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Reducing Insects Contaminations through Stored Foodstuffs by Use of Packaging and Repellency Essential Oils

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Abstract

Protection of stored agricultural products against insects is carried out with chemical insecticides. They have harmful effects for human being, animal and environment. This research carried out on plant essential oils, which are one of the harmless materials and act like contact-fumigant from offering the prospect for using in stored product. They should have the ability to repel the insects. The objective of the present study was to test the properties of *Prunus amygdalus* L. and *Mentha viridis* L. for preventing the penetration of pest insects, including: *T. castaneum*, *S. granaries, S. paniceum* and *R. dominica*, to packaged cereals. As foodstuff was packaged by PE polymer and placed into a container 10 g of wheat and flour. The repellent essential oils used in the interior surface of containers. The releasing of insects carried out around the containers to determinate the insect's penetration percentage with effect of repellents. The highest concentration counted was 1.75 µl of essential oil per 0.5 ml acetone. The results showed that *P. amygdalus* had the most repellency effect on *T. castaneum* that cause 78.52% contamination deduction inside the packaged crop in comparing with control. In addition, *M. viridis* caused the most repellency on *S. granarius* (63.81%). The results demonstrated the efficacy of these essential oils for using it in organic food protection. They can prevent the infestation of the stored-product pests to the warehouse.

Keywords: essential oils, packaging, stored-pests, penetration, food preservation

Introduction

From storage to consumption by consumers, the agriculture products are exposed to attack by pest insects. Insects are the most serious pests that can contaminate the food by penetration of products in warehouses. Despite modern food storage and distribution systems, most packaged food products, with the exception of canned and frozen goods, are subject to attack and penetration by insects (Mullen and Highland, 1988). The most insects use their sense of olfaction to find food. There are two types of insects that attack packaged products: "penetrators", which are insects that can bore holes through packaging materials; and "invaders", which are insects that enter packages through existing holes, such as folds and seams and air vents (Highland, 1984; Newton, 1988). They can enter foodstuffs packages and also, move from one package to other packages in the stores. *Tribolium castaneum* Hb. (*Col.: Tenebrionida*e), *Sitophilus granarius* L. (*Col.: Curculionidae*), *Rhyzopertha dominica* F. (*Col.: Bostrychidae*) and *Stegobium paniceum* (*Col.: Anobidae*) are some of the stored-product insects that are capable of penetrating food packaging. Many researches have been carried out to determine penetration abilities of various species of stored-product insects into packaged agricultural products, recently (Bowditch, 1997; Allahvaisi *et al.*, 2009). In all of the researches that have been done on the penetration of insects to different materials, the effect of repellent of essential oils on these materials has not been tested. Also, this matter whether the various parts of stored foodstuffs packages in the presence of repellents is different or no, is important for what resting packages in store. Therefore, this study had two purposes: to explore the possibility of using these insect repellents to prevent pests from infesting food packages, and to achieve what repellents in stores have been used for decrease contamination of foodstuffs packages.

Materials and methods

Insects

Three insect species, *T. castaneum*, *S. granaries, S. paniceum* and *R. dominica* were reared in the laboratoryat 27 ± 1°C and 65 ± 5% relative humidity (R.H.). All species had been cultured in the laboratory for over five years. 10 days old adults were used in all the experiments. *S. paniceum* and *T. castaneum* was reared on wheat flour mixed with 5% brewer's yeast; *R. dominica* and *S. granarius* were reared on whole kernels of wheat.

Plant essential oils

Two commercially available essential oils were tested in this study. They were obtained from *Mentha viridis* and

Prunus amygdalus. These oils were assayed against *T. castaneum*, *S. granaries, S. paniceum* and *R. dominica* adults.

The used polymer

In this study, the permeability of transparent and flexible PE polymer with 16.5-μm tested against stored-insect pests that it is current polymer for foodstuffs packaging (Allahvaisi *et al.*, 2009). Polymeric sheets were cut into 15×22 cm pieces with the aid of a template and afterwards 8×10 cm pouches was prepared through the sealed polymeric pieces, with the aid of press plastic machine for packaging 10 g foodstuffs (wheat and flour). These pouches were completely without any pores.

Essential oils concentrations

Repellent activity of *T. castaneum, S. granaries, R. dominica* and *S. paniceum* was studied by using five dilutions of each oil (0.44, 0.77, 1.1, 1.42, 1.75% w/w) prepared in 0.5 ml acetone. Aliquots of 1.5 ml of each dilution were sprayed on walls of the container containing foodstuff packaging to achieve homogeneous distribution.

Penetration test

In this study, one of the prepared pouches was hanged in the top of a 150 cc container, vertically. Then repellent essential oils used on the interior surface of containers containing foodstuffs packages. On the various parts of each container created the holes in the same size and any container was put inside the second container (300 cc) which the adult insects released inside these containers. So, the insect's penetration ability with effect of repellents determined. Also, a control test (water was used instead of oils) used. Tests were repeated three times. The number of applied insects in any replication was 50 adults with 7-10 days old that starved 24 hours. Finally, the containers capped with a filter fine lace-mesh lid to confine the potential escape and to keep out foreign objects. The experiments were conducted at 27±1°C, 65±5% R.H. in dark condition. The packages were extracted from the jars and examined for penetrations, daily. All repellence assays were conducted in the laboratory. The penetration by the pests started from less than 48 hours and the highest insects penetration occurred usually after 3 days. Whereas these two essential oils had knock down properties (Al-Jabr, 2006), the insects died during experimental period were replaced by the same aged adults from the same treatments. When a puncture was created or one insect was observed inside the packaging, it would be considered the beginning of penetration and data was recorded in immediately. Each hole, made by the insects on the packaging polymer was counted as penetration, but the only way to determine penetration percentage was counting the penetrated insects number of punctures (Allahvaisi *et al.*, 2009). The counting continued until 5 days, daily. The punchers number created by insects on various sites of packages showed that arrival sites of pest insects in different parts can be effective on repellent percentage of essential oils.

Data analysis

Statistical analysis of data was carried out with MSTATC and EXCEL software and Randomized Complete Design (RCD) and the means were compared with Duncan's mean test.

Results and discussion

The results showed repellent percentage of two essential oils on pests is different. From among the applied insects *S. paniceum* had the most penetration in both oils. This pest penetration occurred in used polymer for less than 48 hours and the most penetration was in 72 hours. More tested insects penetrated to packages until 72 hours but the most penetration was in fifth day. However, the used pests in control test penetrated less than 24 hours and the most penetration was in 48 hours. The statistical analysis revealed a significant difference among tested pests. The results show the permeability percentage of pests to packages with essential oils is very less in comparison with control test. *P. amygdalus* had the most repellence effect on *T. castaneum* (Al-Jabr, 2006). Whereas *M. viridis* caused the most repellency on *S. granaries, M. viridis* prevented *S. granarius* penetration of treated foodstuffs packages so that no insects of this pest at concentrations of 1.42 and 1.75% w/w penetrated through PE polymer as packaging material that this was considerable in comparison with control and both PE polymer and essential oils had bilateral effect on each other and significantly reduced the number of insects penetrating to the treated foodstuffs packages (Tab. 1). So, the reduction of the penetration by *M. viridis* in comparison with the control test may be due to its repellent and antifeeding properties. These results obtained in the case of *P. amygdalus* at 1.1, 1.42, 1.75% w/w concentration that they were effected on *Tribolium castaneum*, either.

After five days, the repellency activity of *P. amygdalus* against tested pests is following with: *T. castaneum*> *S. granarius*> *R. dominica*> *S. paniceum* (Tab. 2). Also, the effect of *M. viridis* on tested pests was ranked in the order of increasing repellency as: *S. granarius*> *T. castaneum*>*R. dominica*> *S. paniceum* (Tab. 3). So that, there was a significant difference among permeability of these pests to foodstuffs packaged with PE polymer.

On the other hand, there was a significant difference between the pests penetration to PE polymer in treated and control tests. The statistical analysis of obtained data from treated and control tests showed that there is a bilateral effect between packaging and essential oils that Tab. 4 shows average penetration of insects in 0.44%w/w

Tab. 1. Average penetration percentage of pest insects trough PE polymer with two different essential oils

Plant Oils	Insect	Average penetration of insects to packages at concentrations (%)				
		0.44	0.77	1.1	1.42	1.75
P. amygdalus	*S. granarius*	16±0.65	12.3.±0.6	6.1±0.53	1.2±0.28	00.0±00.0
	T. castaneum	13.7±0.11	7.78±0.5	00.0±00.0	00.0±00.0	00.0±00.0
	S. paniceum	30.7±0.22	24.8±0.18	13±0.18	7.84±0.22	2.7±0.32
	R. dominica	25±0.5	19.31±0.7	11±0.3	5.15±0.25	0.8±0.36
M. viridis	*S. granarius*	14.65±0.27	9.2±0.51	3.8±0.24	00.0±00.0	00.0±00.0
	T. castaneum	19.5±0.8	11.32.±0.5	6.89±0.61	2.76±0.55	0.289±0.22
	S. paniceum	37.96±0.57	28.5±0.4	15±0.36	10.2±0.32	3. 54±0.36
	R. dominica	31.78±0.5	23.3±0.7	14.7±0.18	9.9±0.26	5.4±0.4

Tab. 2. Comparison of average penetration percentage of pest insects through PE polymer in various concentrations of *P. amygdalus*

Plant Oils	Insect	Average penetration of insects to packages at concentrations (%)				
		0.44	0.77	1.1	1.42	1.75
P. amygdalus	*S. granarius*	16±0.65	12.3.±0.6	6.1±0.53	1.2±0.28	00.0±00.0
	T. castaneum	13.7±0.11	7.78±0.5	00.0±00.0	00.0±00.0	00.0±00.0
	S. paniceum	30.7±0.22	24.8±0.18	13±0.18	7.84±0.22	2.7±0.32
	R. dominica	25±0.5	19.31±0.7	11±0.3	5.15±0.25	0.8±0.36
Means		21.35±0.37a	16.05±0.5b	7.52±0.18c	3.55±0.19d	0.87±0.17e

The dissimilar words show significant differences among the concentrations ($p \leq 0.05$)

Tab. 3. Comparison of average penetration percentage of pest insects through PE polymer in various concentrations of *M. viridis*

Plant Oils	Insect	Average penetration of insects to packages at concentrations (%)				
		0.44	0.77	1.1	1.42	1.75
M. viridis	*S. granarius*	14.65±0.27	9.2±0.51	3.8±0.24	00.0±00.0	00.0±00.0
	T. castaneum	19.5±0.8	11.32.±0.5	6.89±0.61	2.76±0.55	0.289±0.22
	S. paniceum	37.96±0.57	28.5±0.4	15±0.36	10.2±0.32	3.54±0.36
	R. dominica	31.78±0.5	23.3±0.7	14.7±0.18	9.9±0.26	5.4±0.4
Means		25.97±0.535a	18.08±0.53b	10.1±0.35c	5.715±0.28d	2.31±0.245e

The dissimilar words show significant differences among the concentrations ($p \leq 0.05$)

Tab. 4. Average penetration percentage of pest insects trough PE polymer with two different essential oils

Insect / Essential oils	*S. granarius*	*T. castaneum*	*S. paniceum*	*R. dominica*	Mean
P. amygdalus	20.07.±0.19	16.48±0.61	26.17±0.19	21.32±0.36	21.01±0.34 a
M. viridis	19.06±0.36	22.44.±0.55	31.075±0.4	25.2±0.32	24.444±0.41 a
Control	29.7±0.65	31.6±0.11	45.82±0.22	40.03±0.5	36.79±0.37 b

The dissimilar words show significant differences among the concentrations ($p \leq 0.05$)

Tab. 5. Mean infestation and penetration of insects from various parts of containers to packages

Mean of punctures on PE packages (%)									
Treatment and Control		*P. amygdalus*			*M. viridis*			water	
Insect	top	middle	bottom	top	middle	bottom	top	middle	bottom
S. granarius	14.1	0	1.072	13	3.33	0	11.02	5.4	15.13
T. castaneum	11.63	4.73	2.168	19.5	0	0.05	10.12	0.009	12.07
S. paniceum	17.4	10.6	6.34	16.02	15.25	8	21.3	5.35	16
R. dominica	13.23	11.33	2.6	24.2	0	0	14.23	7.02	16.22

concentration. Also Al-Jabr (2006) showed that *M. viridis* and *P. amygdalus* are repellent to many insects.

The infestation of insects and the number of holes created on the top part of foodstuffs packages were more and the least infestation exposed at the part of bottom (Tab. 5) that this is for the reason that at the top of container the essential oils concentration may be less in effect of air entrance. Therefore packages resting in stores should be in the state that there were repellents at the all parts. However, in control test the packaging polymer permeability was less at the middle parts that this matter shows the effect of essential oils in keeping away pests (Cline, 1978). The main insecticide case of essential oils is plant volatile compounds (Papachristos and Stamopoulos, 2002; Keita *et al.,* 2000). Barriers such as packaging polymers developed for preventing the migration of pyrethrins into packaging (Highland, 1975), or similar barriers may prevent the contamination of food by essential oils.

Conclusions

The results of this study should be viewed from an aspect of improving the packaging material using both packaging and repellents to reduce the pest insects' penetration into foodstuffs packages in warehouses, significantly so that sometimes no insects had penetration at all. Least penetration of adult insects observed in the presence of *P. amygdalus* had the most repellency effect on *T. castaneum*. Allahvaisi *et al.* (2009) showed insects' penetration at bottom of packages was more than middle but in this study repellents cause the most penetration of insects at the top of packages that is exposed to air. Also, the repellence percentage for tested insects was high for two essential oils but it was most in *P. amygdalus*. The dose-response relationships reported in this study provide a foundation for future investigations of *P. amygdalus* and *M. viridis* oil as vapor toxicant and repellent against adults of other pests.

According to the results of this research and some other studies, a suitable packaging and pests repellent could be suitable from the viewpoint of preventing insect penetration and would be as a safe method for IPM programmers which could further reduce the application of the synthetic chemicals and prevent the infestation of the stored-product pests.

References

Allahvaisi, S., A. A. Pourmirza and M. H. Safaralizade (2009). Packaging of Agricultural Products for Preventing Tobacco Beetles Contaminations. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 37(2):218-222.

Al-Jabr, M. A. (2006). Toxicity and Repellency of Seven Plant Essential Oils to *Oryzaephilus surinamensis* (*Coleoptera: Silvanidae*) and *Tribolium castaneum* (*Coleoptera: Tenebrioidae*). Scient. J. King Faisal Univ.

Bowditch, T. G. (1997). Penetration of Polyvinyl Choloride and Polypropylene Packaging Films by *Ephestia cautella* (*Lepidoptera: Pyralidae*) and *Plodia interpunctella* (*Lepidoptera: Pyralidae*) Larvae, and *Tribolium confusom* (*Coleoptera: Tenebrionida*e). J. Econ. Entomol. 90(4):1028-101.

Cline, L. D. (1978). Penetration of seven common packaging materials by larvae and adults of eleven species of stored-product insects. J. Econ. Entomol. 71:726-729.

Highland, H. A. (1975). Insect-resistant textile bags: new construction and treatment techniques. USDA Technical Bulletin, pp.1511.

Highland, H. A. (1984). Insect infestation of packages, 311-320pp. In: F. J. Baur (Eds.). Insect Management for Food Processing. American Association of Cereal Chemists, St. Paul, MN.

Keita, S. M., C. Vincent, J. Schmit, J. T. Arnason and A. Belanger (2001). Efficacy of essential oil of *Ocimum basilicum* L. and *O. gratissimum* L. applied as an insecticidal fumigant and powder to control *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae). J. Stored Prod. Res. 37:339-349.

Mullen, M. A. and H. A. Highland (1988). Package Defects and Their Effect on Insect Infectation of Infestation of Instant Non-fat Dry Milk. J. Packag. Tech. 2:226-269.

Newton, J. (1988). Insects and packaging- a review. International Biodeterioration 24:175-187.

Papachristos, D. P. and D. C. Stamopoulos (2002). Toxicity of vapors of three essential oils to the immature stages of *Acanthoscelides obtectus* (Say) (*Coleoptera: Bruchidae*). J. Stored Prod. Res. 38:365-373.

Sakuma, M. and H. Funkami. (1985). The linear track olfactometer: An assay device for taxes of the German cockroach, *Blattella germanica* (Linn.) toward their aggregation pheromone. J. Applied Entomol. and Zool. 74(6):523-525.