 2013; **18**: 13320-39.
[18] Armania N, Yazan LS, Musa SN, Ismail IS, Foo JB, Chan KW, et al. *Dillenia suffruticosa* exhibited antioxidant and cytotoxic activity through induction of apoptosis and G2/M cell cycle arrest. *J Ethnopharmacol* 2013; **146**: 525-35.
[19] Yazan LS, Ong YS, Zaaba NE, Mohd Ali R, Foo JB, Tor YS. Anti-breast cancer properties and toxicity of *Dillenia suffruticosa* root aqueous extract in BALB/c mice. *Asian Pac J Trop Biomed* 2015; **5**(12): 1018-26.
[20] Gülçin I, Mshvildadze V, Gepdiremen A, Elias R. Antioxidant activity of saponins isolated from ivy: alpha-hederin, hederasaponin-C, hederacolchiside-E and hederacolchiside-F. *Planta Med* 2004; **70**(6): 561-3.
[21] Sur P, Chaudhuri T, Vedasiromoni JR, Gomes A, Ganguly DK. Antiinflammatory and antioxidant property of saponins of tea [*Camellia sinensis* (L) O. Kuntze] root extract. *Phyther Res* 2001; **15**(2): 174-6.
[22] Xi M, Hai C, Tang H, Chen M, Fang K, Liang X. Antioxidant and antiglycation properties of total saponins extracted from traditional Chinese medicine used to treat diabetes mellitus. *Phyther Res* 2008; **22**(2): 228-37.
[23] Rodrigues HG, Diniz YS, Faine LA, Galhardi CM, Burneiko RC, Almeida JA, et al. Antioxidant effect of saponin: potential action of a soybean flavonoid on glucose tolerance and risk factors for atherosclerosis. *Int J Food Sci Nutr* 2005; **56**(2): 79-85.
[24] Smina TP, Mathew J, Janardhanan KK, Devasagayam TP. Antioxidant activity and toxicity profile of total triterpenes isolated from *Ganoderma lucidum* (Fr.) P. Karst occurring in South India. *Environ Toxicol Pharmacol* 2011; **32**(3): 438-46.
[25] Yoshida Y, Niki E. Antioxidant effects of phytosterol and its components. *J Nutr Sci Vitaminol (Tokyo)* 2003; **49**(4): 277-80.
[26] Scalbert A, Johnson IT, Saltmarsh M. Polyphenols: antioxidants and beyond. *Am J Clin Nutr* 2005; **81**(1 Suppl): 215S-7S.
[27] Rao AV, Gurfinkel DM. The bioactivity of saponins: triterpenoid and steroidal glycosides. *Drug Metabol Drug Interact* 2000; **17**(1–4): 211-35.
[28] Man S, Gao W, Zhang Y, Huang L, Liu C. Chemical study and medical application of saponins as anti-cancer agents. *Fitoterapia* 2010; **81**(7): 703-14.
[29] Harwood HJ Jr, Chandler CE, Pellarin LD, Bangerter FW, Wilkins RW, Long CA, et al. Pharmacologic consequences of cholesterol absorption inhibition: alteration in cholesterol metabolism and reduction in plasma cholesterol concentration induced by the synthetic saponin beta-tigogenin cellobioside (CP-88818; tiqueside). *J Lipid Res* 1993; **34**(3): 377-95.
[30] Rajput ZI, Hu SH, Xiao CW, Arijo AG. Adjuvant effects of saponins on animal immune responses. *J Zhejiang Univ Sci B* 2007; **8**(3): 153-61.
[31] Ono R, Ma ZJ, Yamaguchi M. Prolonged intake of fermented soybean diets with supplementation of isoflavone and saponin prevents bone loss in ovariectomized rats. *J Health Sci* 2000; **46**(1): 70-4.
[32] Niu Y, Li Y, Huang H, Kong X, Zhang R, Liu L, et al. Asperosaponin VI, a saponin component from *Dipsacus asper* wall, induces osteoblast differentiation through bone morphogenetic protein-2/p38 and extracellular signal-regulated kinase 1/2 pathway. *Phyther Res* 2011; **25**(11): 1700-6.
[33] Pandey KB, Rizvi SI. Plant polyphenols as dietary antioxidants in human health and disease. *Oxid Med Cell Longev* 2009; **2**(5): 270-8.
[34] Useful tropical plants. *Dillenia excelsa. Useful tropical plants*; 2014. [Online] Available from: http://tropical.theferns.info/viewtropical.php?id=Dillenia+excelsa [Accessed on 3rd July, 2016]
[35] Sustenance of Sambah Bagangan key to success of 3MPK tea. *The Brunei times*; 2011. [Online] Available from: http://www.bt.com.bn/news-national/2011/12/27/sustenance-sambah-bagangan-key-success-3mpk-tea [Accessed on 23rd January, 2016]
[36] Ata A, Mbong N, Iverson CD, Samarasekera R. Minor chemical constituents of *Vitex pinnata*. *Nat Prod Commun* 2009; **4**: 1-4.
[37] Setyowati FM. [Ethnopharmacology and usage of medicinal plant in Dayak Tunjung Tribe, East Kalimantan]. *Media Litbang Kesehatan* 2010; **20**(3): 104-12 [Indonesian].
[38] Meena AK, Niranjan US, Rao MM, Padhi MM, Babu R. A review of the important chemical constituents and medicinal uses of *Vitex* genus. *Asian J Tradit Med* 2011; **6**(2): 54-60.
[39] Khaizil Emylia Z, Siti Nurulsyuhada R, Noor Izani NJ, Hasmah A. Anti-proliferative activity of four species of Malaysian 'ulams' towards selected cancer cell lines. *Malays J Med Sci* 2008; **15**(Suppl 1): 147.
[40] Malek SN, Lee GS, Hong SL, Yaacob H, Wahab NA, Faizal Weber JF, et al. Phytochemical and cytotoxic investigations of *Curcuma mangga* rhizomes. *Molecules* 2011; **16**(6): 4539-48.
[41] Ahmed Hamdi OA, Syed Abdul Rahman SN, Awang K, Abdul Wahab N, Looi CY, Thomas NF, et al. Cytotoxic constituents from the rhizomes of *Curcuma zedoaria*. *ScientificWorldJournal* 2014; **2014**: 321943.
[42] Ramesh S, Rajasekar K, Venkata Raju RR. Preliminary phytochemical studies on leaves of *Vitex* species (Verbenaceae), used by the local adivasi communities of Andhra Pradesh. *World J Pharm Pharm Sci* 2013; **2**: 6143-50.
[43] Yakubu MT, Adeshina AO, Oladiji AT, Akanji MA, Oloyede OB, Jimoh GA, et al. Abortifacient potential of aqueous extract of *Senna alata* leaves in rats. *J Reprod Contracept* 2010; **21**(3): 163-77.
[44] Singh B, Nadkarni JR, Vishwakarma RA, Bharate SB, Nivsarkar M, Anandjiwala S. The hydroalcoholic extract of *Cassia alata* (Linn.) leaves and its major compound rhein exhibits anti-allergic activity via mast cell stabilization and lipoxygenase inhibition. *J Ethnopharmacol* 2012; **141**(1): 469-73.
[45] Chatterjee S, Chatterjee S, Dutta S. An overview on the ethno-phytopathological studies of *Cassia alata* - an important medicinal plant and the effect of VAM on its growth and productivity. *Int J Res Bot* 2012; **2**(4): 13-9.
[46] Essien EE, Walker TM, Ogunwande IA, Bansal A, Setzer WN, Ekundayo O. Volatile constituents, antimicrobial and cytotoxicity potentials of three *Senna* species from Nigeria. *J Essent Oil Bear Plants* 2011; **14**(6): 722-30.
[47] Jaabir MSM, Hussain AM, Afsar TS, Kumar SS. Study on the apoptotic properties of methanolic extracts of *Peltophorum pterocarpum*, *Cassia auriculata*, *Cassia alata* and *Lamprachaenium microcephalum*. *Biomed Pharm J* 2009; **2**(2): 381-5.
[48] Pieme CA, Penlap VN, Ngogang J, Kuete V, Catros V, Moulinoux JP. *In vitro* effects of extract of *Senna alata* (Ceasalpiniaceae) on the polyamines produced by leukaemia cells (L1210). *Pharmacogn Mag* 2009; **4**(17): 8-13.
[49] Varghese GK, Bose LV, Habtemariam S. Antidiabetic components of *Cassia alata* leaves: identification through α-glucosidase inhibition studies. *Pharm Biol* 2013; **51**(3): 345-9.
[50] Alalor CA, Igwilo CI, Jeroh E. Evaluation of the antibacterial properties of aqueous and methanol extracts of *Cassia alata*. *J Pharm Allied Health Sci* 2012; **2**(2): 40-6.
[51] Sule WF, Okonko IO, Omo-Ogun S, Nwanze JC, Ojezele MO, Ojezele OJ, et al. Phytochemical properties and *in-vitro* antifungal activity of *Senna alata* Linn. crude stem bark extract. *J Med Plants Res* 2011; **5**(2): 176-83.
[52] Plewako H, Holmberg K, Oancea I, Rak S. Increased expression of lipoxygenase enzymes during pollen season in nasal biopsies of pollen-allergic patients. *Allergy* 2006; **61**(6): 725-30.
[53] Morris J. Legume genetic resources with novel "value added" industrial and pharmaceutical use. In: Janick J, editor. *Perspectives on new crops and new uses*. Alexandria: ASHS Press; 1999, p. 196-201.

[54] Panichayupakaranant P, Kaewsuwan S. Bioassay-guided isolation of the antioxidant constituent from *Cassia alata* L. leaves. *Songklanakarin J Sci Technol* 2004; **26**(1): 103-7.

[55] Chatterjee S, Chatterhee S, Dey KK, Dutta S. Study of antioxidant activity and immune stimulating potency of the ethnomedicinal plant, *Cassia alata* (L.) Roxb. *Med Aromat Plants* 2013; **2**(4): 1-6.

[56] Morris JB. Characterization of medicinal *Senna* genetic resources. *Plant Genet Resour* 2009; **7**: 257-9.