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Original article (Orijinal araştırma)

Repellency of three plant essential oils against red flour beetle *Tribolium castaneum* (Herbst, 1797) (Coleoptera: Tenebrionidae)

Un biti, *Tribolium castaneum* (Herbst, 1797) (Coleoptera: Tenebrionidae)'a karşı üç bitki esansiyel yağının kaçırıcı etkileri

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Summary

Tribolium castaneum (Herbst, 1797) is an insect pest found in stored products. To control this pest, it is necessary to develop safe alternatives to replace hazardous fumigants. This research aimed to determine the

Introduction

In stored products worldwide, insect pest infestation may cause up to 40% damage (Matthews, 1993). *Tribolium castaneum* (Herbst, 1797) (Coleoptera: Tenebrionidae) is known as the most common insect pest in stored food for human and animal consumption. It affects a wide range of products, including beans, cacao, dried, flour, fruits, grain, nuts, peas and spices. The presence of both adults and larvae in stored food directly affects the quality and quantity of products (Campbell & Runnion, 2003). Insects may cause damage to seed embryos, resulting in decreased germination (Baier & Webster, 1992; Moino et al., 1998). Therefore, control of stored-product pests is necessary to provide a stable and safe food supply at affordable prices (Nadeem et al., 2012; Ukeh et al., 2012; Jahromi et al., 2014). Control of pests in stored products relies on gaseous fumigants, including hazardous chemicals, such as methyl bromide or phosphine. There is a global concern about the negative effects of these chemicals, including direct toxicity to users, increasing cost of

Area preference test

Area preference tests were performed using the area preference method of Tapondjou et al. (2005) with modifications. Working solution (0.1 mL) of essential oil was uniformly applied to half a filter paper disk to a final concentration of 31.5 μg/cm^2. The same volume of the solute without essential oil was applied to the other half to serve as a control. Paper disks were placed in 90-mm petri dishes and the solvent allowed drying. One hour after the application, 20 adults of *T. castaneum* were placed in the center of each paper disk. The dishes were covered with black plastic to provide darkness and placed in the

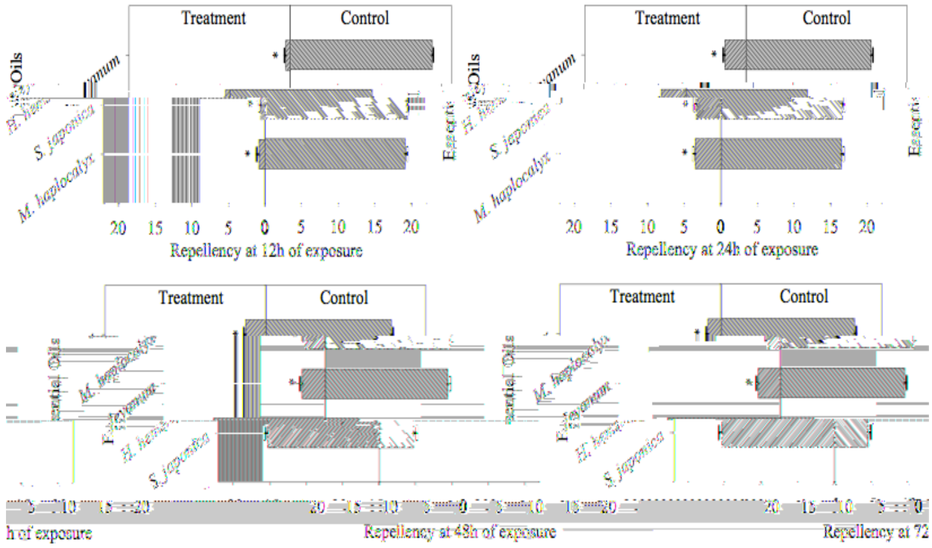

Figure 1. Mean number and SE of repellency at 12, 24 48 and 72 h of *Tribolium castaneum* adults' release. Values are means of 8 replicates (20 insects/replicate). The mean numbers of adults in the treated and control were analyzed by paired t-test at significance level of $P < 0.05$.

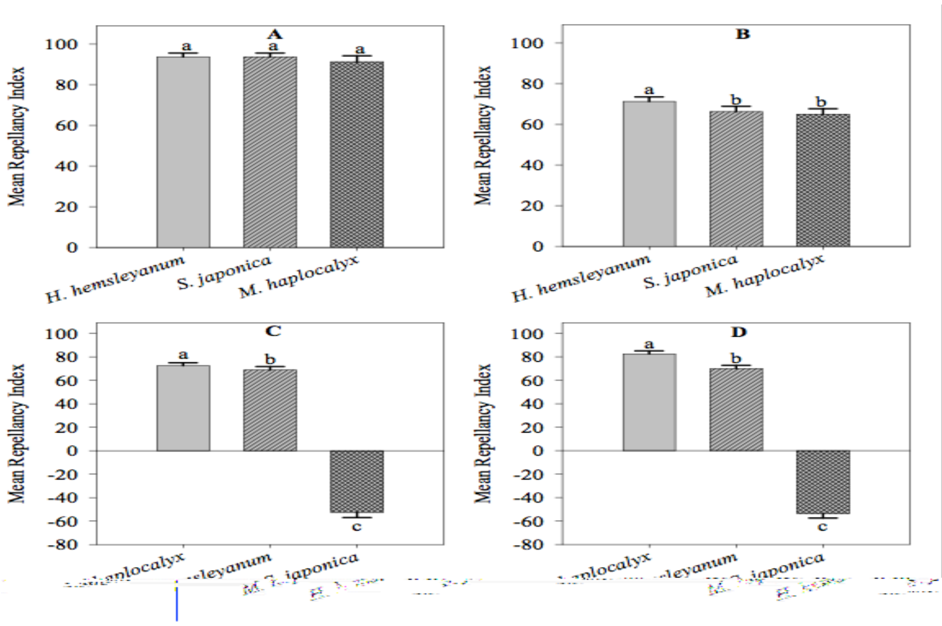

Figure 2. Percentage (mean ± SE) of repellency of *Tribolium castaneum*: A: 12 h after insect release, B: 24 h after insect release, C: 48 h after insect release, D: 72 h after insect release. Values are means of 8 replicates. The mean numbers of adults were analyzed by one-way ANOVA, using a Tukey HSD post-hoc test at significance level of $P < 0.05$.

Gas chromatography and mass spectrometry

After recording strong repellency for the essential oils tested, the oils were analyzed by GC-MS. The results revealed complex mixtures of chemical constituents with nine major components identified in each oil. The primary chemicals identified from *H. hemsleyanum*, *M. haplocalyx* and *S. japonica* oils are presented in Table 1.

Table 1. Chemical components of essential oils based on GC-MS assay

Components	Retention Time (minutes)	Percent of Total (%)
Hypericum hemsleyanum oil		
Phenol, 3-methyl	7.26	2.4
Palmitic acid	12.64	2.6
Hexadecanoic acid, ethyl ester	12.73	1.0
2H-1-benzopyran	13.45	0.7
9,12-Octadecadienoic acid (Z,Z)	13.49	5.1
Linoleic acid ethyl ester	13.55	1.9
Osthole	13.61	35.6
Lomatin acetate	14.47	0.3
1,2-dihydrocyclobuta[b]anthracen-1-one	15.05	6.7
Mentha haplocalyx oil		
L-(-)-menthol	7.85	8.3
Cyclohexanol, 5-methyl-2-(1-methylethyl)	7.89	2.0
2-Hexadecen-1-ol, 3,7,11,15-tetramethyl	11.94	1.2
Hexadecanoic acid	12.64	4.4
Hexadecanoic acid, ethyl ester	12.74	1.2
Phytol	13.33	1.3
9,12-Octadecadienoic acid (Z,Z)	13.49	1.6
9,12,15-Octadecatrienoic acid, (Z,Z,Z)	13.52	4.5
24(Z)-Methyl-25-homocholesterol	23.88	1.4
Stemona japonica oil		
4-Vinylphenol	8.40	0.3
2-Furancarboxaldehyde, 5-(hydroxymethyl)	8.53	0.7
dl-Stenine	14.17	0.9
9,10-Anthracenedicarbonitrile	16.26	0.4
1-Tert-butyl-5-methoxy-2,2-dimethylindan	17.59	7.6
Benzo[a]naphthacene	21.13	1.6
Methyl 4,5,7-trimethoxy-2-naphthoate	21.55	5.7
Stemonine	22.33	31.2
Syn-7-benzhydrylbicyclo[2.2.1]heptan-2-one	23.28	3.3

Discussion

In this study the repellency of the three essential oils, *M. haplocalyx* oil was the most repellent for the targeted insect species, and its repellency was maintained throughout the assessment period. Previous studies showed repellency effects from *Mentha* sp. against many insect and non-insect pests. El-Seedi et al. (2012) investigated the oils of *Mentha* sp. which showed strong repellency (93.2% using a 15 μg/cm^2 concentration in a lab test and 59.4% using 6.5 μg/cm^2 on test cloths in the field) against ticks, *Ixodes ricinus* (L., 1758). A 14-d experiment was conducted in Ebeling choice boxes to determine the toxicity and repellency of *Mentha* oil to American cockroaches (*Periplaneta americana* (L., 1758)) and German cockroaches (*Blattella germanica* (L., 1767)); it showed 100% repellency to both species during each day of the experiment (Appel et al. 2001). Ren et al. (2007) reported that *M. haplocalyx* oil showed bioactivity, such as repellency, insecticidal properties, and growth and reproduction regulation, against numerous insect pests. *Mentha haplocalyx* contains the active components of hexadecanoic acid ethyl ester, menthol and phytol. Hexadecanoic acid ethyl ester (palmitic acid ester) and linoleic ethyl of these essential oils against store-product pests, including the fumigant and contact toxicity of these essential oils and their chemical components against larval stage of *T. castaneum*.

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References

Appel, A. G., J. G. Michael & J. T. Marla, 2001. Repellency and toxicity of mint oil to American and German cockroaches (Dictyoptera: Blattidae and Blattellidae). Journal of Agriculture and Urban Entomology, 18: 149-156.

Baier, A. H. & B. D. Webster, 1992. Control of *Acanthoscelides obtectus* Say (Coleoptera: Bruchidae) in *Phaseolus vulgaris* L. seed stored on small farms. II. Germination and cooking time. Journal of Stored Products Research, 28: 295-299.

Brem, B., C. Seger, T. Pacher, O. Hofer, S. Vajrodaya & H. Greger, 2002. Feeding deterrence and contact toxicity of *Stemona* alkaloids — A source of potent natural insecticides. Journal of Agricultural and Food Chemistry, 50: 6383-6388.

Campbell, J. F. & C. Runnion, 2003. Patch exploitation by female red flour beetles, *Tribolium castaneum*. Journal of Insect Science, 3: 1-8.

Ciepielewska, D., K. Bozena & N. Mariusz, 2005. Effect of plant extract on some stored-product insect pests. Polish Journal of Natural Sciences, 18: 7-14.

El-Seedi, H. R., S. K. Nasr, A. Muhammad, A. T. Eman, G. Ulf, P. Katinka & B. K. Anna-Karin, 2012. Chemical composition and repellency of essential oils from four medicinal plants against *Ixodes ricinus* nymphs (Acari: Ixodidae). Journal of Medical Entomology, 49: 1067-1075.

Haeseler, G., D. Maue, J. Grosskreutz, J. Bufler, B. Nentwig, S. Piepenbrock, R. Dengler & M. Leuwer, 2002. Voltage-dependent block of neuronal and skeletal muscle sodium channels by thymol and menthol. European Journal of Anaesthesiology, 19: 571-579.

Isman, M. B., 2000. Plant essential oils for pest and disease management. Crop Protection, 19: 603-608.

Isman, M. B., 2006. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annual Review of Entomology, 51: 45-66.

Jahromi, M. G., A. A. Pourmirza & M. H. Safaralizadeh, 2014. Repellent effect of sirinol (garlic emulsion) against *Lasioderma serricorne* (Coleoptera: Anobiidae) and *Tribolium castaneum* (Coleoptera: Tenebrionidae) by three laboratory methods. African Journal of Biotechnology, 11: 280-288.

Jananie, R. K., V. Priya & K. Vijayalakshmi, 2011. Determination of bioactive components of *Cynodon dactylon* by GC-MS analysis. New York Science Journal, 4: 16-20.

Jegadeeswari, P., A. Nishanthini, S. Muthukumaraswamy & V. R. Mohan, 2012. GC-MS analysis of bioactive components of *Aristolochia krysagathra* (Aristolochiaceae). Journal of Current Chemical and Pharmaceucal Science, 2: 226-236.

Karina, C. G., P. B. Nayive, P. C. Nerlis, S. Elena & O. V. Jesus, 2014. Plants cultivated in Choco, Colombia, as source of repellents against *Tribolium castaneum* (Herbst). Journal of Asia-Pacific Entomology, 17: 753-759.

Kotan, R., S. Kordali, A. Cadir, M. Kesdek, Y. Kaya & H. Kilic, 2008. Antimicrobial and insecticidal activities of essential oil isolated from Turkish *Salvia hydrangea* DC. ex Benth. Biochemical Systematics and Ecology, 36: 360-368.

Krishnaiah, D., T. Devi, A. Bono & R. Sarbatly, 2009. Studies on phytochemical constituents of six Malaysian medicinal plants. Journal of Medicinal Plant Research, 3: 67-72.

Lee, B. H., P. C. Annis, F. Tumaalii & W. S. Choi, 2004. Fumigant toxicity of essential oils from the Myrtaceae family and 1,8

Moino, A. J., S. B. Alves & R. M. Pereira, 1998. Efficacy of *Beauveria bassiana* (Balsamo) Vuillemin isolates for control of stored-grain pests. Journal of Applied Entomology,