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Efficiency of Essential Oils and Gamma adiation against Lesser Grain Borer, *Rhyzopertha Dominica* Fabricius. (Coleoptera:Bostrochidae)

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Abstract

Stored grain pests can be controlled by essential oils and gamma radiation. Tested the effect of seven essential oils: Fennel seeds, caraway seeds, ginger rhizome, lavender flowers, cinnamon seeds, marjoram leaves and rosemary leaves at 0.5, 1, 2 and 4% (W/V) concentrations and evaluate gamma radiation effect at four rate doses (40-80-160 and 320Gy). The results showed that cinnamon oil was the most toxic and ginger was the least toxic compared other essential oils. All of essential oils used had been arranged in descending order according to their toxicities to R. dominica adults as follows: Cinnamon> caraway > marjoram> fennel> rosemary> lavender> garlic. Some of used oils have been highly toxic at low concentration in short exposure time. As well as some of other oils might be need longer exposure time and higher concentrations to achieve satisfactory control of the insects. The results obtained that mortality was increased by increasing the radiation dose and time exposure. At 15 days post-irradiation the mortality rates were 5.0, 40.0, 66.7 and 81.7% for adults irradiated at 40, 80, 160 and 320 Gy, respectively. The reduction in F_1-progeny ranged from 82.4-99.5% at the same doses.

Keywords: Essential oil, gamma- radiation, *Rhyzopertha dominica*, stored wheat grains.

INTRODUCTION

Cereal grains (sorghum, maize, wheat and rice) consider very important food sources in world wide. (Hamed and Nadeem, 2012). Grains are infested and attacked by many insect pests during growth until storage in the store. (Shiferaw *et al*., 2011). Insect pests causes a lot of post harvest losses in many of the stored grains and this lead to concern significant for consumers, farmers and the food industry (Hossain *et al.,* 2016). Irradiation was considered a viable alternative against insects of stored grain and it had been recognized a safe method by the (FAO), (Hossain *et al*., 2014) and World Health Organization. Irradiation should be used in appropriate and safe dose on the food to both of the nutritionally adequate and consume. Aromatic plants which have essential oils considered a alternative insecticides on the stored grain pests. (Regnault-Roger *et al*., 2002). Plant essential oils have insecticidal activity on the insect stored grains. (Cardiet *et al.,* 2012 and Hossain *et al*., 2019). Essential oils are different in quality and components by extraction method, geographical and growing conditions (Yang *et al*., 2005).

MATERIALS AND METHODS

1. Insect culture of *R. dominica*

The insect was reared in plastic jar containing 1kg of sterilized wheat kernels which treated by freezing at -18°C for 2 weeks before application to eliminate any possible infestation by any insect species. 800 adults of *R. dominica* were introduced into the plastic jars contain 2kg for laying eggs and covered with muslin cloth and fixed with rubber bands. For (1-2 weeks), then kept it under controlled conditions at the rearing laboratory room.

2. Essential oils

Fennel seeds, *Foeniculum vulgare* (Family: *Apiaceae*),caraway seeds, *Carum carvi* (Family: *Apiaceae*), ginger rhizome, *Zingiber officinale* (Family: *Fingiberaceae*), lavender flowers, *Lavandula angustifolia* (Family: *Lamiaceae*), cinnamon seeds, *Cinnamomum verum* (Family: *Lauraceae*,), marjoram leaves, *Origanum majorana* (Family: *Lamiaceae*), and rosemary leaves, *Salvia rosmarinus* (Family: *Lamiaceae*) was obtained from National Research Centre and tested at 0.5, 1, 2 and 4 % (W/V) concentrations.

3. Irradiation

Samples were irradiated from a Co-60 India source at a dose rate of 0.737 KGy/hr. The Co-60 irradiation cell-220 (GC220) source was supported by the Atomic Energy of Canada at the National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt. At doses (40-80-160 and 320) Gy.

4. Bioassay tests

4.1. Plant oils:

20 g of wheat grains were mixed thoroughly with 5 different concentrations. The jars were covered with muslin cloth and sealed with rubber band, and kept for 48 hours at room temperature for oil adsorption. 3replicates of non-treated grains of wheat were made as control. 20 of *R. dominica* adults were introduced into each jar. Mortality recorded after 1, 3, 5, 7 and 14 days from exposure. %mortality was take after 24hr and calculated according to Abbott's formula (1925) and computed according to Finney (1971). After 14 days adults were removed from all replicates and kept under laboratory conditions for 60 days to inspect the number of F_1- progeny. Ldp line program was used in statistical analysis.

4.2. Irradiation quarantine treatment:

20g of wheat grains for 20 adults of *R. dominica* were put into plastic jars and let for 15 days. 3 replicates for each treatment and control. After 15 days, 20 adults of R. *dominica* with wheat grains were introduced into small cloth bags, then closed well with rubber band. Samples were irradiated to different doses from (40-80-160 and 320) Gy dose. Mortality counts were recorded after 5, 10, 15 and 20 days after treatment. After 20 days removed all insects from all replicates and kept under laboratory conditions. Mortalities were recorded for 45 days to inspect the number of F_1- progeny. After 45 days the insects from the F_1- progeny of *R. dominica* have been put into 50 g of wheat

grains into plastic jars for 10 days. After 10 days all the adults' insects were remove from all replicates and kept them for 45 days under the laboratory conditions to inspect the number of F_2- progeny.

RESULTS AND DISCUSSION

1. Effect of plant oils on the *R. dominca* adult:

The present studies were carried out to determined efficiency of gamma radiation and plant oils against *R. dominica*. The mean mortality% of *R. dominica* adult treated with different oils at different concentration and exposure periods. The efficiency of seven oils fennel, caraway, ginger, lavender, cinnamon, marjoram and rosemary were compared with each other. At 0.5, 1, 2 and 4 % (W/V) concentration and 1, 3, 5, 7 and 14 days exposure periods were compared for each other concentration. Results concerning to toxic of marjoram, lavender, caraway and rosemary on reduction in progeny and mortality of *R. dominca* are given in Tables (1). Values of mortality increase with increasing of concentration and exposure time especially with caraway oil. Caraway was more effective than three oils. The highest recorded mortality were found to be (61.7- 95.0%), (48.3- 88.3%), (11.7-83.3%) and (0.0- 78.3%) after 1day at 1and 2% concentration for caraway, marjoram, lavender and rosemary, respectively. These values recorded after 5 days were (100- 100%), (76.7-100%), (38.3- 100%) and (75.0- 93.3.3%) for the same oils and concentration, respectively. 100% mortalities were given by marjoram, rosemary, lavender and caraway oils at 4% concentration after one day post treatment. Reduction in F_1-progeny reneged from (52.3-100%), (21.5-100%), (98.9-100%) and (48.0-100%) at different concentrations for marjoram, lavender, caraway and rosemary oils, respectively. The results obtained from Table (continuo) revealed obviously that cinnamon oil was more toxic to adults of *R. dominca* than fennel and ginger after 3days. After one day from treatments mortalities were (48.3, 70.0, 88.3 and 100%), (11.7, 43.3, 91.7 and 100%) and (0.0, 0.0, 11.7 and 78.3%) at various concentrations for cinnamon, fennel and ginger oils, respectively. These, values were reached 100%, 100% and (58.3, 66.7, 86.7 and100%) after 14 days at the same oils, respectively. Reduction in F_1-progeny ranged from (100-100%), (98.9-100%) and (48.0-100%) for cinnamon, fennel and ginger oils at various concentration, respectively. The results showed that all oils used have potential of protection to control storage product insect of *R. dominca*. The used of cinnamon, fennel, caraway and rosemary oils were more effective for control followed by ginger and lavender. These results are comparable with those of Stevanovic and Radanovic (2012) evaluated the effect of essential oils *Rosemarinus officinalis* and *Mentha pulegium* against *R. dominica*. The results showed that *R. officinalis* was more efficacy than *M. pulegium* and LC50 of *R. officinalis* and *M. pulegium* were 87.11 and 473.8 %, respectively. Lucic *et al*. (2015) evaluated the effect of lavender oil, leaves powder and stem powder against *T. castaneum, R. dominica* and *S. oryzae*. They showed that lavender oil causes the highest mortality. Suhaira *et al.* (2018) studied the effect of *Helianthus annuus* oils (sunflower) and *Zingier officinale* (ginger) against *R. dominica*. The results showed that in 2% *Z. officinale* oil was lesser protectant than *H. annuus*. Zayed (2018) evaluated the efficacy of marjoram oil (1.0, 2.0, 3.0 and 4.0%) and powder (0.5, 1.5, 3.0 and 5.0%) and malathion (0.04, 0.06, 0.08 and 0.1%) against *R. dominica.* Who showed that marjoram oil was higher than marjoram powder. Also, Izdebska *et al.* (2021) compare effect of *Carum carvi* L. and *Foeniculum vulgare* Mill oils. At 0.1 and 1% concentrations against *S. granarius* and *R. dominica*. They revealed that *C. carvi* and *F. vulgare* essential oils have greatest deterrent effect at lower dose on the insects. Patil *et al*. (2021) tested the efficacy of cinnamon, orange, eucalyptus oils against *S. oryzae, O. surinamensis, R. dominica* and *T. castaneum.* They observed that cinnamon oils were the highest effect against the insects.

Table (1): Effect of botanical oils on *the* adults of *R. dominca* and reduction in F_1-progeny under laboratory conditions.

Plant oil Treatment	Conc. (W/V)%	(%)Adult mortality after indicated days					Average NO. of emerged Adults after 60 days	% reduction in F_1-Progeny
		1	3	5	7	14		
marjoram	0.5	5.0±0.0	31.7±0.6	51.7±0.6	70.0±1.0	81.7±0.6	43.7	52.3
	1	48.3±1.5	70.0±1.0	76.7±0.6	85.0±0.0	91.7±0.6	12.7	86.2
	2	88.3±0.6	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	4	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
lavender	0.5	0.0±0.0	5.0±0.0	11.7±0.6	21.7±0.6	26.7±0.6	72.0	21.5
	1	11.7±0.6	26.7±0.6	38.3±0.6	43.3±0.6	55.0±1.0	1.0	98.9
	2	83.3±0.6	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	4	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
caraway	0.5	11.7±0.6	30.0±1.0	50.0±0.0	100.0±0.0	100.0±0.0	1.0	98.9
	1	61.7±0.6	85.0±1.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	2	95.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	4	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
rosemary	0.5	0.0±0.0	8.3±0.6	60.0±1.0	73.3±0.6	85.0±1.0	47.7	48.0
	1	0.0±0.0	46.7±0.6	75.0±1.0	81.7±1.2	88.3±0.6	7.7	91.6
	2	78.3±0.6	88.3 ±0.6	93.3±0.6	100.0±0.0	100.0±0.0	0.0	100.0
	4	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
Cinnamon	0.5	48.3±0.6	71.7±0.6	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	1	70.0±1.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	2	88.3±0.6	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	4	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
fennel	0.5	11.7±0.6	28.3±0.6	60.0±1.0	100.0±0.0	100.0±0.0	1.0	98.9
	1	43.3±0.6	53.3±0.6	73.3±0.6	100.0±0.0	100.0±0.0	0.0	100.0
	2	91.7±0.6	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	4	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
ginger	0.5	0.0±0.0	8.3±0.6	15.0±0.0	35.0±1.0	58.3±0.6	68.0	25.8
	1	0.0±0.0	20.0±1.0	28.3±1.5	55.0±1.0	66.7±0.6	50.0	45.5
	2	11.7±0.6	35.0 ±1.0	46.7±0.6	81.7±0.6	86.7±0.6	41.0	55.3
	4	78.3±0.6	85.0±0.0	90.0±0.0	95.0±0.0	100.0±0.0	2.0	97.8
Control		0.0	0.0	0.0	0.0	0.0	91.7	0.0

Lethal concentration of fennel, caraway, ginger, lavender, cinnamon, marjoram and rosemary oils on adults of *R. dominica*.

Lethal concentration and confidence limits of fennel, caraway, ginger, lavender, cinnamon, marjoram and rosemary oils on the adults of *R. dominica* after different exposure periods were shown in Table(2-3). Data obtained that the most toxic insecticide was cinnamon oil 0.408% followed by caraway 0.630% after 3 days. While the least toxic insecticide was ginger 1.921% followed by lavender 1.149% and rosemary oil 1.045% at the same time. Also, the toxicity of fennel, caraway, ginger, lavender,

cinnamon, marjoram and rosemary oils were increased with increasing the exposure times.

Table (2) Confidence limits and lethal concentration of lavender, ginger and rosemary oils against the adults of *R. dominica* after different exposure periods.

Plant oils	Exposure period (days)	LC_{50}	Slope
Lavender	Day 3	1.149 b (1.042-1.260)	5.485
	Day5	0.998 a (0.894-1.105)	4.800
Ginger	Day 3	1.921 b (1.022-3.362)	3.070
	Day5	1.651 b (1.386-1.958)	2.351
Rosemary	Day 3	1.045 b (0.927-1.173)	4.371
	Day5	0.428 a (0.271-0.564)	2.164

N.B:
CL: confidence limits, toxicity index = [(LC_{50} of the most toxic tested compound/LC_{50} of the tested compound) x100]. Sun (1950).
LC_{50} values within the same row having different letters are significantly different (95% FL did not overlap). Finney (1971).

Table (3) Confidence limits and lethal concentration of fennel, caraway, cinnamon and marjoram oils against the adults of *R. dominica* after different exposure periods.

Plant oils	Exposure period (days)	LC_{50}	Slope
Fennel	Day 1	1.013 b (0.898-1.138)	4.334
	Day 3	0.787 a (0.680-0.893)	3.721
Cinnamon	Day 1	0.565 a (0.422-0.695)	2.477
	Day 3	0.408 a (0.258-0.468)	6.471
Caraway	Day 1	0.889 a (0.790-0.992)	4.425
	Day 3	0.630 a (0.557-0.702)	5.351
marjoram	Day 1	1.064 b (0.949-1.191)	4.681
	Day 3	0.680 a (0.588-0.770)	4.235

N.B:
CL: confidence limits, toxicity index = [(LC_{50} of the most toxic tested compound/LC_{50} of the tested compound) x100]. Sun (1950).
LC_{50} values within the same row having different letters are significantly different (95% FL did not overlap). Finney (1971).

The toxicity index of various tested oils against the adults of *R. dominica* adults.

The toxicity index of the adults of *R. dominica* under laboratory conditions were presented in Table (4). The results shown that cinnamon was the highest efficacy and ginger was the least toxic compound, against *R. dominica* adults.

Table (4) Toxicity index of various tested oils against the adults of *R. dominica*.

Treatments	Lethal concentrations at 3 day (w/v%)		
	LC_{50}	Slope	Toxicity index
Fennel	0.787	3.721	51.84
Caraway	0.630	5.351	64.76
Cinnamon	0.408	6.471	100
Marjoram	0.680	4.235	60.00
Ginger	1.921	3.070	21.23
Lavender	1.149	5.485	35.50
Rosemary	1.045	4.371	39.04

N.B:
CL: confidence limits, toxicity index = [(LC_{50} of the most toxic tested compound/LC_{50} of the tested compound) x100]. Sun (1950).

2. Effect of irradiation treatment against *R. dominca*

The data obtained from experiments dealing with the irradiation of *R. dominca* adults at various dosage and %reduction in F_1-F_2 progeny are shown in Table (5-6). No mortality in adult of *R. dominca* after treatment of irradiation at 40,80,160 and 320 Gy after 5 and 10 days, post treatment. But these mortalities increased by increase the time after treatment was (5.0, 40.0, 66.7 and 81.7%) for the same doses of irradiation post 15days, While these values of mortalities after 20 days was (10.0, 88.3, 100 and 100%) for 40,80,160 and 320 Gy, respectively. Also, average number of progeny

of *R. dominca* adult after 45days post treatment at 40, 80,160 and 320 Gy were (32.3, 3.3, 1.7and 1.0%). One individuals compared 183.3 individuals for control, While the reduction was 82.4, 98.2, 99.1 and 99.5% at the same doses of irradiation, respectively. The cumulative number of F_1-progeny at 40, 80,160 and 320Gy irradiation were (90.0, 7.0 and 5.0%), respectively. These progeny but on wheat without treatment and left 45days. The results showed that the reduction in F_2-progeny were 400.0, 123.5 and 79.0% for 40,80,160 and 320 Gy, respectively. These results showed that irradiation very effect on the generation fertility of insects to the *R. dominca*. In similar studies, Mikhaiel *et al.* (2016) studied the efficacy of gamma radiation against *T. castaneum*, *S. zeamais*, *R. dominica*, *O. surinamensis*, *S. cerealella*, *P. interpunctella* and *E. cautella* exposed to doses of 750 Gy and (1.5- 3KG). They refer that at the dose of 3KGy after 3days mortality was 100% for *R. dominica* and were 65.10, 51.87 and 10.37% for *T. castaneum*, *O. surinamensis* and *S. zeamais* , respectively. *T. castaneum* was the most resistant one in the tested . Also, Abotaleb *et al.* (2020) investigated the effect of 0, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280 and 300 Gy doses of gamma radiation against *R. dominica* after 1, 3, 5, 7, and 14 days. They found that at 180 Gy mortality was 71.33% after 14 days. No emergence of adults in the F_1 at dose 180 Gy.100% mortality was at doses of 260 to 300 Gy after 14 days.

Table (5): Effect of irradiation treatment at different doses the adults of *R. dominca* and reduction in F_1-progeny under laboratory conditions.

Dose (Gy)	**(%) Adult mortality after indicated days**				**Average NO. of emerged Adults after 45 days**	**% reduction in F_1-Progeny**
	5	10	15	20		
40	0.0±0.0	0.0±0.0	5.0±0.0	10.0±0.0	32.3	82.4
80	0.0±0.0	0.0±0.0	40.0±1.0	88.3±0.6	3.3	98.2
160	0.0±0.0	0.0±0.0	66.7±0.6	100.0±0.0	1.7	99.1
320	0.0±0.0	0.0±0.0	81.7±0.6	100.0±0.0	1.0	99.5
Control	0.0	0.0	0.0	0.0	183.3	0.0

Table (6): Effect of irradiation treatment at number of F_2- progeny after treatment at different doses on *R. dominca* adults under laboratory conditions.

Dose (Gy)	**Cumulative number of F_1-progeny**	**Cumulative number of F_2-progeny**	**Control**
40	90	400	750
80	7	123.5	232
160	5	79	156

CONCLUSION

From the previous results of the various plant essential oil and gamma radiation against *R. dominica*, data clearly that cinnamon oil was the most toxic and ginger was the least toxic among essential oils. Using irradiation at 160 and 320 GY was the

most effective as grain protectants *against R. dominica* adult

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