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Fumigation Activity of Plant Essential Oils against the Adults of *Rhizopertha dominica*

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Abstract: The fumigation activities of 29 plant essential oils against *Rhizopertha dominica* (F.) were determined by the method of treated paper fumigation. At 30 ± 1℃, relative humidity 70%, and concentration of 0.5μl/L, plant essential oils of Cinnamomum cassia, Ilex chinensis and Allium sativum had significance fumigant activities, whose corrected mortalities at exposure times of 24, 36 and 72 hours all reached 98%. Mortalities from Illicium verum and Syzygium aromaticum reached 50% after 72 hours exposure. The corrected mortality of other plant essential oils was less than 10%. The effect of temperature to fumigation activities of 5 plant essential oils was tested. At 20℃ and 30℃, temperature had no significance effect on the fumigation activities of 4 plant essential oils: Cinnamomum cassia, Ilex chinensis, Allium sativum, and Illicium verum, which had significance fumigation activities.

Key words: plant essential oil, fumigant, fumigation, *Rhizopertha dominica* (F.)

Preface

Rhizopertha dominica (F.) belongs to Bostrichidae of Coleoptera, it spreads all over the world and can be seen throughout the year in South China region. It can damage paddy, wheat, corn, potato and their processed goods; the loss in weight of the grain caused by *R. dominica* is 5 – 6 times of its weight, the injured grains are always eaten to empty shell, which will damage the quality and weight of the grain seriously, and it is one of the most common and most important stored grain pests in the grain storage process of our country[1-3].

Plant essential oil is an oleaginous secondary metabolite of plants distilled from natural plants and which has aromatic odor and can volatilize under normal temperatures; its main constituents are monoterpenes, sesquiterpenes and aromatic hydrocarbon derivates. Many reports at home and abroad demonstrated that plant essential oils have several activities on stored grain pests such as prevention, fumigation and killing.[4-6].

Twenty nine essential oils from normal fruits and vegetables, spices or traditional Chinese medicinal materials were selected to perform the research on fumigation activity against *R. dominica*. The aim was to find those oils which have stronger biological activities and to explore their potential effects in controlling stored grain pests. This provides a theoretical basis for control of stored grain pests by plant essential oils and for research of green grain storage technology.

2 Materials and Method

2.1 Tested Insects

R. dominica was provided by the Guangdong Foodstuff Research Institute. It was bred at 25 ± 1℃ and a relative humidity of 70% – 80%. Wheat was from national grain storage depot, and before use, heated at 60℃ to disinfest grain, cooled and adjusted to 14% moisture content. Wheat was placed in wide-mouth bottles and adults added. After seven days, adults were removed. About two weeks after exclusions of the adults from the next generation, adults were removed for testing.

2.2 Tested Plant Essential oil

The tested plant essential oils were self-extracted or provided by Guangzhou Xunyang Essential Oil Development Co., Ltd and Gaoshangmei (Guangzhou) Fine Chemical Co., Ltd. There were 29 oils, from the plants of 17 families and 22 genera. The names and sources of the essential oils are shown in table 1.

Self-extracted essential oils were obtained by vapor distillation. Plant samples purchased from the market were cleaned, dried, and broken into pieces and steam distilled, 12 hours after distillation, the obtained distillate fractions

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Foundation project: national sparking plan project, Code No. of the project: 2007*EA*164014; *Guangdong science and technology plan project. Code No. of the project*: 2007*B*020709001, 2007*B*020709002, 2005*B*20501002

were extracted thrice with diethyl ether. The extract was dried with anhydrous sodium sulfate, concentrated under reduced pressure at 30 – 35℃ in a rotary evaporator and recovered in absolute diethyl ether. The obtained oleaginous liquid was the essential oil, stored at 4℃ prior to use.

2.3 Determination of Fumigation Effect

The method was based on an established procedure [7]. A 100mL Erlenmeyer flask was sealed with a cork and tin foil. 30 adult insects were added. A pin was inserted through the centre of the cork and a 1 cm × 1 cm filter paper was fixed to the end of the pin. Measured quantities of oils were dropped from a micro pipette onto the filter paper. The Erlenmeyer flask was sealed with film. The flask was stored at fixed temperatures. Mortality was assessed after 24, 48 and 72 hours, at 20 ± 1℃ and 30 ± 1℃ and 70% relative humidity. The tested concentration was 0.5μL/L. Flasks with no added oil were used as controls. Each control and treatment were replicated 7 times.

3 Results and Analysis

3.1 Fumigation Effects of 29 Plant Essential Oils on *R. dominica*

Results at 30℃ are shown in table 2; the essential oils of *Cinnamomum cassia*, *Ilex chinensis* and *Allium sativum* had significant fumigation effects on adults of *R. dominica*: the corrected mortalities at 24 hour, 36 hour and 72 hour were 98% – 100%; oils of *Illicium verum* and *Syzygium aromaticum* had corrected mortalities at 24 hour, 36 hour and 72 hour of 60.0%, 64.8%, 64.8% and 28.6%, 43.4%, 50.8% separately; for *M. piperita* and *Mentha spicata*, the corrected mortalities at 24 hour, 36 hour and 72 hour were 17.7%, 21.0%, 23.0% and 0.95%, 7.6%, 14.8% separately; the fumigation effects of other essential oils on *R. dominica* were weaker, the corrected mortality after 72 hours were all below 10%.

3.2 The fumigation Effects of Five Kinds of Plant Essential Oils on *R. dominica* under Two Different Temperatures.

Five essential oils which had significant effects on adults of *R. dominica* were tested at two temperatures; the test results are shown in figure 1. Under the test concentration of 0.5μL/L, 72 hours exposure, there was no obvious effect of *M. piperita* oil on *R. dominica* at 20℃, and the effect was significantly lower than at 30℃; however, temperature had no obvious effect on the toxicity of *Allium sativum*, *Ilex chinensis*, *Cinnamomum cassia* and *Syzygium aromaticum*. These four essential oils had significant fumigation effects on *R. dominica* at both 20℃ and 30℃.

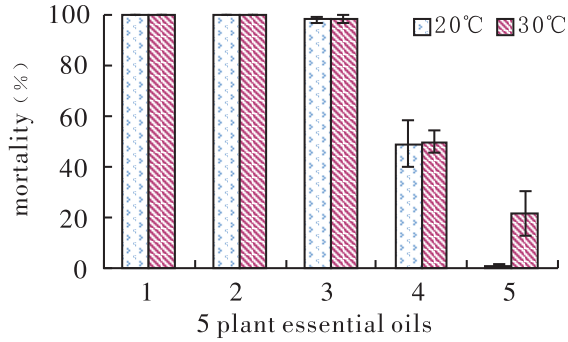

Fig. 1 The fumigation effects of 5 plant essential oils against *R. dominica* adults at temperatures (72h, 0.5μL/L) Plant essential oils: 1. *A. sativum*, 2. *I. chinensis* 3. *C. cassia*, 4. *S. aromaticum*, 5. *M. piperita*

4 Conclusion and Discussion

Green grain storage is a development trend in our country. Performing research and application of the plant source medicines with high effectiveness and low toxicity to replace the existed chemical medicines with high toxicity is an important way to realize green grain storage. However, there was no report on practical application of plant essential oils used as the grain fumigants at home and abroad. The article performed research on fumigation effects of 29 plant essential oils on adults of *R. dominica* initially, in which, under the test conditions, the corrected mortality of *R. dominica* by fumigation of *C. cassia*, *I. chinensis* and *A. sativum* essential oils can reach to 98% and above within 24 hours. The oils can also be effective at 20℃. Essential oils used as fumigants for stored grain pests have prospects, but how to utilize the fumigation activities needs to be resolved urgently.

Acknowledgement

We thank Dr Jim Desmarchelier for help with the manuscript.

Table 1. The source of essential oils for test

No.	Species of plants	Family Names	Genus Names	Part used	Country of origin	Source
1	*Capsicum annuum*	Solanaceae	*Capsicum*	Fruit	China	Xunyang

No.	Species of plants	Family Names	Genus Names	Part used	Country of origin	Source
2	*Zingiber of f icinale* Rosc.	Zigiberaceace	*Zigiber*	Root	China	Xunyang
3	*Citrus limon*	Rutaceac	*Citrus*	Peel	USA	Xunyang
4	*Citrus sinensis*	Rutaceac	*Citrus*	Peel	USA	Xunyang
5	*Citrus paradisi* Macf	Rutaceac	*Citrus*	Peel	Morocco	Xunyang
6	*Citrus reticulata* Blanco	Rutaceac	*Citrus*	Peel	Sichuan, China	Gaoshangmei
7	*Zanthoxylum bungenum* Maxim.	Rutaceac	*Zanthoxylum*	Fruit	Hungary	Gaoshangmei
8	*Piper nigrum*	Piperaceae	Piper	*Fruit*	India	Gaoshangmei
9	*Artemisia argyi* Levl. et Vant.	Asteraceae	*Artemisia*	Stem & Leaf	China	Xunyang
10	*Illicium verum* Hook. f.	Magnoliaceae	*Illicium*	Seed	Guangxi, China	Gaoshangmei
11	*Camellia sinensis*	Theaceae	*Camellia*	Leaf	Guangxi, China	Gaoshangmei
12	*Camellia sinensis*	Theaceae	Camellia	Fruit	*China*	Xunyang
13	*Cinnamomum cassia* Presl	Lauraceae	*Cinnamomum*	Bark	Guangxi, China	Gaoshangmei
14	*Litsea cubeba* (L.) Pers.	Lauraceae	*Litsea*	Fruit	China	Gaoshangmei
15	*Pinus massoniana* Lamb	Pinaceae	*Pinus*	Bark	China	Xunyang
16	*Ilex chinensis* Sims	Aquifoliaceae	*Ilex*	Leaf	Malaysia	Xunyang
17	*Styrax benzoin* Dryand	Styracaceae	*Styrax*	Stem	India	Xunyang
18	*Allium sativum* Linn.	Liliaceae	*Allium*	Fruit	Shandong, China	Gaoshangmei
19	*Allium cepa* Linn	Liliaceae	*Allium*	Corm	Guangdong, China	Extract
20	*Cyclosorus parasiticus* (L.) Farw.	Thelypteridaceae	*Cyclosorus*	Stem & Leaf	Guangdong, China	Extract
21	*Cymbopogon nardus* Stapf	Poaceae	*Cymbopogon*	Full	Guangdong, China	Xunyang
22	*Myristica fragrans* Houtt	Myristicaceae	*Myristica*	Fruit	India	Gaoshangmei
23	Syzygium aromaticum (L.) Merr.	Myrtaceae	*Syzygium*	flower	Indonesia	Gaoshangmei
24	*Eucalyptus tereticornis*	Myrtaceae	*Eucalyptus*	Leaf	China	Xunyang
25	*Agastache rugosus* (F. et M.) Kuntze.	Lamiaceae	*Agastache*	Leaf	China	Xunyang
26	*Rosmarinus officinalis* Linn.	Lamiaceae	*Rosmarinus*	flower	France	Xunyang
27	*Mentha haplocalyx* Briq.	Lamiaceae	*Mentha*	Leaf	China	Xunyang
28	*Mentha piperita*	Lamiaceae	*Mentha*	Stem & Leaf	USA	Xunyang
29	*Mentha spicata Linn.*	Lamiaceae	*Mentha*	Stem & Leaf	China	Xunyang

Table 2. Toxicity of plant essential oils to *R. dominica* adults at 30℃

No.	Essential oils	Corrected mortality %		
		24h	48h	72h
1	*C. annuum*	0.5 ±0.5e	0.9 ±0.6e	3.8 ±2.3ef
2	*Z. of f icinale*	0.5 ±0.5e	3.8 ±1.1e	5.7 ±1.9ef
3	*C. limon*	3.3 ±1.3e	5.7 ±1.7e	9.5 ±2.5def
4	*C. sinensis*	0.5 ±0.5e	2.4 ±0.9e	3.8 ±1.1ef
5	*C. paradisi*	0.00 ±0.00e	1.4 ±0.9e	4.8 ±1.2ef
6	*C. reticulata*	0.5 ±0.5e	0.5 ±0.5e	1.4 ±0.7f
7	*Z. bungenum*	0.9 ±0.6e	0.00 ±0.00e	1.4 ±1.0
8	*P. nigrum*	0.5 ±0.5e	0.00 ±0.00e	0.5 ±0.5f
9	*A. argyi*	1.4 ±0.7e	3.3 ±0.7e	7.1 ±1.3ef
10	*I. verum*	60.0 ±11.9b	64.8 ±10.8b	64.8 ±11.1b
11	*C. sinensis*	0.00 ±0.00e	0.5 ±0.5e	1.4 ±1.0
12	*C. sinensis*	1.4 ±1.0e	3.3 ±1.0e	8.100 ±3.2ef
13	*C. cassia*	98.1 ±1.9a	98.1 ±1.9a	98.1 ±1.9a
14	*L. cubeba*	0.9 ±0.6e	0.9 ±0.9e	6.2 ±2.2ef
15	*P. massoniana*	0.9 ±0.6e	3.3 ±1.6e	4.8 ±1.9ef
16	*I. chinensis*	100.00 ±0.00a	100.00 ±0.00a	100.00 ±0.00a
17	*S. benzoin*	1.9 ±1.0	10.00 ±2.30e	9.5 ±3.2def
18	*A. sativum*	100.00 ±0.00a	100.00 ±0.00a	100.00 ±0.00a
21	*C. nardus*	0.9 ±0.6e	0.00 ±0.00e	1.4 ±1.0
22	*M. fragrans*	2.86 ±1.13e	0.9 ±0.6e	2.9 ±1.3f
23	*S. aromaticum*	28.6 ±7.2c	43.4 ±7.0	50.8 ±4.5b
24	*E. tereticornis*	0.00 ±0.00e	1.4 ±0.7e	3.8 ±1.3ef
25	*A. rugosus*	0.5 ±0.5e	5.7 ±1.7e	3.8 1.5ef
26	*R. officinalis*	1.1 ±0.7e	1.7 ±1.1e	3.3 ±1.5f
27	*M. haplocalyx*	0.5 ±0.5e	1.4 ±0.7e	3.3 ±2.2f
28	*M. piperita*	17.7 ±7.3d	21.0 ±7.3d	23 ±0 8.7c
29	*M. spicata*	0.9 ±0.6e	7.6 ±2.1e	14.8 ±1.6cde

* Tested concentration is 0.5μL/L. Temperature:30℃. Means followed with same letters within the same column are not significantly different at 0.05 level by Duncan's multiple range test.

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