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Insecticidal activity of peppermint and Nutmeg essential oil against the museum pest silverfish

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ABSTRACT

Museums have a long history that it preserves our cultural and natural heritage materials of the past for future generations. These collections are vital source for education and information for researchers and academicians, and India is a tropical country that why there is a high risk of biodeterioration. Adult silverfish is a major museum pest to over biological and natural history species. To control this problem, different control methods such as insecticides, fungicides, herbicides, nematicides etc., were applied but now a day's maximum chemicals are banned due to its carcinogenic side effects. That why the author used natural products with biocidal activity and are ecofriendly. This research is carried out on various concentrations of peppermint and nutmeg essential oil tested for 30, 60, 90 and 120-minutes on the Silverfish. Research shows that there is a number of individual significantly decreased with increasing the oil concentration, treatment duration and interaction between two in both oils. And also observed that which treatment duration have the highest effect on survival of silverfish. The Nutmeg essential oil had the greatest effect on the silverfish in comparison to peppermint. 100 % mortality was recorded in 0.9 ml at 120-minute, when treated with peppermint oil. While in case of nutmeg oils, the 100% mortality in 0.6 ml at 120-minute and 0.6, 0.9mi at 120-minutes, respectively

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KEY WORDS

Adult silverfish, Oil concentration, treatment duration, survivability and mortality (%)

INTRODUCTION

Museums are the custodians of biological materials and natural history collections. These collections including specially one herbarium assembled well maintained, documented and permanent record of distribution of taxes through space and time. Herbarium is a stock of safeguarded plant specimens which is very useful for science, society and research areas (Thiers, 2016). Due to its organic nature the biodeterioration risk in indoor environments such as herbaria, libraries and repositories of archival centres has been a great cause of concern all over the world (Park, *et al.,* 2006; Pasqurella, *et al.,* 2015). Primarily, insect pests were controlled with continued application of various chemical and synthetic insecticides, these applications are applied all over the world (Rust, *et al.,* 1993, Alzogaray, *et al.,* 2011). Because of continued use of these applications show some disadvantages like human health hazards, residual toxicity and development of resistance in insect pest species (Cornwell, 1976, Dinham, 1993). If a specimen has not been deteriorated through biodeterioration over years, it is clear that the specimen has been chemically treated (Borig, 2011). Various entomologists advised that the insecticide and pesticide do not used for pest control (Cheng, *et al.,* 2005, Jang, *et al.,* 2005, Alshehry, *et al.,* 2014, Ahmed, *et al.,* 2015) and instead advocate controlling numbers by focusing on reducing humidity and on heating or freezing infested articles (Slater and Kastanis, 1997). The alternative method should be cost effective, easily available, eco friendly, and harmless to beneficial pests. In India, thousand years ago various plant product traditionally used as insecticides for controlling the insect pest and these are not only healthy but also cost effective and eco friendly. The use of bio-based materials in controlling for insect pest has been observed by many researchers due to the economic and environmental reasons as well as their potential availability and variability (Safian, *et al.,* 2011, Rodrigues, *et al.,* 2012, Alshehry, *et al.,* 2014, Ahmed, *et al.,* 2015).

Application of these Natural products is an innovative attempt for the control of biodeterioration and biodegradation and is ecofriendly in nature (Brahmi, *et al.,* 2016, Gupta, *et al.,* 2021). In this paper the authors

used *Mentha piperita* L. (commonly known as peppermint) and *Myristica fragrans* essential oils for the control of adults silverfish. In all over world, the silverfish is a common household insect pest usually found in damp, cool places (Ebeling, 1975). They belong to the order Thysanura and feed high rich protein, sugar, and starch materials such as paper, the glue on wallpaper and bound books, cereals, and dried meats. For controlling these pest different chemical method was used, but these chemical are banned due to carcinogenic side effects, that's why the author used natural products with biocidal activity had shown alternative and useful source for the control of biodeterioration and are ecofriendly in nature.

Peppermint a perennial aromatic and medicinally important plant belonging to the family Lamiaceae, is widely grown in temperate zones of Europe, North America, Asia, and North Africa and also in other regions of the world. It is commercially used in various industries like food, beverages, pharmaceutical, cosmetic, health and tobacco. The peppermint oil has major chemical compounds consisting of menthol, menthone and menthofuran (Tarhan, *et al*., 2010, Brahmi, *et al*., 2017). Additionally, there is some promising data suggesting that peppermint oil may be beneficial via anti-spasmotic, anti-inflammatory and antibacterial properties (Papathanasopoulos, *et al*., 2013). Peppermint essential oil has been reported for its insecticidal and antifeedant activities against wide range of pests (Hanan, 2013, Khani, *et al*., 2017). The essential oil obtained from Nutmeg plays an important role in plant defense, protecting against many infections (Latha, *et al*., 2005). This oil also shown to be toxic to insects such as cockroaches (Krishnamoorthy and Rema, 2001), termites (Pal, *et al.*, 2011), nematicidal activity against the southern root-knot nematode Meloidogyne incognita (Tylenchida:Heteroderidae) (Gotke and Maheshwari,1990) and antimicrobial activity against Salmonella typhi (Rani and khullar, 2004).

The purpose of this research was to determine if essential oils could be used in the reduction or eradication of the silverfish. Two types of essential oil were tested (peppermint and Nutmeg) to determine the oil concentration of the population through a 30, 60, 90 and 120-minute contact bioassay. The oil producing the lowest concentration after 120-minutes was deemed most effective as it would be the most comparable to a museum.

Materials and Method

Stock culture

The adults Silverfish were collected from Maulana Azad Library basement and Departmental storeroom in Museology, Aligarh Muslim University, Aligarh (27.88 N 78.08 E) U.P, India. They were reared in plastic containers ($15\times20\times10cm^3$) and provided unlimited amount of cellulose containing mixed diets in a 1:1 ratio (composition of mixed feed: milk powder, oatmeal, yeast,1:9:1). The diets were daily replenished, and all the set up were placed at 25±3ºC in 90% relative humidity in the dark place. Adult silverfish collected from the basement time to time and added to the laboratory culture in order to avoid inbreeding. The Silverfish colony had been established at least 9 to 12 months before the study. The experiments were carried out in the laboratory condition of department of Museology, AMU.

Experimental setup

The adult's silverfish were taken from the stock culture. The peppermint, and Nutmeg oils were form four different concentration (0, 0.3, 0.6 & 0.9ml) with the help of FILTER PAPER BIOASSAYS. Thereafter, following experimental treatments were designed:

1. Control condition
2. 0.3 ml of peppermint Oil
3. 0.6 ml of peppermint Oil
4. 0.9 ml of peppermint Oil

To evaluate the activity of insecticides of peppermint, the filter papers ($2 \times 2cm^2$) were deep in above oil concentrations then dry and placed into Petri dishes (9cm diameter × 1.0 cm height). The ten adult silverfish were released and a few drops of water were put onto the bottom edge of each of the Petri dish. These set up were placed in a growth chamber maintained at 25±2°C and 90% relative humidity. The number of individual survived and % mortality was recorded periodically for up to 30, 60, 90 and 120-minutes, respectively using the expression,

Mortality (%) = (Number of dead silverfish/Total number of test silverfish) × 100.

The same experiment was repeated in 0.6 and 0.9 ml concentration of peppermint oils. All the above set up also treated with Nutmeg oil at all oil concentration, and these experiments were repeated in to 3 time.

Statistical analysis

Data obtained on number of adult mortality were analyses by using two-way ANOVA followed by post hoc Turkey's test with oil concentration (0.3, 0.6, 0.9ml) and duration of treatment (30, 60, 90 and 120-minutes) as an independent factor. All analysis were carried out by using MINITAB16 statistical software (Minitab Inc, State college, Pennsylvania, USA)

Results

In the treatment of peppermint oils, the result of two way ANOVA revealed that the survivability was significantly influenced by oil concentration ($F=10.22$; $P<0.0001$; $df=3,159$) and treatment duration ($F=6.32$; $P<0.000$; $df=3,159$) and interaction between two was insignificant ($F=0.81$; $P=0.607$; $df=9,159$). While in case of Nutmeg oil, survivability of Adult Silverfish was significantly influenced by both oil concentration ($F=64.58$; $P<0.0001$; $df=3,159$) as well as duration of treatment ($F=36.10$: $P<0.0001$: $df=3,159$). The overall interaction between the two independent factors were also significant ($F=4.37$;$P<0.0001$;$df=9,159$). In both oils, the number of adults decreased with increase in treatment duration at all oil concentration and comparison of means was significant (table-1). It was also found that the nutmeg oil has high toxicity for adult silverfish as compared to peppermint. The mortality (%) of adults slowly increased with increasing the concentration of both oils at 30-minutes. The 100% mortality was recorded in 0.9ml concentration of peppermint at 120-minutes (Figure-1), while in case of nutmeg oil, the 0.6ml at 120- minute and 0.9 ml at 90 and 120-minutes respectively (Figure-2).

Discussion

In the present study the mortality of adult Silverfish increased with increasing the oil concentration and treatment duration. The Nutmeg oil is very toxic showing the contact toxicity activity as compare to

peppermint oil. The mortality of adult silverfish is totally dependent on nature of oils, and these oils are very useful for control of museum pests. 100% mortality was recorded in 0.6ml of oil concentration of nutmeg at 120 minutes and 0.9ml at 90-minutes respectively. My result was supported by Kodjo, et al. (2011) that the Nutmeg oil showed a strong larvicidal activity with 100% mortality against third instar larvae of diamondback moth sometimes called cabbage moth. In Nutmeg oil higher mortality was recorded to 86.66% in comparison to hazelnut oil 80.83% against *Callosobruchus maculatus* (Haghtalab, *et al*., 2009).

The cinnamon had greater toxicity effect against larvae and adults of *T. castaneum* and *Sitophillus zeamais* respectively (Mondal and Khalequzzaman, 2009). In the analysis of Nutmeg oils enzyme activity, the Nutmeg consists of high aromatic compounds such as myristicin which triggered reduction in enzyme activity. Myristicin acts as a narcotic which interferes with acetyl cholinesterase activity resulting in brain damage (Chun, *et al.*, 2015), and also reported that extract of n-hexane in nutmeg at a dose of 100-150 µg/mL significantly degrades activity of acetyl cholinesterase in white mice (Dhingra, *et al.*, 2006). On the same study, Kasim, et al. (2014) reported that cinnamon consist of compounds such as 1, 2- naphthalenedione ethanone and borneol where cinnamaldehyde is the main toxic compound. Furthermore study by Kim, et al. (2003) also indicated cinnamon has a fumigant and contact effect against *Lasioderma serricorne* F., *Sitophilus oryzae*, and *C. chinensis* at a dose of 0.7 mg/cm^2 with a percentage of 100% within 24-hours. Although various plant products are reported to have insecticidal or fumigant activity against insect pests (Kim and Ahn, 2001, Kim, *et al.*, 2003, Choi, *et al.*, 2006, Park *et al.*, 2006, Sahaf, *et al.*, 2007).

This research has brought attention to the effects essential oils have on the adult silverfish. Depending on the intended target, essential oils have a high probability of success towards pest species and limited deleterious effects as compared to pesticides. Ultimately, both personal and large scale pest management programs should consider essential oils as an alternative to pesticides.

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Table-1: Effect of varying concentration (0.3, 0.6, 0.9) of Peppermint and Nutmeg oil at different treatment duration (control, 30, 60, 90 and 120-Minutes) on survival of adult's silverfish.

Concentration Oil (ml)	Treatment duration (minutes)	Adults survival	
		Peppermint	Nutmeg
Control	30	10.00±0.00a$^{(A)}$	10.00±0.00a$^{(A)}$
	60	10.00±0.00a$^{(A)}$	10.00±0.00a$^{(A)}$
	90	10.00±0.00a$^{(A)}$	10.00±0.00a$^{(A)}$
	120	9.80±0.45a$^{(A)}$	9.80±0.45a$^{(A)}$
0.3	30	9.80±0.45a$^{(A)}$	10.00±0.00a$^{(A)}$
	60	8.60±0.89A$^{(A)}$	4.20±1.10b$^{(B)}$
	90	7.20±1.30b$^{(B)}$	1.00±0.71c©
	120	6.80±0.84b$^{(B)}$	0.00±0.00d$^{(D)}$
0.6	30	8.80±0.45b$^{(B)}$	10.00±0.00a$^{(A)}$
	60	6.80±1.30b$^{(C)}$	3.00±1.22b$^{(B)}$
	90	5.80±1.79c©	0.80±0.45c©
	120	4.8±1.30c$^{(D)}$	0.00±0.00d$^{(D)}$
0.9	30	8.80±0.45a$^{(A)}$	10.00±0.00a$^{(A)}$
	60	6.20±0.45b$^{(B)}$	0.00±0.00b$^{(B)}$
	90	4.00±1.58c©	0.00±0.00c©
	120	0.00±0.00 d$^{(D)}$	0.00±0.00d$^{(D)}$
F$_{(Oil\ concentration)}$		**10.12****	**64.10****
F$_{(Treatment\ duration)}$		**6.32***	**36.10****
F$_{(Oil\ concentration\ X\ treatment\ duration)}$		**0.81^{NS}**	**4.37***

Values are Mean± S.E.
* and ** denote F-values to be significant at P<0.01, respectively.
NS denotes F-values to be non-significant at P>0.05.
Smaller alphabets represent comparison of means between oil concentration and larger alphabets in parentheses represent comparison across the treatment duration.

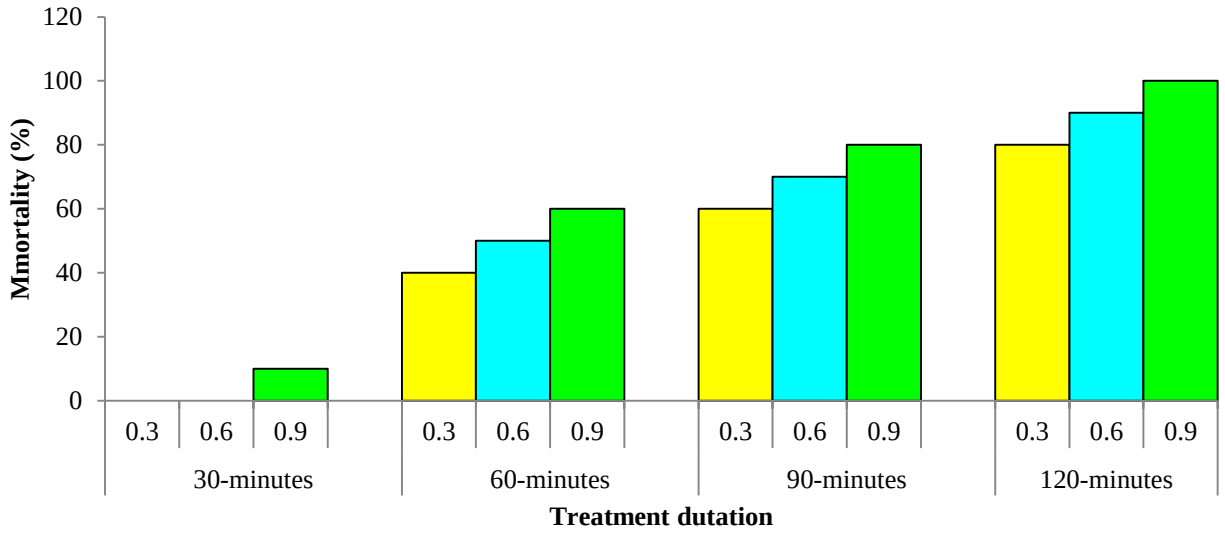

Figure-1: Effect of varying concentration (0.3, 0.6, 0.9ml) of peppermint oil at different treatment duration (30, 60, 90 & 120-Minutes) on % mortality of adult silverfish.

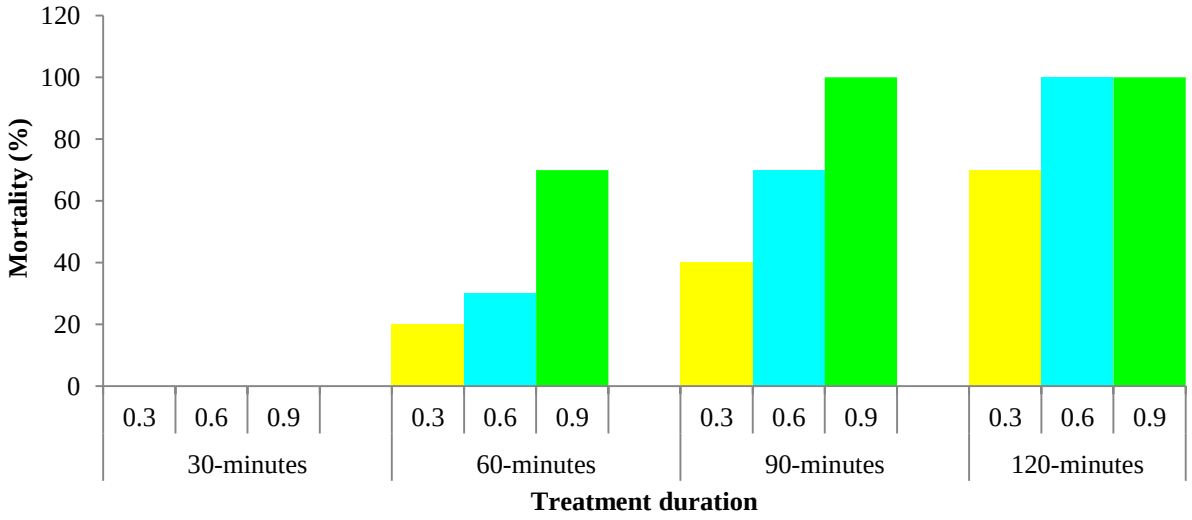

Figure-2: Effect of varying concentration (0.3, 0.6, 0.9ml) of Nutmeg oil at different treatment duration (30, 60, 90 & 120-Minutes) on % mortality of adult silverfish.

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