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Repellency Effect of Synthetic Volatiles and Essential Oils against *Callosobruchus maculatus* and *Tribolium castaneum*

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ABSTRACT: To develop economically feasible and effective alternate to chemical insecticides to manage the stored product insect pests, the combinations of essential oils and synthetic volatiles were tested for their repellent effect due to fumigation against adults of pulse beetle *Callosobruchus maculatus* and red flour beetle *Tribolium castaneum*. The plant based essential oils like *Ocimum basilicum* and *Mentha piperita* and synthetic volatile compounds like Propionic acid and Benzaldehyde and their combination were tested for the repellency effect in laboratory conditions by using filter paper, four choice olfactometer and y-shaped olfactometer methods. The selected essential oils and synthetic volatile compounds were procured and tested individually and as well as in different combinations as follows: (i) Propionic acid (ii) Benzaldehyde (iii) *M. piperita* (iv) *O. basilicum* (v) Propionic acid + Benzaldehyde (1:1) (vi) *M. piperita* + *O. basilicum* (1:1) (vii) Propionic acid + *M. piperita* (1:1) (viii) Propionic acid + *O. basilicum* (1:1) (ix) Benzaldehyde + *M. piperita* (1:1) (x) Benzaldehyde + *O. basilicum* (1:1) (xi) Propionic acid + *M. piperita* + *O. basilicum* (1:1:1) and (xii) Benzaldehyde + *M. piperita* + *O. basilicum* (1:1:1). The repellency effect of essential oil and synthetic volatiles and their combination was carried out with two different concentrations @ 1% and 3% prepared by dissolving in acetone. Among the various combination tested at 2 HAT and 4 HAT against the *C. maculatus* and *T. castaneum*, Benzaldehyde + *M. piperita* + *O. basilicum* 3% performed better in causing maximum per cent repellency in all the three methods. Therefore, combinations of essential oils and synthetic volatiles *viz.,* Propionic acid and Benzaldehyde could be used as an alternate to the conventionally used chemical fumigants to control stored product pests and may also be incorporated in the storage pest management programme to avoid the resistantce development.

Keywords: Essential oil, Olfactometer, Metabolites, Repellency, Storage pests, Synthetic volatiles.

Abbreviations: HAT, hours after treatment.

I. INTRODUCTION

In India, food grain production has reached 250 million tonnes in the year 2010-2011, in that almost 20-25 % food grains are spoiled by stored grain insect pests [1]. More than 1,660 insect species are reported to be associated with stored-products including species that are granivores, fungivores, omnivores and natural enemies and distributed in the orders Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera and Psocoptera [2]. In Indian subcontinent, the most important pests of stored grain and pulses are divided into two groups, namely, primary pests, those which are able to piercing and infesting the kernel of grain and have juvenile stages that develop within the kernel of grain and secondary pests that cannot infest whole grain but feed on broken grain pieces, debris, high moisture seeds and grain damaged by primary pests.

In general, the juvenile stages of the secondary pest are found external to the grain. It is often thought that secondary invaders cannot initiate infestation. One of the important primary pests is pulse beetle *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae) and the secondary pest is rust-red flour beetle, *Tribolium castaneum* (Herbst), (Coleoptera: Tenebrionidae) [3]. The chemical insecticides are effective, their repeated use has led to residual toxicity, environmental pollution and an adverse effect on food besides side effect on humans [4-6]. Synthetic fumigants developed and used to control these pests in storage are found to leave residues in/on grains and beetles have been started to develop resistance against Ethylene-di-Bromide (EDB) and Aluminium Phosphide (phosphine) during storage condition [7-9]. The continuous and blanket use of synthetic chemicals not only has led to develop resistant strains but also accumulate more toxic residues on food grains that are used for human consumption which has led to the health hazards [10, 11]. Plant based materials which are more readily recyclable and less likely to pollute the environment and also less toxic to mammals. There is lot of toxic plant compounds produced naturally by various plant species that might be well-suited with newer pest control approaches [12]. Propionic acid occurs in the blend of volatile compounds emitted by barley grains [13]. However, it is also commonly used by the food industry as a preservative agent in several food products. It serves as preventing the fungal growth and also control the insects especially in storage of moist food grains. Benzaldehyde and its derivatives could be used as an alternate to the traditionally used chemical fumigants to manage the stored product pests. It is extracted from many nuts, seeds and leaves. Benzaldehyde and Propionic acid is generally regarded as safe food additive and preservatives in the United States and is accepted as a flavouring substance in European Union. Both benzaldehyde and propionic acid were organic compounds and are easily biodegradable [14]. Many plant essential oils showed a broad spectrum of activity against insect pests and plant pathogenic fungi ranging from insecticidal, antifeedant, repellent, oviposition deterrent, growth regulatory and antivector activities. The bioactivity of essential oils of *Mentha piperita*, *Ocimum basilicum* and *Origanum compactum* was evaluated against the adults of *Rhyzopertha dominica* and *Sitophilus oryzae* by using fumigation and repellency at different concentrations [15]. These oils also have a long tradition of use in the protection of stored product pests. Keeping the above in view, an attempt was made to develop economically feasible and also effective alternate to chemical insecticides to manage the stored product insect pests. The combinations of essential oils and synthetic volatiles were tested for their repellent effect due to fumigation against adults of *C. maculatus* and *T. castaneum*.

II. MATERIALS AND METHODS

The test insects namely Pulse Beetle, *C. maculatus* and Red flour beetle *T. castaneum* were reared for the present study. The adult insects were obtained from stored product insect culture at the Department of Entomology and these beetles were reared on healthy and clean grains/flour in glass jars. The test insects were mass cultured in 1kg capacity glass jar of size 15 × 10 cm containing respective food materials such as black gram for *C. maculatus* and wheat flour for *T. castaneum* each 500 g as a nutritional source at 60-70 % relative humidity and temperature ranged from 30-35ºC. Maximum of seven days were allowed for mating and oviposition. Then the parent stocks were removed and food media containing eggs were incubated in the temperature and humidity as mentioned above in darkness to obtain same aged insects. With the interval of two generations, half of the completely infested grains/flour was replaced with the same quantity of uninfested materials [16].

The essential oils namely, *Mentha piperita* (pepper mint) oil and *Ocimum basilicum* (ocimum) oil and the synthetic volatile compounds *viz.*, Propionic acid and Benzaldehyde were selected and used for this study and purchased from Allins Exports Private Limited, Noida, Uttar Pradesh and Sisco Research Laboratories Private Limited, Mumbai respectively.

Filter paper method: The filter paper method was used for testing the repellent activity of synthetic volatile compounds and essential oils and their combinations against the test insects. This method was carried out in glass petridishes (diameter 8.5 and height 1.2 cm).

The serial dilution of two different concentrations (1 and 3 %) of synthetic volatile compounds, essential oils and their combinations were prepared in acetone (100 µl). Whatman No. 1 filter paper was cut into two equal halves and the treatments were applied to one half of the filter paper uniformly using micropipette. The other half of the filter paper was treated with acetone only. The treated filter paper was dried to evaporate the solvent completely. Both halves were attached with cellophane tape and placed at the bottom of petridishes. Ten adults of test insect were released at the centre of filter paper disc and then petridishes were covered and kept in dark. Three replicates were set for each concentration of synthetic volatile compounds, essential oils and their combinations. In control one half is treated with acetone and another half was untreated. Number of insects on both halves of the filter papers was recorded 2 hours and 4 hours after treatment in mild light [17].

Percent repellency (% R) = (C – T)/(C + T) ×100

C - Number of insects on control side and
T - Number of insects on treated side.

Four choice olfactometer: The four choice olfactometer was used for testing the repellent effects of synthetic volatile compounds and essential oils and their combinations against the test insects. This apparatus consists of a central chamber (25 cm long by 25 cm wide by 5 cm high) from which project out wards four glass tubes (arms) (17 cm long by 3 cm in diameter). The top of the central chamber provided with insect releasing port and the bottom with small orifice. The end of the each arms and central orifice were connected to the airflow. The different concentrations (1 and 3 %) of synthetic volatile compounds, essential oils and their combinations were prepared by dissolving in acetone (100 µl). The seeds/flour were treated with these combinations and placed inside of each arm. Twenty adult beetles were released on the insect releasing port and for control seeds without treatment were used [18]. After 2 hours and 4 hours of the treatment, number of insect present on each arm was observed and Percent Repellency was calculated by using the formula

Percent repellency (% R) = (C – T)/(C + T) × 100

C - Number of insects on control side and
T - Number of insects on treated side.

Y-shaped olfactometer: To determine the repellent effects of synthetic volatile compounds and essential oils and their combinations, the Y-shaped olfactometer was used. Two concentration *viz.*, 1% and 3% of synthetic volatile compounds and essential oils and their combinations were impregnated with Whatman No.1 filter paper and placed on one arm of Y-shape, while the other arm was used as control without treatment. Twenty adult beetles (2-7 days old) were selected from the culture and were released in entry point of olfactometer. After 2 hours and 4 hours of the treatment, the number of released insects were measured at treated and control. Three replicates were set for each treatment. In control, one arm with acetone treated seeds while the other was untreated [19]. Percent Repellency (PR) values was computed by using the formula

Percent repellency (% R) = (C – T)/(C + T) × 100

C - Number of insects on control side and
T - Number of insects on treated side.

The data obtained from the laboratory experiments were analysed statistically by using Completely Randomised Block Design (CRBD) and ranked using Least Significant Difference (LSD).

III. RESULTS AND DISCUSSION

Filter paper method: The repellency effects of selected synthetic volatile compounds and essential oils and their combinations against *C. maculatus* are shown in Table 1 and Fig. 1. The result revealed that the maximum per cent repellency (88.66%) was observed in Benzaldehyde + *M. piperita* + *O. basilicum* 3% and it differed significantly from other treatments followed by Benzaldehyde + *M. piperita* 3% and Benzaldehyde + *M. piperita* + *O. basilicum* 1% with 78.33% and 76.00% respectively at 2 HAT and found to be statistically on par with each other. The minimum per cent repellency was noticed in the treatment, Propionic acid + Benzaldehyde 1 % with 20.00 % repellency which is followed by Propionic acid 1 % with 26.66 % and Propionic acid 3 % with 38.33%. The results of 4 HAT revealed that maximum repellency was noticed in the treatment, Benzaldehyde + *M. piperita* + *O. basilicum* 3% with 96.66% and it showed significant from other treatments, which is followed by Benzaldehyde + *M. piperita* 3% with 90.00% repellency. The treatments, Benzaldehyde + *M. piperita* + *O. basilicum* 1% and Benzaldehyde + *M. piperita* 1 % were recorded with 80.00 % repellency each whereas the minimum per cent repellency was evidenced in Propionic acid 1% with 40.00 % followed by Propionic acid 3% and Propionic acid + Benzaldehyde 1% with 43.33% each. The treatments, Propionic acid 1%, Propionic acid 3% and Propionic acid + Benzaldehyde 1% were found to be statistically on par with each other. No repellency was observed both in the control and in the comparative check acetone. The repellency against *T. castaneum* was noticed maximum in Benzaldehyde + *M. piperita* + *O. basilicum* 3 % with 76.66 % and it had significant difference from other treatments after 2 HAT followed by Benzaldehyde + *M. piperita* 3 % and Benzaldehyde + *M. piperita* + *O. basilicum* 1% with 63.33% and 56.66% respectively. The minimum per cent repellency was observed in the treatment, Propionic acid + Benzaldehyde 1% with 23.33% which is followed by Propionic acid 1% and Benzaldehyde 1 % with 26.66% each respectively and found to be on par with each other. The results of repellency effect of various treatments at 4 HAT revealed the maximum repellency per cent in the treatment Benzaldehyde + *M. piperita* + *O. basilicum* 3% (96.66 %) which is followed by Benzaldehyde + *M. piperita* + *O. basilicum* 1%, Benzaldehyde + *M. piperita* 3% and Benzaldehyde + *M. piperita* 1% with 83.33%, 80.00% and 76.66% repellency respectively whereas the minimum per cent repellency was observed in Benzaldehyde 1 % with 30.00 % followed by Benzaldehyde + *O. basilicum* 3% with 40.00 % and Propionic acid 1 % with 43.33 % (Table 1) (Fig. 2). The results are supported by [20] the reports of the repellency test of *Ocimum grattissimum* essential oil and its important constituent eugenol against *C. chinensis* through choice bioassay in petriplates. After 24-h, 78 to 93 % repellency was observed at the concentration of 0.05 to 0.20 % v/w. They suggested the major reason for the negative per cent repellency values may due to the presences of high contact toxicity of eugenol. Further, the results are supported by [21] who found that the effect of essential oil of *Eucalyptus globulus* and *Ocimum grattissimum* were observed as 9.16+0.30 and 8.50+0.22 repellency respectively for *T. castaneum* and 8.66+0.33 and 8.16 + 0.30 for *S. oryzae*. The repellency of both insects increased with concentration from 0.05 % to 0.40 % at exposure time of 4 hours. These observations were confirmed that the essential oil which extracted from these plant had more repellency against both insects due to presence of the alkaloids like menthol, menthone (pepper mint oil) and eugenol (ocimum oil). It is clear that the present study revealed the ocimum oil combination gives maximum repellency even at low concentration among the other combinations. This may be due to the presence of methyl eugenol and linalool in ocimum. Also supported by the findings of [22] as the major constituents of *O. basilicum* is methyl chavicol, geranial, linalool.

Table 1: Effect of repellency of selected synthetic volatile compounds and essential oils and their combinations against adults of *Callosobruchus maculatus* and *Tribolium castaneum* using filter paper method.

S.No.	Treatments	% Repellency (*C. maculatus*)		% Repellency (*T. castaneum*)	
		2 HAT	4 HAT	2 HAT	4 HAT
1.	Propionic acid 1 %	26.66 (31.07)^{f}	40.00 (39.23)^{f}	26.66 (30.78)^{fg}	43.33 (41.15)^{f}
2.	Propionic acid 3 %	38.33 (38.24)^{e}	43.33 (41.15)^{f}	43.33 (41.15)^{cde}	73.33 (59.21)^{bc}
3.	Benzaldehyde 1 %	40.00 (39.23)^{e}	56.66 (48.84)^{e}	26.66 (30.99)^{fg}	30.00 (33.21)^{g}
4.	Benzaldehyde 3 %	46.66 (43.08)^{d}	66.66 (54.99)^{de}	36.66 (37.99)^{ef}	50.00 (45.00)^{ef}
5.	Propionic acid + Benzaldehyde 1%	20.00 (26.56)^{g}	43.33 (41.15)^{f}	23.33 (28.28)^{g}	46.66 (43.07)^{f}
6.	Propionic acid + Benzaldehyde 3%	58.33 (49.80)^{c}	63.33 (52.77)^{e}	46.66 (43.07)^{de}	63.33 (52.77)^{cd}
7.	Benzaldehyde + *O. basilicum* 1%	40.00 (39.23)^{e}	60.00 (50.77)^{e}	36.66 (37.22)^{ef}	60.00 (50.77)^{de}
8.	Benzaldehyde + *O. basilicum* 3%	56.66 (48.84)^{c}	76.66 (61.22)^{cd}	40.00 (39.23)^{de}	40.00 (39.23)^{fg}
9.	Benzaldehyde + *M. piperita* 1%	60.00 (50.77)^{c}	80.00 (63.43)^{c}	53.33 (46.92)^{bcd}	76.66 (61.22)^{b}
10.	Benzaldehyde + *M. piperita* 3%	78.33 (62.29)^{b}	90.00 (71.56)^{b}	63.33 (52.77)^{b}	80.00 (63.43)^{b}
11.	Benzaldehyde + *M. piperita* + *O. basilicum* 1 %	76.00 (60.67)^{b}	80.00 (63.43)^{c}	56.66 (48.84)^{bc}	83.33 (66.14)^{b}
12.	Benzaldehyde + *M. piperita* + *O.basilicum* 3%	88.66 (70.34)^{a}	96.66 (83.66)^{a}	76.66 (61.22)^{a}	96.66 (83.66)^{a}
13.	Acetone	5.00 (12.92)^{h}	0.000 (0.28)^{g}	0.00 (0.28)^{h}	0.00 (0.28)^{h}
14.	Control	0.00 (0.28)^{i}	0.000 (0.28)^{g}	0.00 (0.28)^{h}	0.00 (0.28)^{h}
SEd		1.18	3.26	3.79	3.56
CD (0.05)		2.24	6.68	7.77	7.31

*Mean of three replications
*HAT – Hours After Treatment
*Values in parenthesis are arc sine transformed
*Values with different alphabets differ significantly according to LSD

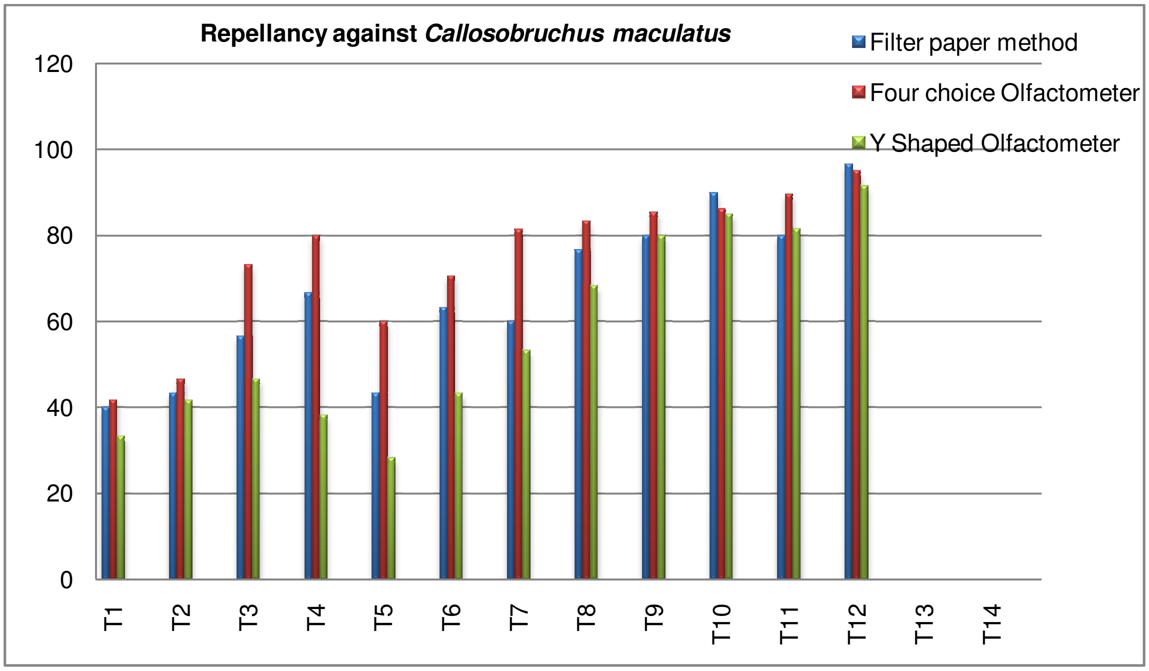

Fig. 1. Comparison of repellency activities against *Callosobruchus maculatus.*

Four choice olfactometer: At 2 HAT, the maximum per cent repellency (85.71 %) was reported in Benzaldehyde + *M. piperita* + *O. basilicum* 3 % against *C. maculatus* followed by Benzaldehyde + *M. piperita* 3 % and Benzaldehyde + *M. piperita* + *O. basilicum* 1 % with 77.77 % and 75.00 % respectively whereas Benzaldehyde + *M. piperita* 3 % and Benzaldehyde + *M. piperita* + *O. basilicum* 1 % were found to be on par statistically. The minimum per cent repellency was noticed in the treatment Propionic acid 1 % with 33.33 %. followed by Propionic acid 3 % and Benzaldehyde 1 % recorded 41.66 % each. While observing at 4 HAT, the maximum per cent repellency was found in Benzaldehyde + *M. piperita* + *O. basilicum* 3 % with 95.22 % followed by Benzaldehyde + *M. piperita* + *O. basilicum* 1 % observed with 89.29%. The treatments, Benzaldehyde + *M. piperita* 3% (86.29%) and Benzaldehyde + *M. piperita* 1% (85.46 %) were followed suit whereas Benzaldehyde + *M. piperita* 3 % and Benzaldehyde + *M. piperita* 1 % were showed no significant difference. The minimum per cent repellency was witnessed in Propionic acid 1% (41.65%) followed by Propionic acid 3% (46.65%) and Propionic acid + Benzaldehyde 1% (60.00%) whereas Propionic acid 1% and Propionic acid 3% were statistically equal (Table 2) (Fig. 1).

The maximum per cent repellency against *T. castaneum* was recorded in Benzaldehyde + *M. piperita* + *O. basilicum* 3% and Benzaldehyde + *M. piperita* 3 % with 94.00 % and 92.58% respectively and were statistically on par with each other at 2 HAT. This was followed by Benzaldehyde + *O. basilicum* 3% and Propionic acid + Benzaldehyde 3 % with 88.87% and 86.29% respectively. The minimum per cent repellency was evidenced in the treatment, Propionic acid 1% (36.65 %) and Benzaldehyde + *O. basilicum* 1 % (43.32%). While observing at 4 HAT, the maximum per cent repellency was noticed in Benzaldehyde + *M. piperita* +*O. basilicum* 3 % with 96.00%, Benzaldehyde +*M. piperita* 3 % and Benzaldehyde + *O. basilicum* 3% recorded 92.57% each and were statistically on par. The minimum per cent repellency was noticed as 55.32% in Propionic acid 1% followed by 67.76% in Benzaldehyde + *O. basilicum* 1% (Table 2) (Fig. 2). The results of repellency bioassay conducted by using four choice olfactometer revealed that the maximum repellency was observed in the treatment Benzaldehyde + *M. piperita* + *O. basilicum* 3% with 95.22% and 96.00 % against *C. maculatus* and *T. castaneum* at 4 HAT respectively.

Y-shaped olfactometer: The results of repellency against *C. maculatus* during 2 HAT revealed the maximum effect from Benzaldehyde + *M. piperita* + *O. basilicum* 3 % treatment with 78.33% and it differed significantly from other treatments, followed by Benzaldehyde + *M. piperita* 3% and Benzaldehyde + *M. piperita* + *O. basilicum* 1 % with 76.66% and 71.66% respectively. The repellency of Benzaldehyde + *M. piperita* + *O. basilicum* 3 % and Benzaldehyde + *M. piperita* 3% were statistically on par and exhibited similar effects. The minimum per cent repellency was evidenced in the treatment, Propionic acid 1% (8.33%) which is closely followed by Benzaldehyde 1 %, Propionic acid 3 % and Propionic acid + Benzaldehyde 1% with 15.00 %, 16.66 % and 18.33% respectively and found to be statistically on par with each other. The results of 4 HAT showed that maximum repellency was noticed in the treatment, Benzaldehyde + *M. piperita* + *O. basilicum* 3% recorded 91.66 % close on the heels of the treatment, Benzaldehyde + *M. piperita* 3%, Benzaldehyde + *M. piperita* + *O. basilicum* 1 % and Benzaldehyde + *M. piperita* 1% were followed suit with 85.00 %, 81.66% and 80.00% repellency respectively whereas the minimum per cent repellency was observed in Propionic acid + Benzaldehyde 1% with 28.33% followed by Propionic acid 1%, Benzaldehyde 3% and propionic acid 3 % with 33.33%, 38.33% and 41.66%

respectively (Table 3) (Fig. 1). The repellency effects of selected synthetic volatile compounds and essential oils and their combinations against *T. castaneum* are furnished in Table 3 and Fig. 2.

Table 2: Effect of repellency of selected synthetic volatile compounds and essential oils and their combinations against adults of *C. maculatus* and *T. castaneum* using four choice olfactometer.

S. No.	Treatments	% Repellency *Callosobruchus maculatus*		% Repellency *Tribolium castaneum*	
		2 HAT	4 HAT	2 HAT	4 HAT
1.	Propionic acid 1%	33.33 (35.26)^{h}	41.65 (40.19)^{h}	36.65 (37.25)^{e}	55.32 (48.05)^{e}
2.	Propionic acid 3%	41.66 (40.20)^{g}	46.65 (43.08)^{h}	70.46 (57.09)^{d}	81.31 (64.41)^{bc}
3.	Benzaldehyde 1%	41.66 (40.20)^{g}	73.32 (58.95)^{f}	72.13 (58.18)^{d}	80.00 (63.54)^{c}
4.	Benzaldehyde 3%	58.33 (49.80)^{e}	80.00 (63.44)^{e}	82.11 (65.06)^{c}	86.65 (68.71)^{b}
5.	Propionic acid + Benzaldehyde 1%	50.00 (45.00)^{f}	60.00 (50.77)^{g}	82.20 (65.06)^{c}	86.65 (68.59)^{b}
6.	Propionic acid + Benzaldehyde 3%	58.33 (49.80)^{e}	70.65 (57.22)^{f}	86.29 (68.31)^{bc}	86.28 (68.31)^{b}
7.	Benzaldehyde + *O. basilicum* 1%	58.33 (49.80)^{e}	81.53 (64.60)^{de}	43.32 (41.16)^{e}	67.76 (55.43)^{d}
8.	Benzaldehyde + *O. basilicum* 3%	66.66 (54.76)^{d}	83.33 (65.93)^{cde}	88.87 (70.58)^{b}	92.57 (74.94)^{a}
9.	Benzaldehyde + *M. piperita* 1%	71.08 (57.47)^{c}	85.46 (67.70)^{cd}	82.22 (65.31)^{c}	82.21 (65.99)^{bc}
10.	Benzaldehyde + *M. piperita* 3%	77.77 (61.89)^{b}	86.29 (68.50)^{cd}	92.58 (74.95)^{a}	92.57 (74.94)^{a}
11.	Benzaldehyde + *M. piperita* + *O. basilicum* 1%	75.00 (60.01)^{b}	89.67 (71.33)^{b}	83.32 (65.99)^{c}	83.32 (65.99)^{bc}
12.	Benzaldehyde + *M. piperita* + *O.basilicum* 3%	85.71 (68.00)^{a}	95.22 (77.49)^{a}	94.00 (75.90)^{a}	96.00 (78.90)^{a}
13.	Acetone	0.00 (0.28)i	0.00 (0.28)^{i}	0.00 (0.28)^{f}	0.00 (0.28)^{f}
14.	Control	0.00 (0.28)i	0.00 (0.28)^{i}	0.00 (0.28)^{f}	0.00 (0.28)^{f}
SEd		1.10	1.70	1.98	2.18
CD (0.05)		2.27	3.49	4.06	4.46

*Mean of three replications
*HAT – Hours After Treatment
*Values in parenthesis are arc sine transformed
*Values with different alphabets differ significantly according to LSD

Table 3: Effect of repellency of selected synthetic volatile compounds and essential oils and their combinations against adults of *C. maculatus* and *T. castaneum* using Y- shaped olfactometer.

S.No.	Treatments	% Repellency (*C. maculatus*)		% Repellency (*T. castaneum*)	
		2 HAT	4 HAT	2 HAT	4 HAT
1.	Propionic acid 1%	8.33 (16.59)^{f}	33.33(35.25)^{gh}	6.66 (14.75)^{g}	23.33 (28.85)^{h}
2.	Propionic acid 3%	16.66 (24.04)^{e}	41.66 (40.17)^{ef}	11.66 (19.88)^{f}	36.66 (37.22)^{ef}
3.	Benzaldehyde 1%	15.00 (22.78)^{e}	46.66 (43.08)^{de}	10.00 (18.43)^{fg}	41.66 (40.19)^{de}
4.	Benzaldehyde 3%	31.66 (34.23)^{d}	38.33 (38.24)^{fg}	26.66 (31.07)^{e}	33.33 (35.25)^{fg}
5.	Propionic acid + Benzaldehyde 1%	18.33 (25.30)^{e}	28.33 (32.14)^{h}	13.33 (21.33)^{f}	28.33 (32.14)^{gh}
6.	Propionic acid + Benzaldehyde 3%	33.33 (35.21)^{d}	43.33 (41.16)^{ef}	31.66 (34.18)^{e}	36.66 (37.25)^{ef}
7.	Benzaldehyde + *O. basilicum* 1%	50.00 (45.00)^{c}	53.33 (46.91)^{d}	45.00 (42.13)^{d}	48.33 (44.04)^{d}
8.	Benzaldehyde + *O. basilicum* 3%	55.00 (47.87)^{c}	68.33 (55.77)^{c}	50.00 (45.00)^{d}	63.33 (52.74)^{c}
9.	Benzaldehyde + *M. piperita* 1%	68.33 (55.77)^{b}	80.00 (63.43)^{b}	61.66 (51.75)^{c}	75.00 (60.00)^{b}
10.	Benzaldehyde + *M. piperita* 3%	76.66 (61.14)^{a}	85.00 (67.21)^{b}	71.66 (57.86)^{ab}	80.00 (63.43)^{ab}
11.	Benzaldehyde + *M. piperita* + *O. basilicum* 1%	71.66 (57.86)^{ab}	81.66 (64.69)^{b}	65.00 (53.73)^{bc}	76.66 (61.14)^{b}
12.	Benzaldehyde + *M. piperita* + *O.basilicum* 3%	78.33(62.29)^{a}	91.66 (73.40)^{a}	73.33 (58.93)^{a}	83.33 (65.95)^{a}
13.	Acetone	0.00 (0.28)^{g}	0.00 (0.28)^{g}	1.66 (4.49)^{h}	1.66 (4.49)^{i}
14.	Control	0.00 (0.28)^{g}	0.00 (0.28)^{i}	0.00 (0.28)^{h}	0.00 (0.28)^{i}
SEd		2.25	2.18	2.20	2.13
CD (0.05)		4.57	4.48	4.52	4.37

*Mean of three replications
*HAT – Hours After Treatment
*Values in parenthesis are arc sine transformed
*Values with different alphabets differ significantly according to LSD

During 2 HAT, the maximum per cent repellency was observed in Benzaldehyde + *M. piperita* + *O. basilicum* 3% treatment with 73.33% while Benzaldehyde + *M. piperita* 3% and Benzaldehyde + *M. piperita* + *O. basilicum* 1% treatment were followed suit with 71.66% and 65.00 % respectively. The minimum per cent repellency was noticed in the treatment, Propionic acid 1% (6.66%) which is followed by Benzaldehyde 1% (10.00%) and Propionic acid 3% (11.66%). The results of 4 HAT revealed that maximum repellency per cent was in the treatment with Benzaldehyde + *M. piperita* + *O. basilicum* 3 % (83.33%) followed by Benzaldehyde + *M. piperita* 3%, Benzaldehyde + *M. piperita* + *O. basilicum* 1% and Benzaldehyde + *M. piperita* 1% with 80.00%, 76.66%, 75.00% respectively whereas the minimum per cent repellency was seen in Propionic acid 1% with 23.33% followed by Propionic acid + Benzaldehyde 1%, Benzaldehyde 3% and Propionic acid 3% with 28.33%, 33.33% and 36.66% respectively. The present study revealed that repellency rate was increased when the concentration of treatments and time increased. This showed that repellency and concentration were proportional to each other. It may be due to the presence of phytochemicals of the essential oils, pungency of synthetic volatiles and the occurrence of major constituents, menthol and eugenol in the peppermint oil and ocimum oil respectively [23].

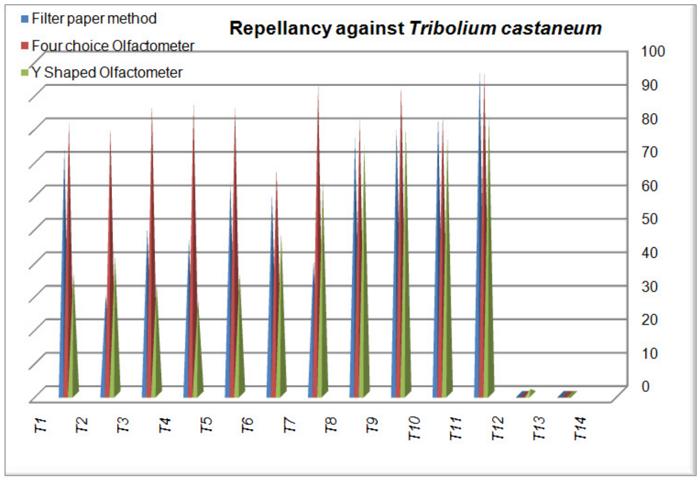

Fig. 2. Comparison of repellency activities against *Tribolium castaneum.*

IV. CONCLUSION

It is concluded from the repellency effect of essential oils and synthetic volatile compounds that Benzaldehyde + *M. piperita* + *O. basilicum* 3 % had maximum repellency effect against *C. maculatus* and *T. castaneum* in all the three methods. Hence, combinations of essential oils and synthetic volatile *viz*., Propionic acid and Benzaldehyde could be used as an alternate to the conventionally used chemical fumigants to control stored product pests.

V. FUTURE SCOPE

Further studies are required on the safety issues of synthetic volatiles and essential oils against non-target organisms and to explore the mechanism of action against target pests. Furthermore, isolation and characterization of the essential oil constituents will provide complete insight into the pesticidal activity and will be helpful in the preparation of easily usable formulations against stored produce pests. Hence, the use of naturally occurring synthetic volatile compounds and essential oils of plant species may also be incorporated in the stored grain pest management programme as an alternative so as to avoid the usage of harmful synthetic chemicals and can avoid resistant development.

Conflict of Interest. None.

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REFERENCES

[1]. Rajashekar, Y., Gunasekaran, N., & Shivanandappa, T. (2010). Insecticidal activity of the root extract of *Decalepis hamiltonii* against stored-product insect pests and its application in grain protection. *Journal of Food Science and Technology*, *47*(3), 310-314.

[2]. Hogstrum, D. W. & Subramanyam, B. (2009). Stored Product Resources. AACC International, ST. Paul, Minnesota. 509p.

[3]. Zettler, L. J., & Keever, D. W. (1994). Phosphine resistance in cigarette beetle (Coleoptera: Anobiidae) associated with tobacco storage in the southeastern United States. *Journal of Economic Entomology*, *87*(3), 546-550.

[4]. Dubey, S. C., Suresh, M., & Singh, B. (2007). Evaluation of *Trichoderma* species against *Fusarium oxysporum* f. sp. ciceris for integrated management of chickpea wilt. *Biological Control*, *40*(1), 118-127.

[5]. Kumar, R., Mishra, A. K., Dubey, N. K., & Tripathi, Y. B. (2007). Evaluation of *Chenopodium ambrosioides* oil as a potential source of antifungal, antiaflatoxigenic and antioxidant activity. *International Journal of Food Microbiology*, *115*(2), 159-164.

[6]. Singh, D., & Mehta, S. S. (2010). Menthol containing formulation inhibits adzuki bean beetle, *Callosobruchus chinensis* L.(Coleoptera; Bruchidae) population in pulse grain storage. *Journal of Biopesticides*, *3*(3), 596-603.

[7]. Brito, J. P., Baptistussi, R. C., Funichelo. M., Oliverra, J. E.M., & Bortoli, S. A. (2006). Effect of essential oils of Eucalyptus spp. under *Zabrotes sunfasciatus* (Both. 1833) (Coleoptera: Bruchidae) and *Callosobruchus maculates* (Fab.), (Coleoptera: Bruchidae) in two beans species. *Bol sanidad Veg plagas, 32*(4), 573-580.

[8]. Kim, S. I., Roh, J. Y., Kim, D. H., Lee, H. S., & Ahn, Y. J. (2003). Insecticidal activities of aromatic plant extracts and essential oils against *Sitophilus oryzae* and *Callosobruchus chinensis*. *Journal of Stored products research*, *39*(3), 293-303.

[9]. Rani, P. U., & Rajasekharreddy, P. (2010). Insecticidal activity of (2n-octylcycloprop-1-enyl)-

octanoic acid (I) against three Coleopteran stored product insects from *Sterculia foetida* (L.). *Journal of pest science*, *83*(3), 273-279.
[10]. Sharma, K., & Meshram, N. M. (2006). Bioactivity of essential oils from *Acorus calamus* and *Syzygium aromaticum,* against *Sitophilus Journal of Medical and Aromatic plant science*. *oryzae* (L.) in stored wheat *Biopesticide International*, *2*, 144-152.
[11]. Sharma, S. S., Gill, K., Malik, M. S., & Malik, O. P. (2000). Insecticidal antifeedant and growth inhibitory activities of essential oils of some medicinal plants. *Journal of Medical and Aromatic plant science, 2*, 6-9.
[12]. Dubey, N. K., Srivastava, B., & Kumar, A. (2008). Current status of plant products as botanical pesticides in storage pest management. *Journal of Biopesticides*, *1*(2), 182-186.
[13]. Maga, J. A. (1978). Cereal volatiles, a review. *Journal of Agricultural and Food Chemistry*, *26*(1), 175-178.
[14]. Lee, B. H., Choi, W. S., Lee, S. E., & Park, B. S. (2001). Fumigant toxicity of essential oils and their constituent compounds towards the rice weevil, *Sitophilus oryzae* (L.). *Crop protection*, *20*(4), 317-320.
[15]. Bounoua-Fraoucene, S., Kellouche, A., & Debras, J. F. (2019). Toxicity of four essential oils against two insect pests of stored grains, *Rhyzopertha dominica* (Coleoptera: Bostrychidae) and *Sitophilus oryzae* (Coleoptera: Curculionidae). *African Entomology*, *27*(2), 344-359.
[16]. Rahman, A., & Talukder, F. A. (2006). Bioefficacy of some plant derivatives that protect grain against the pulse beetle, *Callosobruchus maculatus*. *Journal of Insect Science*, *6*(1), 1-10.
[17]. Chaubey, M. K. (2011). Fumigant toxicity of essential oils against rice weevil *Sitophilus oryzae* L. (Coleoptera: Curculionidae). *Journal of Biological Sciences*, *11*(6), 411-416.
[18]. Pugazhvendan, S. R., Elumalai, K., Ross, P. R., & Soundarajan, M. (2009). Repellent activity of chosen plant species against *Tribolium castaneum*. *World Journal of Zoology*, *4*(3), 188-190.
[19]. Hassan, W. U. (2018). Toxicity, repellency and development inhibition of several essential oils against storage pest *C. maculatus* (Coleopetra: Bruchudae). *M. Sc., Thesis*. Bogor Agricultural University. 51 p
[20]. Ogendo, J. O., Kostyukovsky, M., Ravid, U., Matasyoh, J. C., Deng, A. L., Omolo, E. O., ... & Shaaya, E. (2008). Bioactivity of *Ocimum gratissimum* L. oil and two of its constituents against five insect pests attacking stored food products. *Journal of Stored Products Research*, *44*(4), 328-334.
[21]. Kéita, S. M., Vincent, C., Schmit, J. P., Arnason, J. T., & Bélanger, A. (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]. *Journal of Stored Products Research*, *37*(4), 339-349.
[22]. Hadipanah, A., Ghahremani, A., Khorrami, M., & Ardalani, M. (2015). Diversity in Chemical Composition and Yield of Essential oil from Three Ecotypes of Sweet Basil (*Ocimum basilicum* L.) in Iran*. Biological Forum – An International Journal*, 7(1): 1802-1805.
[23]. Asawalam, E. F., Emosairue, S. O., & Hassanali, A. (2008). Essential oil of *Ocimum grattissimum* (Labiatae) as *Sitophilus zeamais* (Coleoptera: Curculionidae) protectant. *African Journal of Biotechnology*, *7*(20), 3771-3776.

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