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Contact toxicity of some plant volatile oils against pulse beetle, *Callosobruchus maculatus* (Coleoptera: Bruchidae)

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Abstract
The contact toxicity of plant volatile oils of ginger oil (*Zingiber officinale*), patchouli oil (*Pogostemon cablin)*, garlic oil (*Allium sativum*), cinnamon oil (*Cinnamomum zeylanicum*) and lemon oil (*Citrus limon*) were evaluated at 0.01%, 0.05%, 0.1%, 0.5% and 1.0% against the pulse beetle, *Callosobruchus maculatus* (F.). The results indicated that *Zingiber officinale* was found more effective and exhibited toxicity against the insects followed by *Cinnamomum zeylanicum* oil. The contact toxicity of *Cinnamomum zeylanicum* oil recorded lower egg hatching of 5.00% which was obtained in higher concentration of 1.0% and *Zingiber officinale* showed no hatching of eggs at higher concentration of 0.5% and 1.0%. The larval mortality of 100% were found in *Cinnamomum zeylanicum*, *Zingiber officinale* and *Allium sativum* in higher concentration of 0.5% and 1.0% respectively. Adult mortality were found highest in *Cinnamomum zeylanicum* resulting 90.0% at higher concentration of 1.0% followed by *Zingiber officinale* which recorded 85.0% and *Pogostemon cablin* which obtained 82.50% respectively. So, all the five plant volatile oils were found to be effective in different stages of the insect and these plant volatile oils can be considered as an alternative in the management of *Callosobruchus maculatus.*

Keywords: *Callosobruchus maculatus*, *Cinnamomum zeylanicum*, *Zingiber officinale*, *Pogostemon cablin*, *Allium sativum*, contact toxicity, plant volatile oils

Introduction
India is the largest producer and consumer of pulses in the world contributing around 25-28% of the total global production. Pulses are well suited in rainfed conditions and require less farm resources, hence farmers prefer to grow them from economic point of view throughout the country. In India 12.5 million tons of edible legumes are produced every year and nearly 18.6% of cowpea alone damaged by bruchids during storage [4, 5]. The most common pulse pest is the cowpea weevil (*Callosobruchus* sp) and the genus *Callosobruchus* has been reported to be a serious pest in the middle and Far East, Africa and India. At 30ºC and 70% RH some species of bruchids takes only a weeks to develop from egg to pupa and damaged ranging from 30-70% of the grain has been reported. The toxicity of a large number of essential oils and their constituents has been evaluated against a number of stored product insects. The plant volatile oils extracted from aromatic plants have insecticidal properties and could be considered as alternative insecticides [7, 8].
Most of the essential oil constituents are volatile, natural, complex compounds characterized by a strong odour and are formed by aromatic plants as secondary metabolites. The use of edible oils as contact insecticides to protect grains, especially legumes against storage insects is traditional practice in many countries in Asia and Africa. This method is convenient and inexpensive for the protection of stored seeds in household and on small farms. A laboratory experiment was therefore conducted to study the contact toxicity of insecticidal action of certain plant volatile oils against *C. maculatus* a stored grain pest.

Materials and Methods
C. maculatus was collected from the seed processing unit of Central Agricultural University, Imphal and was maintained in the laboratory for one year on *Vigna mungo* at room temperature and studies were done in the laboratory of Department of Entomology, College of Agriculture, Central Agricultural University, Imphal in 2017 in a Completely Randomized Design (CRD) with four replications.

The contact toxicity of five plant volatile oils viz; Ginger oil (*Zingiber officinale*), Patchouli oil (*Pogostemon cablin*), Garlic oil (*Allium sativum*), Cinnamon oil (*Cinnamomum zeylanicum*) and Lemon oil (*Citrus limon* were studied with five different concentrations of 0.01%, 0.05%. 0.1%. 0.5% and 1.0% against the egg, larva and adult of *C. maculatus.*

Contact toxicity was done in petri plates containing filter paper inside (Whatman no.1). In the center of each plate, 30 grains of green gram with single eggs laid on the same day was taken for study. The hatching of the eggs was noted for every day and was determined on the basis of changing of transparent egg (fresh egg) into white opaque and presence of excreta within the egg chorion. The number of eggs with deposition of white excreta in the egg chorion was recorded as number of egg hatched. Similarly, contact toxicity of larval mortality was studied in the same way and 30 grains of green gram with single eggs laid on the same day was taken for study. The eggs were kept for hatching and after 5 days of hatching, the grain with the larva was placed over a filter paper and treated with each oil. The larval mortality was recorded based on the number of adult emerged. The contact toxicity on adult was studied by keeping 30 adults of unsexed on the center of each plate. The adult mortality was recorded after 24 and 48 hours after the treatment to know the adult mortality of the different concentration of oils.

Results and Discussion

The data on the contact toxicity of some plant volatile oils on the percent egg hatching of *C. maculatus* is depicted in (Table 1). Ginger showed no hatching of eggs at higher concentration of 0.5% and 1.0% oil. However, ginger at low concentration of 0.01% showed 57.5% egg hatching which decreased with the increase in oil concentration *i.e.* 55.0%, 25.0% at 0.05% and 0.1%. Similarly, cinnamon oil also proved strong contact toxicity recording minimum egg hatching of 5.0% and 2.5% at higher concentration of 0.5% and 1.0% respectively and which also showed comparatively more toxic effect on the egg hatching of 25.0% and 12.5% even at lower concentration of 0.01% and 0.1% in comparison. Patchouli oil was proved next best followed by lemon and garlic.

These results are in close conformity with those of earlier workers who also reported the works in ginger oil and garlic oil. Chaubey [1] reported the biological activities of *Zingiber officinale* and *Piper cubeba* essential oils against pulse beetle, *C. chinensis* and reported that both the essential oils reduced the hatching rate of the insect when fumigated. Similarly, Chaubey [2] also reported *Allium sativum* oils significantly reduced egg hatching rate in *C. chinensis* when fumigated with (0.141, 0.212, 0.282, 0.353 and 0.423) µl cm^3 respectively. In the present investigation, ginger oil caused failure of egg hatching at higher concentration of 0.5% and 1.0% and cinnamon oil also showed strong contact toxicity leading to 5.0% and 2.5% egg hatching at 0.5% and 1.0% oil concentration respectively.

Table 1: Contact toxicity of some plant volatile on the percent egg hatching of *C. maculatus.*

Plant Volatile Oils	Concentration Of Oils (%)				
	0.01%	**0.05%**	**0.1%**	**0.5%**	**1.0%**
Patchouli oil	65.00 (54.06)	50.00 (44.78)	45.00 (42.05)	30.00 (33.05)	30.00 (33.05)
Lemon oil	87.50 (72.11)	65.00 (54.00)	67.50 (59.13)	30.00 (30.05)	37.50 (37.22)
Cinnamon oil	25.00 (30.00)	12.50 (20.70)	12.50 (20.70)	5.00 (12.90)	2.50(4.86)
Garlic oil	52.50 (46.43)	52.50 (46.43)	60.00 (50.89)	65.00 (54.59)	42.50 (40.61)
Ginger oil	57.50 (49.33)	55.00 (48.17)	25.00 (30.00)	0.00 (0.33)	0.00 (0.33)
Control	93.25(75.53)	95.25(78.12)	98.50 (83.84)	93.75(77.48)	97.00 (81.44)
S.E. (d)	5.06	5.17	5.96	4.10	3.77
C.D.(p=0.05)	14.41	14.74	16.99	11.69	10.74

Data represented are based on the average of four replications.
Figure in the parenthesis are angular transformed values.
Means followed by different letters are significantly different at 5% level.

The data on the contact toxicity of some plant volatile oils on the percent larval mortality and adult mortality are depicted in (Table 2). All the five oils were found to be effective at higher concentration of 0.1%, 0.5% and 1.00% in larval mortality and recorded in the range of 97.5% - 100%. The contact toxicity of all these five plant oils were also effective even at lower concentration of 0.1%, 0.05% and 0.01% concentration which showed larval mortality in the range of 65.0% to 100% indicating strong contact toxicity of plant volatile oil. The present findings was found similar with the contact toxicity of plant volatile oils of *Zingiber officinale, Mentha pulegium, Piper cubeba, Alium sativum* on the larval mortality of *C. maculatus* by Chaubey[1]; Chaubey [2]; Loni and Panahi [3], which corroborates with the contact toxicity of all the five volatile oils studied in the present investigation in terms of larval mortality of *C. maculatus*.

Likewise, the adult mortality was 90.0% in cinnamon followed by ginger oil showing 85.0% and patchouli oil 82.5% at higher concentration of 1.0% concentration. The adult mortality was comparatively low at lower concentration of 0.01% and 0.05% in case of lemon oil and patchouli oil. Lemon oil and garlic proved least effective in respect to adult mortality showing 57.5% and 42.5% at higher concentration of 1.0%.These findings derive support from Loni and Panahi [3] which reported *Zingiber officinale* to be the most toxic on all the growth stage of *C. maculatus*. Similarly, toxicity of lemongrass oil and citrodora oil Raja and William [6] and leaf powder of *Tridax procumbens* and *Withania somnifera* Yankanchi and Lendi [9] which corroborates with the present study.

Table 2: Contact toxicity of plant volatile oils on the percent larval mortality and adult mortality of *C. maculatus*.

	Larval Mortality					Adult Mortality				
Conc. %	**0.01%**	**0.05%**	**0.1%**	**0.5%**	**1.0%**	**0.01%**	**0.05%**	**0.1%**	**0.5%**	**1.0%**
Patchouli oil	65.00 (54.06)	67.50 (55.2)	100 (90.00)	100 (90.00)	100 (90.00)	0 (0.33)	0 (0.33)	62.50 (52.2)	72.50 (58.6)	82.50 (65.4)
Lemon oil	80.00 (63.4)	87.50 (69.3)	90.00 (71.57)	92.50 (74.1)	97.50 (80.9)	0 (0.33)	12.50 (20.4)	55.00 (47.95)	55.00 (47.95)	57.50 (49.3)
Cinnamon oil	90.00 (71.57)	95.00 (77.1)	100 (90.00)	100 (90.00)	100 (90.00)	22.50 (28.2)	32.50 (34.3)	60.00 (50.8)	70.00 (56.9)	90.00 (71.57)
Garlic oil	65.00 (54.06)	72.50 (58.4)	92.50 (74.1)	100 (90.00)	100 (90.00)	10.00 (18.4)	12.50 (20.4)	27.50 (31.5)	30.00 (33.2)	42.5 (40.7)
Ginger oil	82.50 (65.3)	85.00 (67.2)	72.50 (58.4)	100 (90.00)	100 (90.00)	12.50 (20.4)	22.50 (27.7)	57.5 (49.3)	75.00 (60.6)	85.00 (67.5)
Control	1.75 (5.42)	6.25 (14.4)	3.00 (9.9)	5.50 (13.5)	5.00 (12.9)	7.50 (15.6)	2.75 (9.3)	5.00 (12.9)	5.50 (13.5)	5.50 (13.5)
S.E. (d)	1.54	2.79	2.83	3.50	1.86	1.54	2.79	2.83	3.50	1.86
C.D. (p=0.05)	4.38	7.95	8.07	9.96	5.3	4.38	7.95	8.07	9.96	5.31

Data represented are based on the average of four replications.
Figure in the parenthesis are angular transformed values.
Means followed by different letters are significantly different at 5% level.

Conclusion

The present experimental results suggested that Cinnamon and Zinger oil are effective in all the immature stages and have the efficiency to reduce the pulse beetle. It is therefore required to study about Cinnamon and Zinger oil as it reduce environmental problems, chemical pesticides and maintain a balance in agro ecosystem.

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