Volume 1(2) July 2016

اونيۏرسيتي تيكنولوݢي مارا
UNIVERSITI
TEKNOLOGI
MARA

Borneo Akademika

ISSN 2462-1641

Borneo Akademika

BORNEO AKADEMIKA
UiTM CAWANGAN SABAH

(ISSN: 2462-1641)

Content

MOLLUSCICIDAL ACTIVITY OF THE PLANT *Acacia mangium* (Willd.) AGAINST THE SNAIL *Pomaceae canaliculata* (Lam.)

HENDRY JOSEPH[1], MUHAMMAD MU'IZZUDDIN ZULKAPLI[2], HASNIDAR ISKANDAR[3] & SHARMIZA SANIN[4]

[1]*Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA, Sabah Branch, Locked Bag 71, 88997 Kota Kinabalu, Sabah*
e-mail: hendry@sabah.uitm.edu.my

[2,3,4]*Faculty of Applied Sciences, Universiti Teknologi MARA, Sabah Branch, Locked Bag 71, 88997 Kota Kinabalu, Sabah*

ABSTRACT

The Golden Apple Snail (GAS) or *Pomacea canaliculata* as it is scientifically known, is a major pest of paddy. It can be managed by using cultural techniques, biological control and synthetic molluscicides. While bio-pesticide is an effective and safer alternative, economical mass production can be a constraint. In Sabah, the planting of *Acacia mangium* is an agroforestry initiative in the paper pulp industry, and efforts to recycle its industrial byproduct are suggested. Therefore this study aims to screen the beneficial phytochemical compounds of *Acacia mangium*, to test its molluscicidal activity, and to determine the effective dosage that can cause mortality on GAS. Phytochemical screenings of *Acacia mangium* methanol extract from the leaves, flower, and bark detected the presence of saponin, a class of chemical compound reported to be toxic to snails. The bark was particularly chosen due to its abundant availability as a processing byproduct. The molluscicidal activity was tested using dip bio-assay experiment. The test solution was prepared by mixing ground *Acacia mangium* bark with distilled water and the concentration was adjusted to 25 mg/ml, 50 mg/ml, 75 mg/ml, and 100 mg/ml respectively. *Furcraea selloa* var. *marginata*, a plant that has been reported to be toxic to GAS was used as positive control and prepared with similar concentrations while distilled water was used as negative control. The *Acacia mangium* aqueous extract recorded 100% snail mortality starting from the concentration of 50 mg/ml within 24 hours, similar to the *Furcraea selloa* var. *marginata* aqueous extract. Meanwhile, no mortality was observed in the negative control solution. The lethal concentration (LC_{50}) of *Acacia mangium* and *Furcraea selloa* var. *marginata* was identified at 25 mg/ml and 24 mg/ml respectively. The results from this study have confirmed the molluscicide effectiveness of *Acacia mangium* on GAS.

Keywords: *Acacia mangium*; *Pomacea canaliculata*; saponins; dip bio-assay

ABSTRAK

Siput gondang emas (SGE) atau nama saintifiknya *Pomacea canaliculata* adalah musuh utama tanaman padi. Siput ini boleh dikawal dengan kaedah kawalan kultura, kawalan biologi, dan racun siput sintetik. Pengunaan racun perosak biologi adalah pilihan yang selamat dan berkesan. Walaubagaimanapun, penghasilan racun perosak biologi secara besar-besaran belum dapat dilaksanakan. *Acacia mangium* adalah inisiatif perladangan hutani untuk industri pulpa dan kertas di Sabah. Usaha untuk mengitar semula sisa perindustrian telah dicadangkan, maka kajian ini dijalankan untuk mengesan kehadiran bahan kimia baik dari pokok *Acacia mangium*, menguji aktiviti racun siput, dan mendapatkan dos yang paling berkesan untuk membunuh SGE. Ujian fitokimia telah mengesan kehadiran saponin iaitu sejenis bahan kimia tanaman yang telah dilaporkan toksik terhadap siput. Kulit kayu *Acacia mangium* telah dipilih sebagai bahan kajian kerana ianya boleh diperolehi dengan banyak hasil dari sisa perindustrian. Kehadiran aktiviti racun siput diuji dengan kaedah rendaman. Bahan rawatan disediakan dengan mencampurkan kulit kayu *Acacia mangium* yang telah dihancurkan dengan air suling dan disediakan pada kepekatan 25 mg/ml, 50 mg/ml, 75 mg/ml, and 100 mg/ml. *Furcraea selloa* var. *marginata*, sejenis tumbuhan yang telah dibuktikan toksik kepada SGE digunakan sebagai kawalan positif dan disediakan pada kepekatan yang sama manakala kawalan negatif adalah menggunakan air suling. Ekstrak basah *Acacia mangium* didapati mencatatkan peratusan kematian siput sebanyak 100% pada kepekatan 50 mg/ml dalam masa 24 jam dan *Furcraea selloa* var. *marginata* juga memberikan keputusan yang sama. Tidak ada siput yang mati pada rawatan kawalan negatif. Kepekatan maut (LC_{50}) *Acacia mangium* dan *Furcraea selloa* var. *marginata* dicatatkan pada kepekatan 25 mg/ml dan 24 mg/ml. Hasil dari kajian ini telah mengesahkan keberkesanan *Acacia mangium* sebagai racun perosak biologi kepada SGE.

Kata kunci: *Acacia mangium*; *Pomacea canaliculata*; saponin; kaedah rendaman

1. Introduction

The major problem faced by farmers in paddy cultivation is pests and one of them is the Golden Apple Snail (GAS) or *Pomacea canaliculata* (Lam.). It is native to South America and was initially introduced to developing countries for commercial production (Anderson, 1993; Matienzo, 1984). The many unsuccessful events to commercialise the snail has led to its uncontrolled release into the open environment via floods and irrigation canals, proliferated to such an extent that they are now considered as one of the 100 worst invasive alien species in the world (ISSG, 2006). GAS was first reported in Malaysia in 1991 in the state of Kedah (Anon., 1992). Meanwhile, in Sabah it was first sighted in Keningau in 1992. Currently the total infested area in Sabah stands at 8000 ha (Teo, 2012). Among the suggested control measures for GAS are the cultural technique by handpicking and managing the water level (Teo, 1999), biological control by introducing ducks into the paddy field (Teo, 2001), and using synthetic molluscicides for example $CuSO_4$, metaldehyde and niclosamide (Halwart, 1994).

Bio-pesticides are natural products from plants that give a toxicity effect on pests and are gaining more attention because they are considered safer to humans, animals, and the environment. Some plants have been found to exhibit molluscicidal activities and among them are *Nicotiana tobaccum* (Tangkoonboribun & Sassanarakkit, 2009), *Furcraea selloa* var. *marginata* (Teo, 2012), *Azadirachta indica* (Rosdiyani & Siti Noor Hajar, 2012), *Moringa oleifera* (Coelho da Silva et al., 2013), *Camellia oleifera* (Kijprayyoon et al., 2014), and many others. The chemical compound that is responsible for the molluscicidal activities is saponin as reported by Huang et al. (2003), Sparg et al. (2004), San Martín et al. (2008), and Kijprayyoon et al. (2014). Saponin can cause apoptosis, an incident of uncontrolled cell death, and inflammatory responses that eventually lead to death of the snails (Hostettmann & Marston, 2005; Oleszek, 2002).

Acacia mangium (Willd.) belongs to the genus *Acacia* and is characterised by a large amount of substances in the wood structures. It was introduced in Malaysia as source of timber for the wood industry (Matsumura, 2011). The tree part of *Acacia mangium*, particularly the bark, is usually unwanted and the leave, unused. Since calls have been made for greater sustainability and an ecologically friendly environment, recycling of industrial byproducts is a good initiative. A previous study has reported the presence of triterpenoid saponin in *Acacia auriculiform* (Uniyal et al., 1992). Therefore, in this study we aim to screen the phytochemical constituents from the tree parts of *Acacia mangium* to assess its molluscicidal activity and to determine the effective dosage that can cause mortality on GAS.

2. Materials and Methods

2.1. *Source of GAS*

GAS were collected from the paddy fields in Kota Belud, authenticated and brought to the Science and Agrotechnololgy Laboratory Complex, *Universiti Teknologi MARA* (UiTM) Sabah, Kota Kinabalu Campus.

2.2. *Acclimatisation of GAS*
A number of healthy adult snails were allowed to acclimatise for 7 days in a plastic aquarium containing a 10 cm layer of soil which was taken from the paddy field. Thereafter, each aquarium was filled with 15-20 cm of distilled water and this was changed daily. During acclimatisation, the snails were supplied with untreated newly sprouted rice seedlings as their food source.

2.3. *Plant parts collection*
Disease-free and healthy leaves, flowers, and the bark of the *Acacia mangium* were collected from the Sabah Forest Development Authority (SAFODA) Research and Development Centre in Kinarut, Papar. The samples were cleaned, dried, and cut into small pieces. *Furcraea selloa* var. *marginata* were collected at *Unit Ladang*, UiTM Sabah, and used as positive control.

2.4. *Plant parts extraction*
The plant parts were cleaned and left to dry in an open shaded area. The dry samples were grounded into powder form with an electrical blender in order to provide a greater surface area (Redfern et al., 2014) To obtain a solvent extract, 20 g of the finely powdered dry sample was homogenised in 200 ml of methanol (0.1 w/v), was left overnight, and filtered with Whatman No.1 sterilised filter paper. The filtrate was then evaporated using Rotary Vacuum Evaporator (EYALA OSB-2400) with a temperature of 50°C (Zhang et al., 2010) at 150 rpm. The whole process was repeated to obtain 0.2 w/v and 0.3 w/v of plant crude extracts.

2.5. *Phytochemical screening*
A range of phytochemicals was tested, specifically saponin, phenol, protein (Tiwari et al., 2011), tannins (Obi et al., 2011), flavonoids (Aliyu et al., 2012), steroids (Harborne, 1973), terpenoids (Yadav & Agarwala, 2011), glycosides (Jigna & Chanda, 2007), and alkaloids (Rasool et al., 2010).

2.6. *Aqueous plant extraction*
All plant samples were cleansed by washing them with tap water, dried in an oven for 48 hours, cut into small pieces, and ground into powder form. The powder was weighed separately to 37.5 g, 75.0 g, 112.5 g, and 150.0 g respectively with a digital electronic balance and then mixed with 1500 ml of distilled water to get the concentration of 25 mg/ml, 50 mg/ml, 75 mg/ml, and 100 mg/ml. Distilled water was used as a negative control. The solutions were allowed to mix well for 48 hours before they were filtered through a sieve for removal of suspended particles. The solutions were kept at 4°C until the dip bio-assay was conducted (Siti Noor Hajjar et al., 2012).

2.7. *Dip bio-assay*
The aqueous extraction of *Acacia mangium* and *Furcreae selloa* var. *marginata* were tested against adult *Pomacea canaliculata* according to the method recommended by the World Health Organization (Molla et al., 2013; WHO, 1983). Four different concentrations of the aqueous extraction were tested, each with three replicates of 10 snails. The snails were kept in containers with 300 ml of testing solutions for 24 hours and were statistically arranged according to a completely randomised design (CRD). Tests were carried out at room temperature (28±2 °C). After 24 hours of exposure, the suspension was decanted, the snails were rinsed thrice with distilled water and transferred into fresh distilled water and maintained for another 24 hours for recovery. All groups were observed carefully after 24 hours and the number and the percentage of mortality in each group was calculated. The snails were considered dead if they could not move or retract well into or hang out of the shell, with the body and shell discoloured (Singh & Singh, 2009; Vijay, 2010). The LC_{50} was estimated using probit analysis (Finney, 1971).

2.8. *Data analysis*

The data was analysed using the two-way ANOVA with 95% confidence interval followed by Fishers least significant different (LSD) to separate the means using the IBM SPSS Statistical Version 21.0 software.

3. Results and Discussion

3.1. *Phytochemical screening*

All the phytochemical secondary metabolites that were screened in this study were detected. Saponin was detected in all parts of the *Acacia mangium*, from the bark, leaves, and flower (Table 1). Saponin compounds are beneficial and possess insecticidal and molluscicidal activities since it has a broad and fast-working effect against insect pests (De Geyter et al., 2007) and moluscus (Kijprayyoon et al., 2014).

Alkaloids were detected in all parts of the *Acacia mangium* which were the bark, leaf, and flower (Table 1). The presence of alkaloid compounds in the plant indicates toxic properties (Wink, 2004). However, Schiff (2002) reported that it could also be used as a pain reliever.

Colour changes to reddish-black indicated the presence of terpenoids in the plants. Terpenoids are responsible for antibacterial and antiviral actions (Cock and Kukkonen, 2011). According to Giardi et al. (2010) terpenoids can be used as a substance to reduce cancer cells.

Table 1: Phytochemical screening of the leaf, bark and flower extract of *Acacia mangium*

Plant constituents	Extracts of *Acacia mangium*			Colour changes
	Leaf	Bark	Flower	
Saponin	Detected	Detected	Detected	The formation of layers after indicates the presence of saponin
Alkoloids	Detected	Detected	Detected	The formation of white precipitate indicates that alkaloids were detected
Phenol	Detected	Detected	Detected	The colour reddish-blue determines that the phenolic compound is present
Flavonoids	Detected	Detected	Detected	The yellowish colour shows that flavonoids were detected
Terpenoids	Detected	Detected	Detected	The colour changed to reddish-black and this indicates that the presence of terpenoids
Tannins	Detected	Detected	Detected	The colour of the plant extract changed to greenish-black and this indicates that tannins were detected
Quinoine	Detected	Detected	Detected	Reddish-black colour formed indicates the presence of quinoine
Glycoside	Detected	Detected	Detected	Greenish-blue colour formed indicates the presence of glycoside
Steroids	Detected	Detected	Detected	The colour of the plant extract turned to blue-black and this indicates that steroids were detected
Proteins	Detected	Detected	Detected	Blue colour determines that the plant contains proteins compounds

The presence of phenolic compunds is consistent in all parts of the plants. According to a study by Zhang et al. (2010) the most concentrated phenolic compound can be found in the bark. The results from Table 1 show that the compound can also be found in the leaf and flower. These compounds are strong antioxidants that can be beneficial to living things (Zhang et al., 2010). Santi et al. (2010) reported that this phenolic compound is essential in plant-microbes interaction, and it can also be used as an antimicrobial agent against pathogens (Lattanzio et al., 2006).

Flavonoid compounds also appear as one of the compounds detected in the *Acacia mangium* extract. Umi Kalsom et al. (2001) stated that flavonoid compounds from *Acacia mangium* have the potential to be the substances that support plant growth since they act as antioxidants that react against free radicals during photosynthesis.

Tannin compounds that were present in the plant appeared constantly in each of the plant parts of *Acacia mangium*. It has been know to give a pesticide effect to insects (Freeman & Beattie, 2008). Dykes and Rooney (2007) reported that plants that are rich in tannins are not preferred by birds and insects.

Quinoline in the plant extract has a wide range of benefits including as an antimalarial, antifungal and antibacterial agent (Mohammad et al., 2013). Glycoside components also appeared in the plant extracts. Glycoside has a wide range of characteristics that include antimicrobial, anti-insect, and allelopathic activities which can be used in plant protection (Asri, 2013).

Steroids and proteins were also detected in the screening. Proteins are a very important food source. According to Freeman and Beattie (2008), defensive protein and enzymes are able to suppress the growth of fungi, bacteria, insects, and nematodes. The presence of the bioactive agent in the plants can act as a defence compound against microbes (Wink, 2004) and can be useful in therapeutic treatments.

3.2. *Molluscicidal activity of Acacia mangium*

Snail mortality at 100% was observed starting from the concentration of 50 g/ml for *Acacia mangium* and *Furcraea selloa* var. *Marginata* (the positive control) extracts. There is no significant different (*$P<0.05$*) of snail mortality rate after 24 hours between *Furcraea selloa* var. *Marginata* and *Acacia mangium* (Table 2), which means *Acacia mangium* could be a potential substitute to *Furcraea selloa* var. *Marginata* as molluscicide against GAS.

Table 2: The means of mortality of GAS in *Acacia mangium* and *Furcraea selloa* var. *marginata* aqueous extract.

		Aqueous extract concentration			
		25 mg/ml	50 mg/ml	75 mg/ml	100 mg/ml
		Means of mortality			
Treatment	*Furcraea sp.*	60.00 a	100.00 a	100.00 a	100.00 a
	Acacia sp.	53.33a	100.00 a	100.00 a	100.00 a
	Control	0.00b	0.00 b	0.00 b	0.00 b

* *Means within column followed by the same letters are not significantly different as determined by least significant difference at $P<0.05$.*

3.3. *Effective dosage of plant's aqueous extract*

The Probit Analysis Programme was used to determine the lethal concentration (LC_{50}) of *Acacia mangium* and *Furcraea selloa* var. *marginata*. The current practical bio-molluscicide is the plant extract from *Furcraea selloa var. Marginata* (which is used as the positive control in this study) and this recorded the lowest LC_{50} at 24 mg/ml. Meanwhile for *Acacia mangium* $LC_{50,}$ it is slightly higher at 25 mg/ml. Again, the data from the Probit analysis also suggests that *Acacia mangium* is a potential molluscicide against GAS.

4. Conclusion and Recommendation

Acacia mangium has the potential to act as a bio-pesticide against GAS. Its molluscicidal activities are as potent as that of the *Furcraea selloa* var. *marginata*, a garden plant that was reported earlier to have good mollucicidal activities on GAS. Both *Acacia mangium* and *Furcraea selloa* var. *marginata* gave 100% snail mortality at the concentration of 50 mg/ml. The LC_{50} for *Acacia mangium* is 25 mg/ml compared to 24 mg/ml for *Furcraea selloa* var.

marginata. In order to get a more stable data, a smaller dose of concentration within the range of 25 mg/ml to 75 mg/ml should be tested in future studies. This will reflect a specific rate of mortality on specific concentrations of *Acacia mangium* aqueous extracts. In addition, *in-vivo* studies need to be carried out to observe its effectiveness in the field, as GAS are known to be fitter in their natural environment. Different extraction methods are also suggested because recent studies have shown that a lower LC_{50} was achieved using the alcohol extraction method.

References

Aliyu, R.M., Dabai, Y.U., & Kaw, A. H. (2012). Phytochemical screening and antibacterial activity of the leaf and root extracts of Senna italic. *African Journal of Pharmacy and Pharmocology*, *6*(12), 914-918.

Anderson, B. (1993). The Philippines snail disaster.*The Ecologist*, *23*, 70-72.

Anon (1992). Status Report in the occurrence of *Pomacea* spp., in Peninsula Malaysia. Department of Agriculture (Malaysia).

Asri Insiana Putri (2013). Preliminary Research: In Vitro Selection of *Falcatariamoluccana* (Miq.) Barneby & J.W. Grimes with *Uromycladium tepperianum* (Sacc.) McAlpine Extract Compounds. Proceedings of The Second International Conference of Indonesia Forestry Researcher (INAFOR). 27-28 August 2013. Jakarta, Indonesia.

Cock, I.E. and Kukkonen, L. (2011). An examination of the medicinal potential of *Scaevola spinescens*: Toxicity, antibacterial, and antiviral activities . *Phcog Res*, *3*, 85-94.

Coelho da Silva C.L.P.A., Tatiana, S.V., & Darcilio, F.B. (2013). Molluscicidal activity of *Moringa oleifera* on *Biomphalaria glabrata*: Integrated dynamics to the control of the snail host of *Schistosoma mansoni*. *Rev. Bras. Farmacogn*., *23*, 848 – 850.

Dykes, L., & Rooney, L. W. (2007). Phenolic compounds in cereal grains and their health benefits. *Cereal Foods World*, *52* (3), 105-111.

De Geyter, E., Lambert, E., Geelen, D., & Smagghe, G. (2007). Novel advances with plant saponins as natural insecticides to control pest insects. *Pest Technology*, *1*(2), 96-105.

Finney, D. J. (1971). Probit analysis (3rd edition). Cambridge: Cambridge University Press.

Freeman, B.C., & Beattie, G. A. (2008). An overview of plant defenses against pathogens and herbivores. *The Plant Health Instructor*. DOI:10.1094/PHI-I-2008-0226-01.

Giardi, M.T., Rea, G., & Berra, B. (2010). Bio-Farms for Nutraceuticals: Functional Food and Safety Control by Biosensors. Landes Bioscience, 1002 West Avenue, Austin, Texas 78701 USA.

Halwart, M. (1994). The golden apple snail *Pomacea canaliculata* in Asean rice farming systems: Present impact and future threat. *International Journal of Pest Management*, *40*, 199-206.

Harborne, J.B. (1973). Phytochemicals Methods. Chapman and Hall Ltd., London.

Hostettmann, K., & Marston, A. (2005). Saponins. Chemistry and pharmacology of natural products. Cambridge: Cambridge University Press.

Huang, H. C., Liao, S. C., Chang, F. R., Kuo, Y. H., & Wu, Y. C. (2003). Molluscicidal saponins from *Sapindus mukorossi*, inhibitory agents of golden apple snail, *Pomacea canaliculata*. *JAgr Food Chem*, *51*, 4916-9.

ISSG (2006). Invasive species specialist group. The World Conservation Union. Retrieved September 24, 2013 from http://www.issg.org/S.

Jigna P., & Chanda, S. (2007). Antibacterial phytochemical studies on twelve Indian medical plants. *African Journal of Biomedical Research*, *10*, 175-181.

Kijprayoon, S., Vasana, T., Amorn, P., & Chanya, C. (2014). Molluscicidal activity of *Camellia oleifera* seed meal. *ScienceAsia*, *40*, 393-399.

Lattanzio, V., Veronica, M. T. Lattanzio, & Angela, C. (2006). Role of phenolics in the resistance mechanisms of plants against fungal pathogens and insects phytochemistry. Advances in Research, 37(2) 23-67.

Matienzo, L. H. (1984). Wilson Ang's big foot snails. *Greenfields*, *14*, 24-29.

Matsumura, N. (2011). Yield prediction for *Acacia mangium* plantations in Southeast Asia. *FORMATH*, *10*, 295–308.

Mohammad, M. A., Akranth, M., Om, P. T., Rikta, S., Mohammad, R. A., Sandeep, S., M. A., & Mohammad, S. (2013). Quinoline: A versatile heterocyclic. *Saudi Pharm J.*, *21* (1), 1–12.

Molla, E., Giday, M., & Erko, B. (2013). Laboratory assessment of the molluscicidal and cercariacidal activities of *Balanites aegyptiaca*. *Asian Pacific journal of tropical biomedicine*, *3*(8), 657–662.

Obi, R.K., Nwanebu, F.C., Onuoha, N., & Chieboka, N. (2011). Ethanolic extraction and phytochemical screening of two Nigerian herbs on pathogens isolated from wound infections. *Pharmicieglobale (ijcp)*, *10*(02) 1-10.

Oleszek, W.A. (2002). Chromatographic determination of plant saponins. *Journal of Chromatography*, *A.967*,147-162.

Rasool, R., Gandi, B. A., Akhbar, S., Kamili, A. N., & Masoid, A. (2010). Phytochemical screening of *Prunella vulgaris* L. an important plant of Kashmir. *J. Pham. Sci.*, *23* (4), 402-899.

Redfern, J., Kinninmonth, M., Burdass, D., & Verran, J. (2014). Using soxhlet ethanol extraction to produce and test plant material (essential oils) for their antimicrobial properties. Journal of Microbiology and Biological Education. 15(1); 45–46.

Rosdiyani, M., & Siti Noor Hajar, M.L. (2012). Neem crude extract as potential biopesticide for controlling Golden Apple Snail *Pomacea canaliculata*. Pesticides – *Advances in Chemical and Botanical Pesticides*. http://dx.doi.org/10.5772/48626.

San Martín, R., Ndjoko, K., & Hostettmann, K. (2008). Novel molluscicide against *Pomacea canaliculata* based on quinoa (*Chenopodium quinoa*) saponins. *Crop Protection*, *27*(3-5), 310–319.

Santi M Mandal, Dipjyoti Chakraborty, & Satyahari Dey (2010). Phenolic acids act as signaling molecules in plant-microbe symbioses. *Plant Signaling & Behavior*, *5*(4), 359–368.

Schiff, P. L. (2002). Opium and its alkaloids. *American Journal of Pharmaceutical Education, 66*(2), 186-194.

Singh, A., & Singh, V. K. (2009). Veterinary parasitology molluscicidal activity of Saracaasoca and Thujaorientalis against the fresh water snail *Lymnaea acuminata*, *Veterinary parasitology*, *164,* 206–210.

Siti Noor Hajjar, M. L., Mohd Zaidi, L., & Anis Syahirah, A. B. (2012). The potential of Citronella Grass, *Cymbopogon nardus* as biopesticides against *Plutella Xylostella*. Proceedings of the Universiti Malaysia Terengganu 11th International Annual Symposium on Sustainability Science and Management. 9-11 July 2012. Kuala Terengganu, Malaysia.

Sparg, S. G., Light, M. E., & Staden, J. V. (2004). Biological activities and distribution of plant saponins. *Journal of Ethno pharmacology*, *94,* 219–243.

Tangkoonboribun, R., & Sassanarakkit, S. (2009). Molluscicide from tobacco waste. *Journal of Agricultural Science*, 1(1), 76-81.

Teo, S. S. (1999). Control of the golden apple snail (*Pomacea* spp.) by handpicking using herbage as attractants. Proceedings of the MCB-MAPPS Plant Protection Conference'99 on Sustainable Crop Protection Practices in the Next Millennium. 2-3 November, 1999, Kota Kinabalu, Sabah, Malaysia.

Teo, S. S. (2001). Evaluation of different duck varieties for the control of the golden apple snail (*Pomacea canaliculata*) in transplanted and direct seeded rice. *Crop Protection*, *20,* 599-604.

Teo, S. S. (2012). Golden apple snail (*Pomacea canaliculata* Lamarck, 1819) in Sabah, Malaysia – Current situation and management strategy. Proceedings of the Third International Plantation Industry Conference and Exhibition 2012: Meeting the Future Challenges of Plantation Industry through Innovation and Talent Management. 5-7 November 2012. Le-Meridien Hotel, Kota Kinabalu, Sabah.

Tiwari, P., Kumar, B., Kaur, M., Kaur, G., & Kaur, H. (2011). Phytochemical screening and extraction: A review. *International pharmaceuticasciencia, 1*(1), 98-106.

Umi Kalsom, Y., Khairuddin, H. I., & Zakri, M. M. (2001). Flavonol glycosides from the leaves of *Acacia mangium* and related species. *Malaysian Journal of Analytical Sciences, 1*(7), 109-112.

Uniyal, S.K., Badoni, V., & Sati, O. P. (1992). A new triterpenoid saponin from *Acacia auriculiformis*. *J. Nat. Prod*., *55,* 500-502.

Vijay, P. (2010). Evaluation of molluscicidal activity of some Indian medicinal plants against *Lymnaea acuminate. Int J ApplBiol Pharm Technol*, *1*, 308-311.

WHO (1983). Report of scientific working group on plant molluscicide and guidelines for evaluation of plant molluscicide. *South African Journal of Science*, *93,* 298-606.

Wink, M. (2004). Phytochemical diversity of secondary metabolites. Encyclopedia of Plants and Crop Science. Taylor and Francis, Amsterdam, pp 915-919.

Yadav, R. N. S., & Agarwala, M. (2011). Phytochemical analysis of some medicinal plants. *Journal of Phytology*, *3*(12), 10-14.

Zhang, L. L., Chen, J., Wang, Y., Wu, D., & Xu, M. (2010). Phenolic extracts from *Acacia mangium* bark and their antioxidant activities. *Molecules*, *15*(5), 3567-3577.