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A Review: The Prospects of Wild Zingiberaceae *Elettariopsis Slahmong* to Be Developed as Green Pesticide

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ABSTRACT

Currently, Indonesia's national program for controlling pests and pathogens focus on utilize local plant genetic resource for biopesticide. This study describes the potentiality of essential oils of *Elettariopsis slahmong* CK Lim as biopesticide. The effective biopesticide effects of the essential oil of *E. slahmong* against pests and pathogens on some Indonesia's important agriculture crops have proven during the studies since 2012. Studies have been carried out at the laboratory of plant protection Biology Department Andalas University in Padang, the laboratory of biochemistry Chemistry Department Andalas University, the laboratory of plant protection at Research Station of Bogor Research Institute for Spice and Medicinal Plants in Solok, Tropical Fruit Research Institute in Solok, Faculty of Agriculture Kagoshima University Japan, cacao plantation (farmer property) in Pariaman, commercial cacao plantation in Agam, rubber plantation in Sijunjung and red dragon fruit and banana plantations in Padang (all of these districts are in the Province of West Sumatra) and oil palm plantation in the Province of South Sumatra. The significant bio-insecticide and bio-fungicide effects have indicated against *Helopeltis antonii*, *Setora nitens, Drosophilla melanogaster, Trigona minangkabau, Colletotrichum gloeospoiroides, Phytophthora palmivora* and *Rigidoporus macroporus*, either *in-vitro* or *in-planta*. Essential oils of *E. slahmong* - distilled from either the leaves, the rhizomes or the pseudostems - displayed the highest biopesticide inhibitory activity compared with other essential oils produced by *Cinnamomum burmanii* and *Syzygium aromaticum*. Seven fractions of essential oils of *E.*

slahmong were resulted by using GC-MS and study which of the chemical constituents of the oil has the main role and involve as biopesticide, is being investigated.

Keywords: local genetic resources, *Elettariopsis slahmong*, important agriculture crops, biopesticide, fractions.

INTRODUCTION

The excessive use of chemical inputs to control insect pests and pathogens poses an important problem for present-day plant production systems, health, and environment. Therefore, world's current research priorities for alternative management practices compatible with wise sustainable agriculture and the environment, include the use of plants as the source for biopesticide. Indonesia's national program for controlling pests and pathogens focus on utilizing local plant genetic resource for biopesticide, in the attempt to reduce the use of chemical pesticide. The use of chemical pesticide in crop pest control around the world has caused tremendous damage to the environment, pest resurgence pest and pathogen resistance, lethal effects on non-target organism and very high cost. In Indonesia, there are 7500 plant species have been reported have the medicinal values due to their antimicrobials activities, but only 940 species have been studied (1). This statement implied that these 7500 plants also have a great potentiality to be developed as biopesticide.

Biopesticides are the effective formulated form of active ingredients such as plant extracts (essential oils) to control pests and pathogens, that are highly effective, target specific and could reduce harm to ecological chains (2, 3). The secondary metabolites in plants have been used in the formulation through increase the effectiveness of biopesticide compounds used to reduce the spread of pests and pathogens, while minimizing side effects for being: rich source of bioactive chemicals, biodegradable in nature and eco-friendly. The reality, however is that biopesticide represent only a small fraction of the world pesticide market. The total world production of biopesticide is over 3,000 tons/year compared with the market share of biopesticide which is only 2.5% of the total pesticide market (4).

The considerable research interest in the area of natural product delivery, including various plants in the family Zingiberaceae: *Zingiber officinale, Z. zerumbert, Z. cassumunar, Curcuma xanthorrhica, C. longa, C. zedoria* and *Elettariopsis curtisii* have been frequently reported to have protective effects against insects pests and pathogens (5, 6) but wild zingiberaceae *Elettariopsis slahmong* CK Lim. To my knowledge, this is the first series of studies in using *E. slahmong* as a biopesticide which is currently develops at Biology Department, Faculty of Mathematics, and Natural Sciences-Andalas University in Padang West Sumatra Indonesia (7-11).

Botany and use of *Elettariopsis slahmong* CK Lim

Elettariopsis is a small genus of the family Zingiberacea in the major group Angiosperms (flowering plants) includes 30 species, of which 20 are distributed in Southeast Asia (10, 11). Some of species that can often be found in the wild in Peninsular Malaysia are *E. smithiae* Y.K Kam, *E. rugosa (*Y.K. Kam) C.K. Lim, *E. curtisii* Baker, *E. elan* C. K. Lim, and *E. slahmong* C. K. Lim (12-15).

E. slahmong is a creeping rhizome herbs, 50-145 cm tall, with two to six green leaves and forming pseudostem. Like the other species of this genus, the fruit is globular but the inflorescence is produced from short basal shoots (12). Among the genus of *Elettariopsis*, *E. slahmong* is highly aromatic with the 'stink bug' odor, distinguished from the other species (16, 17). According to Picheansoonthon and Yupparach (24), the habit of this plant group will pop up in the rainy season. In the Province of West Sumatra Indonesia, this plant is found in wet and shade area under canopy of trees in the forests of the Districts of Padang, Agam, Padang Panjang, Tanah Datar, Pasaman, Sijunjung and Solok (15, 17, 18). West Sumatra is part of the 1650 km mountain chains in the tropical rain forest region along Sumatra Island. Leaf of *E. slahmong* is used for culinary for salad and flavoring curry fish in Indonesia, Thailand and Malaysia, (19-22), but there is no report has been mentioned as a biopesticide previously.

Figure-1: *Eletariopsis slahmong* CK Lim (left) and seven fractions of *E. slahmong* with different volume, color and odor (right).

(left, doc. Nasril Nasir 2013) (right, doc. Nasril Nasir 2014)

Essential oils of *Elettariopsis slahmong*

Essential oil is the major chemical constituent of all parts of the *Elettariopsis* species. Terpenes, particularly monoterpenes and scenessquiterpenes, are the major constituents of this essential oil (23). It is volatile at temperature room, hence the name volatile oil or ethereal oil. *E. slahmong* is the most volatile amongst the species of *Elettariopsis.* The scent of particularly crushed leaves of *E. slahmong* has a strongly aromatic herb with the distinctive odor of the "stink bug" (23-25). The stink bug odor of *E. slahmong* probably be attributed to (E)-2-octenal and (E)-2-decenal (26) as it was also detected by Nasir *et al* (19) and Nasir (20). The difference in scence reflects the difference in volatile chemical compositions, mainly monoterpenoids and sesquiterpenoids.

During these studies, plants were collected from different forests in several districts of the Province of West Sumatra. The plants were separated into leaves, rhizomes and pseudotems. All part of the plants was cleaned and washed with water and chopped into small pieces (1-2 cm long), then the fresh chopped were immediately processed to produce essential oil (17). The essential oil of *E. slahmong* was resulted by steam distillation of the rhizomes, leaves and pseudostem.

Essential oil constituent of *E.slahmong* was analyzed by GC-MS and 90 different compounds have been identified whereas 80 were from leaf oil (19, 20). This result differed with Wong *et al* (27) which have found 32 constituents from *E. slahmong* by GC-MS analyses. According to Chairgulprasert *et al* (1), the constituents of the extract can be adjusted by varying the method of extraction. There was no report from Wong *et al* (28, 29) that fractionation work had been done. In these studies, with the collaboration with Prof. Fumio Hashimoto from Kagoshima University Japan, seven fractions were obtained (**Figure 1**) (16). The constituents of leaf, rhizome and four fractions are listed at **Table 1**.

Table-1:is here Essential oil constituents (>1%) of rhizome, leaf and fractions of *Elettariopsis slahmong* analyzed by GC-MS

Essential oil of	Compound
Leaf	2-decanoic acid (48,04%), nonanoic acid (9,18%), 2-octenal (8,97%), nonanal 2,96%, octanal 1,20% and 75 other constituents (< 1%).
Rhizome	2-Tridecenal (39,81%), 2-decanoic acid (27,78%), 2-octenal (7,56%), nonanoic acid (3,85), nonanal 1,33%, eucalyptol (2,13%), octanal 1,09 % and more than 40 other constituents (< 1%).
Fraction 1	2-decanoic acid (31,65%), 2-octenal (17,01%), decenal (12,40%), 6-tetradecene (4,08%), nonanoic decen-1-ol acid (1,37%), and 51 other constituents (< 1%).
Fraction 2	2-Tridecenal (26,57%), decanal (25,65%), 2-octenal (7,72%), octanal 6,86%, 2-decenyl acetat (5,44%), dedecenal (2,35%) and more than 30 other constituents (< 1%).
Fraction 3	(18,82%), decanal (12,95%), decenal (10,55%), octanal (8,42%), 6 tetradecene (3,24%), octenal (1,56%) and 66 other constituents (< 1%).
Fraction 4	2-Tridecenal (19,41%), 2-dimethyl(3cloropropyl)sililoxymethyltetra (16,99%), 2-octenal (16,08%), 1-ethyl-1-(undec-10-enyl)oxy-1-silacyclopenta (16,99%), decanal (2,87%), octanal (2,84%), 6-tridecene (2,79%) more than 30 other constituents (< 1%).

Biopesticide of *Elettariopsis slahmong*

Many *Elettariopsis* species have previously been studied for the chemical compositions of their essential oils, mainly for medicinal purpose such as *E. biphylla* (Chumroenphat *2*), *E. curtisii* (7, 29, 30), *E. elan* (29), *E. rugosa* and *E. smithiae* (30) and *E. wandokthong* (27), but none have been used for biopestsicide, as it is being conducted in this study. As part of an extensive of on-going study to investigate the prospect of West Sumatra's germplasms as natural pesticide sources, my team and I focus our work on the biopesticide potentiality of wild Zingiberaceae *E. slahmong* since 2012 at Andalas University.

During this study, the biopesticide effects of the essential oils of the leaves, rhizomes, pseudostems and the fractions of *E. slahmong* were tested on the insect pests of cacao, oil palm and banana. For the pathogens, tests were limited on fungi which caused disease on cacao, dragon fruit, rubber, and chili. During the studies of using this essential oil against the insect pest *Helopeltis antonii* (Miridae) on cacao *Theobroma cacao* L, *Setoria nitents* (Limacodidae) on oil palm *Elaeis guineensis* Jacq and two insect vectors *Trigona minangkabau* (Apidae) and *Drosophila melanogaster* (Drosophilidae) of banana blood disease bacterium (caused by *Ralstonia solanacearum* Phylotype IV), as well as the pathogens these were *Phytopthora palmivora* on cacao *Theobroma cacao* L, *Rigidiporus macroporus* on rubber *Hevea brasiliensis* (Muell) Arg, *Colletotricum gloeosporioides* on red dragon fruit *Hylozirius polyrhizus* (Weber) Britton & Rose - including when the essential oil of *E. slahmong* was combined with the essential oils produced by other plants sources, - results showed that insects population and pathogens proliferation were greatly reduced (8, 16,19-21). The agriculture commodities being involved in these studies are the important agricultural crops, either in supporting the programs of national food and economic security or international agriculture trade of Indonesia.

Track record of studying essential oils of *E. slahmong* as a biopestsicide in West Sumatra:

Investigation on the potentiality of essential oil of *E. slahmong* as a biopesticide has initiated since 2012 at Biology Department Andalas University in Padang West Sumatra. Studies have collaborated national and internationally with agriculture research institutions, universities, group of farmers and private commercial plantations involving students at bachelor and post graduate levels from departments of plant protection, biology and chemistry. Results of these studies have been published in accredited national and international journals and presented at National Conference of (Buah Nusantara) Indonesia's Fruits in Bukittinggi Indonesia (2013); 65th International Symposium on Crop Protection in Brussels Belgium (2013); Asian Conference on The Life Sciences & Sustainability in Hiroshima Japan (2014); 1st National Symposium of Aromatic and Essential Oils in Padang Indonesia (2014); International Workshop of Research Collaboration in Kagoshima Japan (2014); International Conference on Biopesticide 7 in Antalya Turkey(2014) and 10th Flora Malesiana Conference in Edinburg UK (2016)**.**

From international research collaboration with Kagoshima University Japan, essential oil of *E. slahmong* has successfully been fractionated into seven fractions by using GC-MS. The seven fractions have different volume, color and odor (16) (**Figure 1**). According to Picheansoonthon and Yupparach (24), *E. slahmong* produce a stink bug odor which is recognized by Nasir *et al* (17,18) similar to the odor of insecticide **methidathion, a**n organophosphate insecticide which was banned since in the middle of 1990s in Indonesia. Study to find out constituents of the essential oil of *E. slahmong* as main biopesticide component is being observed. The essential oils of *E. slahmong* and the mixtures (essential oils of *Syzigium aromaticum* and *Cinamomum burmanii*) which were used in these studies were formulated in 25% composition each.

As bio-insecticide

From continuation of laboratories and field works during four years studies, essential oil of *E. slahmong* has proven as a bio-insecticide. Mortality and antifeedant responses of *Drosophilla melanogaster*, which was treated with this essential oil were 44% and 98% (17). *D. melanogaster* is one the active insect vectors of banana blood disease bacteria (*Ralstonia solanacearum)* (13). While *Trigona minangkabau,* the most active and dangerous insect vector of *R. solanacearum* (13), was found paralyzed 44% within 7 minutes and died 70% in 11 minutes after treated with 2 ppm of formulated essential oil of *E. slahmong* /L of water (18). However, when the formula was applied to control *T. minangkabau* on local cooking banana cultivar (Kepok variety) at field, damaged black burned dots on the banana skin occurred. Study regarding to the side effect on banana's skin is being conducted.

At a small scale of cacao plantation (0.5 ha) with the average of 2.5 m plant high in the District of Padang Pariaman, using 1.6 L/ha of formulated essential oil of *E. slahmong* successfully decreased *H. antonii* population up to 78% (18). While at a 400 ha private commercial cacao plantation in the District of Agam consist of 8 -10 years plant age and 2.5-3.0 m plant height, by using 1.6 L/ha of formulated essential oil of *E. slahmong* and the mixture of 0.8 L/ha formulation essential oil of *E. slahmong* which was added with 0.8 of L/ha essential oil of *Cinnamomum burmanii*, suppressed the population of *H. antonii* significantly up to 75.96% and 74.70% six weeks after application. The efficacy of the result had no statistically difference with chemical insecticide (a.i deltamethrin) used in this study with the decrease was 79.04%, however significantly different with control.

Bio-insectiside of *E. slahmong* was also found very strong against the most destroyed pest of oil palm in Sumatra: fire caterpillar *Setora nitens*. From all of seven fractions of *E. slahmong* which have been tested against *S. nitens,* three of them displayed the highest inhibitory antifeedant activity within 7-10 minutes after application. The antifeedant response continued for four days. One of the three inhibiting fractions was found killed the caterpillar by damaging its abdomen, ejected brown liquid material from the damaged site and within 24 hours the caterpillar has dried.

As bio-fungicide

Several dosages of essential oil of *E. slahmong* have been tested to control *Phytopthora palmivora* on cacao, included combination dosage with other plant's essential oils. At the dosage of 1000 ppm of essential oil of *E. slahmong*, it was indicated that *P. palmivora* can be controlled 100%. When the mixture of 0.1 ml essential oil of *E. slahmong* with 0.3 ml of essential oil of *S. aromaticum* in 1L of water was applied, this combination was also successfully controlled *P. phytophthora* up to 100% (28). At field, 1.6 L formulated essential oil of *E. slahmong* per ha, significantly reduced proliferation of *P. palmivora* up to 68% (8). In other study, the application of combination of v/v of 0.45 ml *E. slahmong*: 0.45 ml *S. aromaticum* per 1 L of water also decreased the growth of *Rigidoporos macroporus* 78% (21). *R. macroporus* is known as the most destructive pathogen on rubber and the causal agent of *Havea* white root disease in the world (22).

To control *Colletotrichum gloeospoiroides* on red dragon fruit, the tested essential oils of *E. slahmong* derived from rhizome, leaf and 4 fractions (Fractions 1, 2, 3 and 4). When the dosage of 500 ppm of the oils was used, the best interaction result based on diameter inhibitory growth of *C. gloeospoiroides* was from essential oils produced by fraction 2 (83.83%), followed by rhizome (81.91), fraction 4 (77.26%), fraction 1 (67.53%), leaf (66.96) and fraction 3 (31.32%). However when the dosage was increased up to 1000 ppm, all of the oils from rhizome, leaf and fractions 1, 2, 4, resulted similar effect in controlling the pathogen these were 100%, except fraction 3 which was only 53.44%. In term of antifungal activity, the essential oil of *E. slahmong* displayed a height inhibitory effect in this study. Chairgulprasert *et al* (1) found that the antibacterial properties of the extracts from leaves of *E. curtisii* were less pronounced than those of the extracts from the rhizome, similar to the result in this study.

The antifungal activity of the essential oils of *E. slahmong* may be attributable to the presence of aldehyde constituents. There has been some evidence that aldehydes possess growth inhibitory and microbial activity (23), as it was also find in this study (Table 1). Furthermore, it has been reported that minor components of volatile oils may produce a synergistic antimicrobe effect when combined with other active components (1). From volatile odor study of *E. slahmong*, the best result was by using fraction 1 (57.88%), followed by fraction 2 (54.73)%, leaf oil and rhizome (50.14%), fraction 4 (45.56%) and again the lowest was by fraction 3. During these studies, the volatile effects also inhibited *T. minangkabau* within 7 minutes (18).

CONCLUSIONS

This report proven and highlighted the potentiality of essential oil of *Elettariopsis slamong* CK Lim as a green-pesticide. The works which were focused to determine the anti-pest and anti-fungal revealed excellent biopesticide effect by reducing most of activities of pests and pathogens tested to between 60 to 100%. These results showed that *E. slahmong* can be used and develop as an excellent green pesticide in Indonesia.

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