We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,300

Open access books available

172,000

International authors and editors

190M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Research on One Kind of Essential Oil Against Drugstore Beetle *Stegobium paniceum* (L.)

Can Li

Department of Biology and Engineering of
Environment, Guiyang University, Guiyang
People's Republic of China

1. Introduction

Insect pest management in stored products is facing a crisis due to several serious drawbacks of using insecticides, such as the development of resistance in the treated pest, toxic residues, and the increasing cost of application (Tapondjou et al 2002). Hence it is necessary to develop alternative pest control techniques for protecting stored commodities (Gunasekaran and Rajendran 2005). Toward this end, intensified efforts have lead to an increasing number of research studies to find safe, effective and viable alternatives (Tapondjou et al. 2002). Carbon dioxide gas (CO₂) and essential oils from plants have received considerable attention for the control of stored products insects, because of their relative safety to the non-target organisms (AliNiazee 1972; Bekele et al 1996; Juliana and Su 1983; Sudesh et al 1996; Bouda et al 2001).

Chinese medicinal materials (CMM) are widely available in China. While most of these products are stored prior to use for health protection or disease treatment, great losses often occur during storage due to infestation by insect pests. Drugstore beetle *Stegobium paniceum* (L.) is the most widely encountered insect causing serious damages to stored products. It is one of the dominant species found on stored CMM in Hubei, Guizhou and Shandong, causing huge economic losses (Can et al 2004; Guilin and Wangxi 1996; Zhaohui and Fangqiang 2001). A series of measures have been taken to control infestation (Nielsen 2001; Hashem 2000, Toh 1998; Platt et al 1998). However, concerns over health and safety associated with traditional synthetic insecticides have prompted the development of plant-based insecticides.

The present study explores the efficacy of essential oil from *Z. bungeanum* Maxim against larvae and adults of *S. paniceum*. The contact toxicity and fumigant toxicity were investigated, and the subsequent development of treated insects was recorded.

2. Materials and methods

2.1 Extraction of essential oil

The fruits of *Z. bungeanum* were collected from the mountains in the west of China. After cleaning and pounding into powder, the materials were soaked in clear water (1:5, w:v) at

60°C for 24h. After a 14 hour hydro-distillation, the crude oil was collected, dehydrated with anhydrous sodium sulfate and stored at 4°C until use.

2.2 Collecting and rearing insects

The insects were obtained from a local CMM storehouse. They were mass reared on *Euphorbia kansui* Liou in a growth chamber under controlled conditions (29±1°C; 75±5% r.h.; light for 14 h).

2.3 Fumigant toxicity of crude oil to drugstore beetle

The oil was introduced onto a filter paper (7cm diameter, surface 38.5cm²) placed in the center of a 1L glass jar. To prevent insects from contacting the oil, the insects and cultural medium were separated by a piece of gauze placed around the filter.

Larvae (25 to 30 days-old, n=20 in each of the three replicates) were exposed to concentrations of 12, 24, 48, 96 and 192 ul crude oil in the glass jars. Clear water was used as control. The jars were covered with fine gauze to prevent the insects from fleeing. The insects were incubated in the growth chamber at 29±1°C and 75±5% r.h.. During the exposure, the test insects were fed on *E. kansui* Liou. After exposure of 6 to 144 h, the insect mortalities were determined respectively. Mortality was corrected by Abbotts (1925) formula when the mortality of control insects is above 10%.

Similarly, adult insects (2 to 3 days-old, 20 per replicate) were exposed to concentrations of 12, 24, 48, 96 and 196 ul in 1L glass jars respectively. The glass jars were covered by gauze to prevent the insects from flying away and they were kept in the same conditions as the larvae. Insect mortalities were determined after exposure to oil for 3 to 72 h.

2.4 Contact toxicity of oil to drugstore beetle

The crude oil was diluted with clear water to 200, 400, 667, 1000, and 2000 ppm respectively for this test. One ul of each of these solutions was introduced onto the back of one insect. The glass jars were placed into growth chamber at 29±1°C and 75±5% r.h.. Three replicates of each dose and three controls treated with water were tested (n=20 per replicate). The toxicity to insects was assessed after treating for 12 to 144 h.

2.5 Observation of subsequent development

After LT₅₀ (The median mortality time) treatment, the living insect samples were transferred to similar sized jars and were incubated in the growth chamber, and untreated insects were transferred as a control group. They were under regular observation to assess their subsequent development in another day. The development time of the larvae and the number of eggs laid by each adult were recorded.

3. Results

3.1 Fumigant toxicity of essential oil to drugstore beetle

The percentages of mortality for insects exposed to different doses of oil are shown in Figures 1 and 2. In general, the higher mortality was achieved when the insects were

exposed to a higher dose of oil or a longer exposure period. The dose of 192 $\mu\text{L/L}$ of oil achieved complete mortality of larvae after the pests were exposed for 96 h and the dose of 96 $\mu\text{L/L}$ achieved the same result after exposure of 120 h. The dose of 48 $\mu\text{L/L}$ needed 144 h or longer to achieve complete mortality. The lowest dosage of 12 $\mu\text{L/L}$ induced little mortality (<10%) when the pests were exposed for 6h or shorter.

Fig. 1. Fumigant toxicity of essential oil to the larvae of drugstore beetle *S. paniceum*. Mortality was NOT corrected by Abbotts (1925) formula in all calculations because the mortality of control insect is <5%.

Fig. 2. Fumigant toxicity of essential oil to the adults of drugstore beetle *S. paniceum*. Figure 2 illustrates the fumigant toxicity of essential oil on the adults. The trend is similar to that shown in Figure 1. With the increase of concentration and exposure time, the

percentage of mortality improved. It reached 100% at the concentration of 96 or 192 ul/L of oil with the exposure time of 48 h. After 6 h treatment, the mortality rate was significantly higher than control group at all doses.

Significant differences of susceptibility were noted between adults and larvae under the same conditions. In fumigant test for 12h the calculated regression line equation was $Y=3.24+0.66X$ for larva and $Y=3.05+1.40X$ for adult, respectively (Probit analysis). Similar analysis of 24h treatment generated an equation $Y=3.61+0.70X$ for larvae and $Y=2.80+1.99X$ for adult. Comparison of LD₅₀ values for the two life stages showed that the adult was more susceptible (LD₅₀=24.57 ul/l for 12h; LD₅₀=12.64 ul/l for 24h) than larva (LD₅₀=485.84 ul/l for 12h; LD₅₀=98.92 ul/l for 24h) (Table 1).

Life stages	Fumigant toxicity 24h		Fumigant toxicity 12h	
	LD ₅₀ (ul/l)	Regression model	LD ₅₀ (ul/l)	Regression model
Larva	98.92	$y=3.61+0.70x,r=0.996$	485.84	$y=3.24+0.66x,r=0.988$
Adult	12.64	$y=2.80+1.99x,r=0.968$	24.57	$y=3.05+1.40x,r=0.976$

Table 1. LD₅₀ and regression model calculated for mortality within exposure period of12 and 24 h to fumigant toxicity.

3.2 Contact toxicity of essential oil to drugstore beetle

Figure 3 represents contact toxicity of the larvae of different concentrations of essential oil solution. The dose of 2000 ppm of solution achieved complete mortality of larvae after the pests were exposed for 120 h. The dose of 1000 ppm or 667 ppm of the solution also achieved complete mortality after 144 h exposure (Fig 3). The percentage of mortality of adult reached 100% at the concentration of 2000 ppm and exposure of 144 h. It also achieved complete mortality at 1000 ppm of the solution for 144h (Fig. 4).

Fig. 3. Contact toxicity of essential oil to the larvae of drugstore beetle *S. paniceum*.

Fig. 4. Contact toxicity of essential oil to the adults of drugstore beetle *S. paniceum*.

The mortality of larvae was significantly higher than that of adults (Fig 3 and Fig 4) when treated for the same period and concentration. According to Probit analysis, the calculated regression line equation of 24 h for larva was $Y=1.82+0.91X$ and for adult was $Y=2.35+0.60X$. Similar trend was found with the 48 h data. Comparison of LD₅₀ values for life stages showed that the larva was more susceptible (LD₅₀=3175.91 ppm for 24h; LD₅₀=292.13ppm for 48h) than adult (LD₅₀=23610.74 ppm for 24h; LD₅₀=6784.18 ppm for 48 h) (Table 2).

Life stages	Contact toxicity 24h			Contact toxicity 48h		
	LD ₅₀ (ppm)	Regression model		LD ₅₀ (ppm)	Regression model	
Larva	3175.91	$y=1.82+0.91x$	$r=0.948$	292.13	$y=2.92+0.85x$	$r=9.981$
Adult	23610.74	$y=2.35+0.60x$	$r=0.967$	6784.18	$y=2.09+0.76x$	$r=0.986$

Table 2. LD₅₀ and regression model calculated for mortality within treated time of 24 and 48 h for contact toxicity.

3.3 The subsequent development of test insects

Subsequent observation on the adult pests revealed that the essential oil also prevented adults from laying eggs normally. Significant differences were observed on the number of eggs and development time of larvae between the treated and untreated pests ($p<0.05$). The development time of the treated larvae was 29.77 ± 6.27 (d) ($n=13$), and untreated was 16.77 ± 2.17 (d) ($n=13$) (mean $\pm$ SE). The mean number of eggs laid by treated adult was 14.21 ± 3.28 ($n=27$), comparing with 63.50 ± 23.94 ($n=27$) (mean $\pm$ SE) by the untreated insects.

4. Discussion

Contact and fumigant insecticidal actions of plant essential oils have been well demonstrated against pests in stored products (Murray B. Isman 2000). Several investigations have demonstrated contact, fumigant and antifeedant effects of a range of

essential oil constituents against the red flour beetle *Tribolium castaneum* and the maize weevil *Sitophilus zeamais* (Ho et al 1994, 1995, 1997; Huang and Ho 1998). Essential oils from many plants have been developed as pest control agents. Perhaps the most attractive benefit of using essential oils (or their constituents) as protectants is their low mammalian toxicity (Murray B. Isman 2000).

Insecticidal activity of *Z. bungeanum* Maxim volatile oil was reported before. The results showed that *Z. bungeanum* Maxim volatile oil had high repellent and insecticidal activity against *Sitophilus zeamais* and *Tribolium castaneum*. The volatile constituents of the essential oil were identified by their retention index and mass spectrum in comparison with those of standard synthetic compounds (Zhi'an et al 2001). The major chemical constituents are C₉, C₁₀ alcohols and alkenes. The most abundant constituent was 3-cyclohexen-1-ol, 4-methyl-1-(1-methylethyl) (33.578%), followed by Eucalyptol (15.656%) and Benzene,1-methoxy-4-(1-propenyl) (8.33%). Among those chemical components, beta-Phellandrene (23.2%), alpha-Pinene (1.89%) (Jun et al 2001) could be the key factors to control the pests.

The infestation of stored Chinese medicinal materials by drug store beetle is a serious problem. The use of insecticides is avoided because of toxicity. In this study, we investigated the effects of the essential oil from *Z. bungeanum* on the control of drug store beetle and found that it not only prolonged the development time of larvae but can also prevented adults from laying eggs successfully. Effective contact and fumigant insecticidal actions of such oil were demonstrated, and the essential oil may help control expansion of drugstore beetle populations. Adult drugstore beetles were more susceptible than larvae to fumigant action of the oil. Adults showed higher mortalities at the same concentration than larvae, likely cause by suffocation. However, larvae were more susceptible than adults to contact treatment. These results are likely because the respiration of adults is higher than that of larvae and the adults' hard elytra may have prevented the infiltration of oil. The distinct responses to oil at these two life stages may be attributed to the morphological and behavioral differences (Tapondjou 2002). It is important to note that the susceptibility varies during the life cycle when using these oils as pest control regime.

Essential oil from *Z. bungeanum*, as a plant product, is unlikely to affect the nutritional or medicinal composition of stored CMM. Its use can be beneficial for human health and environment safety (Murray B. Isma 2000). The effectiveness and safety of the essential oil supported its use as a natural pest control agent.

5. Acknowledgements

This research was sponsored in part by Guizhou provincial Modernization of Chinese Material Medical project (No.QKHZYZ[2011]5049), Organization Department of CPC Guizhou Committee [TZJF-2009-02] and Guiyang city science and technology bureau [No. 2010(1-4)].

6. References

- AliNiazee, M.T. (1972). Susceptibility of the confused and red flour beetles to anoxia produced by helium and nitrogen at various temperatures. *Journal of Economic Entomology*, Vol.65, No1, pp. 60-64, ISSN 0022-0493

- Bekele, J. A.; Obeng-Ofori, D.; Hassanali, A. (1996). Evaluation of *Ocimum suave* (W Weed) as a source of repellents toxicants and protectants in storage against three stored product insect pests. *International Journal of Pest Management* ,Vol.42, pp.139-142, ISSN 0967-0874
- Bouda, H.; Tapondjou, L.A.; Fontem, D.A. & Gumedzoe, M.Y.D.(2001), Effect of essential oils from leaves of *Ageratum conyzoides*, *Lantana sitophilus*, *Chromolaena odorata* on the mortality of *Sitophilus zeamais* (Coleoptera, Curculionidae), *Journal of Stored Products Research*, Vol.37, No. 2, (April 2001) , pp. 103-109, ISSN 0022-474X
- Can, L.; Zizhong, L.; & Youlian, Y.(2004). Analysis of the structure of insect community on the stored Chinese Medicinal Materials in Guiyang. *Journal of mountain agriculture and biology*, Vol.23,No.1 (February 2004),pp. 41-45 ISSN 1008-0457
- Guilin, L. & Wangxi, D.(1996). The community quantitative characters of insects on the stored TCM materials. *Journal of huazhong agriculture university* Vol.15,No.4, (December 1996), pp.338-345. ISSN 1000-2421
- Gunasekaran, N. & Rajendran, S. (2005). Toxicity of carbon dioxide to drugstore beetle *Stegobium paniceum* and cigarette beetle *Lasioderma serricorne*. *Journal of Stored Products Research*, Vol.41,No.3,pp.283-294. (September 2005),ISSN: 0022-474X
- Hashem, M.Y. (2000). Suggested procedures for applying carbon dioxide (CO₂) to control stored medicinal plant products from insect pests. *zeitschrift fur pflanzenkrankheiten und pflanzenschutz-journal of plant diseases and protection*,Vol. 107,No.2,(June 2000),pp. 212-217. ISSN 0340-8159
- Ho, S.H.; Cheng, L.P.L.; Sim, K.Y. & Tan, H.T.W.(1994). Potential of cloves (*Syzygium aromaticum* [L.] Merr. and Perry) as a grain protectant against *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* Motsch. *Postharvest Biology and Technology*,Vol.4, No.1-2.(April 1994), pp.179-183,ISSN 0925-5214
- Ho, S.H.; Ma,Y. & Huang, Y. (1997). Anethole, a potential insecticide from *Illicium verum* Hook F., against two stored product insects. *International Pest Control*, Vol.39, No.2, (June 1997), pp.50-51, ISSN 0020-8256
- Ho, S.H.; Ma, Y.; Goh, P.M. & Sim, K.Y. (1995). Star anise, *Illicium verum* Hook F. as a potential grain protectant against *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* Motsch. *Postharvest Biology and Technology*, Vol.6, No.3-4 (October,1995), pp 341-347. ISSN 0925-5214
- Huang, M.T.; Ferraro, T. & Ho, C.T.(1994). Cancer chemoprevention by phytochemicals in fruits and vegetables. *Food Phytochemicals for Cancer Prevention. IACS Symposium Series*,Vol.546, 2-16(December 1993) ISBN13: 9780841227682eISBN: 9780841214101
- Huang, Y.; Hee, S.K.; & Ho, S.H. (1998). Antifeedant and growth inhibitory effects of α-pinene on the stored-product insects, *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* Motsch. *International Pest Control* .Vol.40, No.1, (Appil 1998),pp. 18-20, ISSN 0020-8256
- Huang, Y. & Ho, S.H. (1998). Toxicity and antifeedant activities of cinnamaldehyde against the grain storage insects, *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* Motsch. *Journal of Stored Prodducts Research*. Vol.34, No.1,(January 1998)pp.11-17 ISSN 0022-474X
- Juliana, G. & Su, H.C.F. (1983). Laboratory studies on several plant materials as insect repellents for protection of cereal grains. *Journal of Economic Entomology*. Vol.76, pp. 154-157.ISSN 0022-0493

- Jun,Q.;Tong, C. & Qing, L. (2001). Simultaneous Distillation and Solvent Extraction and GC/MS Analysis of Volatile Oils of *Zanthoxylum Bungeagum* Maxim. *Journal of Guizhou University of technology* (Natural Science Edition) Vol.30,No.6,(November 2001) pp.1-6 ISSN : 1009-0193
- Murray,B. Isman (2000). Plant essential oils for pest and disease management. *Crop Protection*, Vol.19, No.8-10, (September 2000) pp.603-608. **ISSN:** 0261-2194
- Nielsen, P.S. (2001).The effect of carbon dioxide under pressure against eggs of *Ephestia kuehniella* Zeller and the adults of *S. paniceum* (L.) and *Oryzaephilus surinamensis* (L.). *Anzeiger fur Schadlingskunde* Vol.74, No.3,(June 2002),pp.85-88. ISSN 1436-5693
- Platt, R.R.; Cuperus, G.W.; Payton, M.E. Bonjour, E.L. & Pinkston, K.N. (1998). Integrated pest management perceptions and practices and insect populations in grocery stores in south-central United States. *Journal of stored products research*, Vol.34, No.1 (January 1998), pp.1-10 ISSN 0022-474X
- Sudesh, J.; Kapoor, A.C. & Ram, S. (1996). Evaluation of Some Plant Products Against *Trogoderma granarium* Everts in Sorghum and Their Effects on Nutritional Composition and Organoleptic Characteristics. *Journal of stored products research*, Vol.32,No.4(October 1996,),pp.345-392 ISSN 0022-474X
- Tapondjou, L.A.; Adler, C.; Bouda, H. & Fontem, D.A. (2002). Efficacy of powder and essential oil from *Chenopodium ambrosioides* leaves as post-harvest grain protectants against six-stored product beetle. *Journal of stored products research*, Vol.38,No.4.(November 2002), pp.395-402 ISSN 0022-474X
- Toh, C. A. (1998). Studies on pest insects of crude drugs. *Korean Journal of Pharmacognosy*, Vol.29,pp.365-373 ISSN, 0253-3073
- Zhaohui, L. & Fangqiang, Z. (2001). Research on numerical characteristic of the structure of insect community on the stored Chinese Medicinal Materials in Shangdong province. *Stored Food stuff* Vol.30, No.3, (June 2001),pp.12-16. ISSN 1000-6958
- Zhi'an G.; Jingchuan. Z. & Zhihai, X. (2001) Study on Chemical Constituents of the Essential Oil from *Zanthoxylum bungeanum* Maxim by Gas Chromatography-Mass Spectrometry. *Chinese journal of chromatography*, Vol.19, No.6,(November 2001) pp.567-568. ISSN 1000-8713

IntechOpen

Integrated Pest Management and Pest Control - Current and Future Tactics

Edited by Dr. Sonia Soloneski

ISBN 978-953-51-0050-8

Hard cover, 668 pages

Publisher InTech

Published online 24, February, 2012

Published in print edition February, 2012

Integrated Pest Management is an effective and environmentally sensitive approach that relies on a combination of common-sense practices. Its programs use current and comprehensive information on the life cycles of pests and their interactions with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means and with the least possible hazard to people, property, and the environment.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Can Li (2012). Research on One Kind of Essential Oil Against Drugstore Beetle *Stegobium paniceum* (L.), Integrated Pest Management and Pest Control - Current and Future Tactics, Dr. Sonia Soloneski (Ed.), ISBN: 978-953-51-0050-8, InTech, Available from: <http://www.intechopen.com/books/integrated-pest-management-and-pest-control-current-and-future-tactics/research-on-one-kind-of-essential-oil-against-drugstore-beetle-stegobium-paniceum-l->

INTECH
open science | open minds

InTech Europe

University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China

Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

© 2012 The Author(s). Licensee IntechOpen. This is an open access article distributed under the terms of the [Creative Commons Attribution 3.0 License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

IntechOpen

IntechOpen