Journal of Innovations in Pharmaceutical and Biological Sciences (JIPBS)
ISSN: 2349-2759
Available online at www.jipbs.com

Research article

Repellent activity of *Nigella sativa*, *Syzygium aromaticum* and *Azadirachta indica* essential oils against the skin and skin product pest (*Anthrenus verbasci*) in Museums

Fatma Faheem*, **Abduraheem K**

Department of Museology, Aligarh Muslim University, Aligarh, 202002, UP-India.

Key words: Biodeterioration, Cultural material, Essential oil, Natural history collection, Repellent activity.

***Corresponding Author: Fatma Faheem,** Department of Museology, Aligarh Muslim University, Aligarh, 202002, UP-India.

Vol. 6 (4), 57-69, Oct-Dec, 2019.

Abstract

Museums preserve cultural materials of the past for future generations. The natural history collections in museum consist of astonishing richness and full of immense significance. They act as a vital source for primary information on the diversity of life on earth, for today and for our coming generations. However, in India the different varied temperature and humidity of the tropical climate lead to severe biodeterioration. Insect pests are a major problem for museums, even with repeated treatments for insect control. Due to lack of appropriate and unsafe environments are provided in the collection storage and display, the insect infestation regenerate. Therefore, appropriate plans for prevention and control of biodeterioration in museums are critically important measures. In this paper, repellent activity of *Nigella sativa, Syzygium aromaticum* and *Azadirachta indica* essential oils were evaluated at the knockout time of 4 hours against the larvae of *Anthrenus verbasci.* Dose of 1.25ml/cm^3 of clove essential oil was sufficient for 100% repulsion rate (PR%), whereas in case of blackseed oil and neem oil, at dose of 2ml/cm^3, -20% and 50% repulsion rate (PR%) was revealed. The entire experimental set up and the controls were arranged in a laboratory with temperature fluctuating between 25 ± 7ºC and 64 ± 8% RH in a Completely Randomized Design (CRD). Four replications were conducted for each dose that I have used in this study.

Introduction

Museums have a long history going back to the 3rd century B.C, when the first known museum was opened in the University of Alexandria in Egypt. Over the years, however, the museum culture has spread to nearly every part of the world and today it has become uncommon to find any country that does not have a museum. This implies that the concept of the museum has become a global concept that has survived the 20th century. The role of museums is to collect objects, preserve them, research into them and present them to the public for the purpose of education and enjoyment. Among which preservation and conservation is a major field of museum to be dealt with it.

Museum preserves cultural, natural and historical property of the past for future generations [1, 2]. The natural history collections in museum consist of astonishing richness and full of immense significance. They act as a vital source for primary information on the diversity of life on earth, for today and for our coming next generations. The role of museum is to collect objects, preserve them, research into them and present them to the public for the purpose of education and enjoyment. Among which preservation and conservation is a major field of museum to be dealt [3]. However, in India the different varied temperature and humidity of the tropical climate lead to severe problem of biodeterioration. The chemical factors combined with air pollution, bad building maintenance and low budgets that make long-term storage and preservation of valuable collections very difficult for museums, libraries and archives [4, 5].

Insect pests are a major problem to museums, even with repeated treatments of synthetic chemicals for insect control. The insect infestation may regenerate due to lack of appropriate and unsafe environments, provided in the collection storage and display. Therefore, appropriate plans for prevention and control of biodeterioration in museums are critically important measures [6-10]. Most literature survey has indicated that, the research which carried on bionomics and control action of biodeterioration. It is mainly caused by the insects belonging to *Dermestidae* family, there important species are *Anthrenus, Attagenus, Dermestes, Trogoderma, Necrobia and Psocids* [11-13]. Species like *Anthrenus and Attagenus* have been noted to breed in bird's nests and animal burrows in the vicinity of museums, and then which moves from their breeding sites to museum collections of animal objects, resulting causes severe infestation [14]. In addition to these above, beetle pests of *Tenebrionidae, Anobiidae and Ptinidae* are also occasionally observed which deteriorated many important animal products [15]. Mostly these insects are scavengers, they inhabited the nests of birds and mammals and feed on organic materials like feathers, wools, furs, parchment membranes, valuable leather objects, books, journals, papers, dried animal materials etc. These objects entirely form the significant parts of collection in museum, libraries and archives. Such types of important materials are regularly infested by the insects like termites, dermestid beetles, silver fishes, tenebrionides, cockroaches and many other micro-organisms as well [16-19].

Insect pests which feed animal skin and skin products are having unique ability to digest and utilize keratin, a chemically stable structural protein present in wool, feather, hair and horn [20]. Unlike insects feed on food grains, the pests infested on skin and skin products are known to have higher proteinase and aminopeptidase enzyme activities [21]. Some of the insect pests of preserved skin and skin products diapauses these periods, they are more tolerant for extreme climatic conditions and pesticide treatment [22].

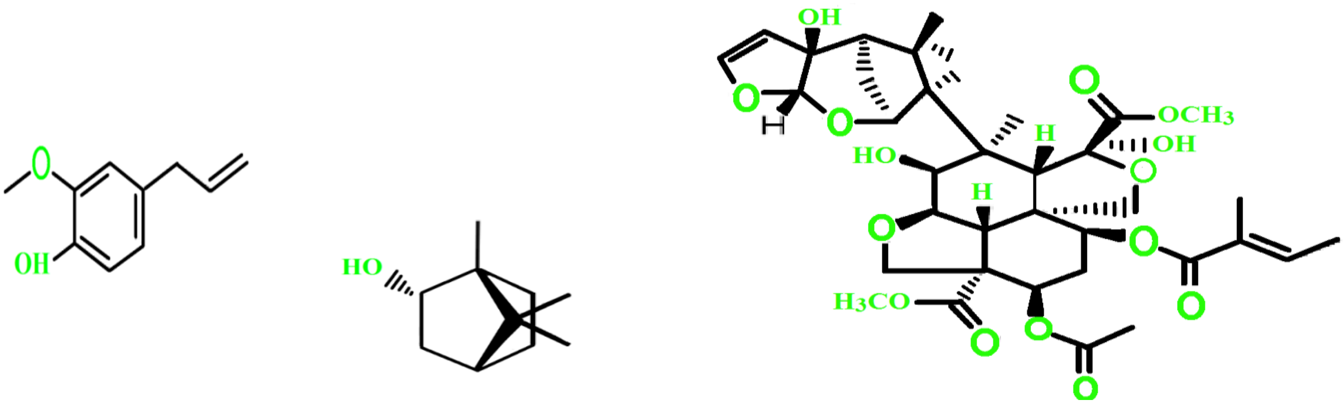
Skin and skin products comprise a major part of natural history collections. Whereas natural history collections plays essential role in disseminating knowledge regarding, evolution, biodiversity, genetics, population and the environmental impacts of climate change, uses of pesticides and so on. Natural history collections have much potential in contribution for the welfare and quality of life of people today. They are massive repositories of information whose value is being increasingly recognized nowadays, in field of scientific research as well as in areas such as environmental conservation, medicine, agriculture, and education. Hence, all of this indicates that there is an utmost need to ensure that natural history collections should be cared with the highest possible standards. Without proper care, ultimately the collections will deteriorate and without accessibility they will be ignored. It is the responsibility of collection managers and curator for taking care of natural history collections, and for making the information accessible to users about the collections for instance, skin and skin products, stored products, textile products, etc. [23-25].

Stored animal products and skin and skin products includes materials like silk, fur, feather, leather, wool, museum preserved collections, hides, honeycomb etc. Such products pests causes infestation to these animal products during storage and sometimes at the processing stages [26]. Museum's stored animal products and skin and skin products, possessing severe pest infestation problems; in spite these fields have not received much attention unlike the infestation problem in collections of plants origin. The extents of loss due to insect pests in museum collections are partially known [27]. The research work has been mostly done in museum field to control and monitor pests of museum animal collections. However, mostly the controls were done with synthetic chemicals, which were supposed to be an effective strategy used extensively during that time [28]. Whereas, the widespread use of synthetic insecticides lead to many negative impacts [29], resulting in increasing attention to natural products. However, generally pest controls were done through synthetic pesticides; their adverse effects have overweighed the benefits associated with their use. Due to overuse of pesticides and other non- degradable chemicals as well as products lead to high health risk factors and also causing several environmental problems, so government has taken severe initiatives for banning it. Therefore, the environmental problems caused due to the overuse of pesticides and other non- decomposing chemicals as well as products have been the matter of serious concern for both the scientists and public in recent years. So this is the time that necessitates the proper use of pesticides to protect human beings and their environment [30].

To overcome the above problems there is an urgent need to develop safe, convenient, environmental friendly and low-cost alternatives. However it is important to analyze the efficacy of various natural products for prevention and control of pest infestations, which means to reduce negative impacts on human health and environments, causes the disturbance in ecosystem [4, 7]. So, it is a prime concern to emphasize the research in this direction, to prevent and control the important museum collections from such harmful biological deterioration that follows the existing traditional conservation methods either indigenous or non-indigenous.

Plants play very important roles in ecological system [31]. It may impart potential alternatives to currently used insect-control agents, because they represent rich source of bioactive chemicals [32]. Nowadays, considerable efforts have been focused on plant derived materials for potentially useful products as bio-insecticides [33], and also the indigenous method of control is highly emphasized globally, through which the use of extracts from medicinal plants and natural products have been considered, that doesn't show any harmful effects on human society, environment and also more commercially viable [34-40]. The compounds found in botanical insecticides are biodegradable and less persistent in the environment. Plants are a rich source of insecticidal compounds and the effectiveness of these compounds has been demonstrated against many animal stored product insects [41]. The figure 1 demonstrates the important chemical constituents found in botanicals used in the present study.

Mode of action as a "repellent" is an important mechanism used to control pest. Repellents are the substances that act as stimulants and elicit avoiding reactions and are non-poisonous. Repellent substances cause insects to orient their movement away from the food source.



Eugenol Burneol Azadirachtin

Fig.1. Represents the important chemical constituents found in botanicals used in the present study.

Arun k Tripathi has observed that the repellents work by a common mechanism in different arthropods is still not clear, and it is conflicting evidence which exists in the past literature [42]. Repellents are the substances used mainly to repel insects in order to protect and keep away to any treated areas or commodities from infestation by IUPAC (The International Union of Pure and Applied Chemistry). According to many report, repellency is a major mechanism by which essential oils and natural products control insect damage to stored products [43].
The test oils used in this study were essential oils of *Syzygium aromaticum, Nigella sativa* and *Azadirachtin indica*. *Syzygium aromaticum* possesses many compounds with biological activity and it is used to control fungus, insect mildews in stored grains [44-47]. There are several compounds in clove oil, but the specific activities of these various compounds against stored product pests have never been examined. The objective of this study was to examine the insecticidal activity of compounds from the clove oil against the dermestid beetles. *Syzygium aromaticum* is commonly known as clove and it is belong to the *Myrtaceae* family. It is cultivated in several countries throughout the world. Clove is important medicinal plants and shows wide range of pharmacological effects consolidated from traditional uses for centuries and are reported in several literatures [48, 49]. They are some of the most valuable spices that have been used for centuries as food preservatives and for many medicinal purposes. Clove possesses anti-diabetic, anti-inflammatory, anti-thrombotic, anesthetic, pain-relieving, and insect-repellent properties [50, 51]. Cloves possess comparatively higher antimicrobial and antioxidant activities than many fruits, vegetables and other spices and should deserve special attention [52]. Sesquiterpenes found in clove were investigated as potential anti-carcinogenic agents [53]. In this study prevention and control is achieved with the variable toxicities of *Syzygium aromaticum* oil individually against larval stage of *A. verbasci*. Essential oils are most effective substances tested against insects [54]. These compounds may act as fumigants [55], contact insecticides [56, 57], repellents [58] and anti-feedants [59] and also may affect some biological parameters that can be reproduction and life span [60] and growth rate [61].
The next oil used in the present study is *Nigella sativa* essential oil. Blackseed is also called as black cumin seeds or kalonji. It is an annual herb possessing a wide range of medicinal uses, apart from its commercial significance as a spice yielding plant. Blackseeds are used as herbal medicine all over the world, which are used for treatment and prevention of a number of diseases. Blackseeds have been beneficial in keeping people healthy since 3,300 years ago. It is one of the earliest cultivated plants in human history. Black seed is a remedy for colds, headache, respiratory, digestive disorders, toothaches, infections, inflammatory disorders, and allergies. In a study, it was investigated that the black seed essential oil had toxic effects against *Rhyzopertha dominica* at different concentrations. It is reported that highest mortality is observed in only 10% of concentration in the time interval of one week. In another study, the essential oil of black seed shows insecticidal and strong repellent activity as well as an in-vitro against the larvae of *Tuta absoluta*. [62]. It was also investigated in an study about the effective toxicity of *Trachyspermum ammi*, *Syzygium aromaticum* and *Nigella sativa* extracts in controlling the infestation of the stored product beetles (*Tribolium castaneum)* [63].
The last test oil used was Neem essential oil. Neem has received much attention from entomologists as a result of its anti-insecticidal properties. Previous studies have shown that neem products are effective against over 300 different insect species. Over 300 compounds have been isolated from neem seeds, where one-third of these are tetranortritepenoids (limnoids). These limonoids include the most active azadirachtin-A and eight other highly active isomers like azadirachtin B-1, moderately active

nimbandiol, salannin, and less active gedunin, vilasinin, azadirone, and azadiradione. The compound azadirachtin, is known to be the most popular and highly oxygenated of these limonoids, through which it has received much attention for an environmentally friendly insect control agent [64-66].

Bionomics

Dermestid beetles have a complete metamorphosis, with the larvae, the only stage which causes serious damage to proteinecious material whereas the adults consume less food comparatively to larvae and therefore causes less damage. Adults may be found indoors or outdoors and are frequently found on flowers where they feed on pollen. Sometimes they are also found feeding on fibers such as rayon, linen, cotton and jute. The insect feeds on animal products can easily digest and utilize keratin, a chemically stable structural protein present in feather, wool, hair and horn [67].

Anthrenus verbasci species commonly known as varied carpet beetle infests the usual range of household articles and museum collections such as carpets, woolen items, silks, skins, furs, feathers, hair, horn, cereals, red pepper, fishmeal, or any processed animal or plant food. In common with other carpet beetles, this species will feed on cottons, linens, and synthetic fibers if they are contaminated, but it will not feed on rayon acetate. The adult carpet beetle feeds only on pollen and nectar of garden flowers but lays its eggs accumulated animal stuff in buildings.

This species has a number of varieties. They differ in shape, size, color, and pattern of the scales, but in general the adults are 2 to 3.5 mm long, and have a varied pattern of white, brownish, and yellowish scales on the back and fine, long, greyish-yellow scales below. Where the elytra terminate, they do not form a cleft as do those of the furniture carpet beetle (*A. flavipes*). The mature larva is 4 to 5 mm long, and has a series of light- and dark-brown transverse stripes. If it is suddenly alarmed, the larva erects the 3 dense tufts of bristles and hair located on each side of the rear end of the body, spreading them out to form beautiful, round plumes. Different views of *A. verbasci* are clearly shown in figure 2. The larvae of *A. verbasci* are commonly known as woolly bears. They are broadest near the rear, and become narrower toward the front end, unlike other carpet beetles. Dorsal view of larvae of *A. verbasci* is shown in figure 3.

The female lays about 40 eggs. There are usually 7 to 8 larval instars, but the number may vary from 5 to 16. The numbers of days for the various stages are as follows: egg, 17 to 18; larva, 222 to 323; and pupa, 10 to 30. The period from egg to adult is 249 to 354 days, and the adult may live another 14 to 44 days [68]. The figure 4 demonstrates the life cycle of *Anthrenus verbasci*. The cuticles of larvae have more long-chain hydrocarbons and a higher degree of unsaturation of hydrocarbons as well as esters than in adults comparatively. These differences in composition have been considered responsible for reduced penetration of the larval cuticle by insecticides and thereby the higher tolerance of that particular developmental stage [69].

Figure 2. Ventral and dorsal view of adult *Anthrenus verbasci.*

Figure 3. Dorsal view of larvae *Anthrenus verbasci.*

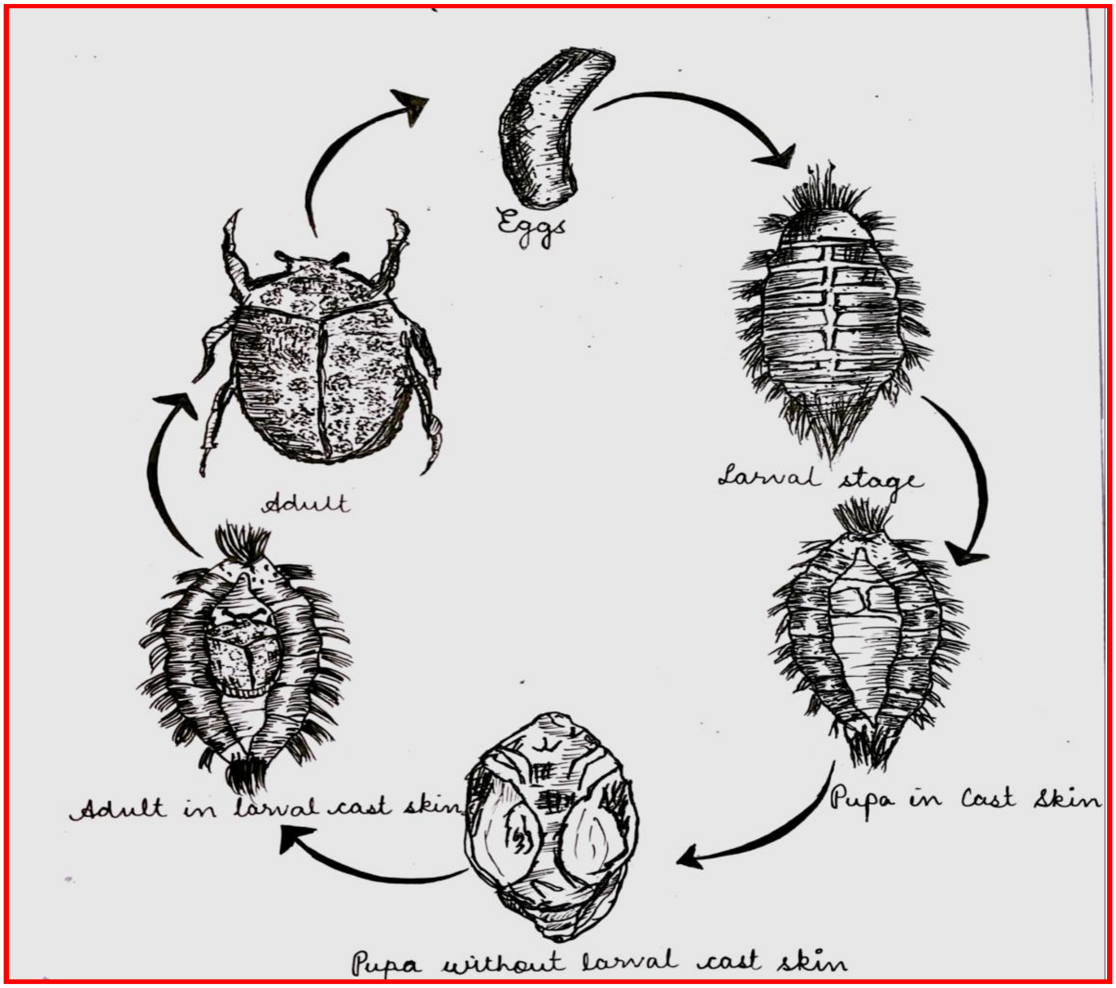


Figure 4. Demonstrate the life cycle of *Anthrenus verbasci.*

Experimental approach

Collection of test oil

Nigella sativa, Syzygium aromaticum and *Azadirachta indica* essential oils were purchased from herbal pharmacy in Aligarh. It was kept in proper air tighter glass container and placed in a cooled place for applying in experiments. The taxonomic position of all the botanicals is given below.

Taxonomic position of Blackseed	
Kingdom	*Plantae*
Division	*Magnoliophyta*
Class	*Magnoliopsida*
Order	*Ranunculales*
Family	*Ranunculaceae*
Genus	*Nigella*
Species	*Sativa*

Taxonomic position of Clove	
Kingdom	*Plantae*
Division	*Magnoliophyta*
Class	*Magnoliopsida*
Order	*Myrtales*
Family	*Myrtaceae*
Genus	*Syzygium*
Species	*Aromaticum*

Taxonomic position of Neem	
Kingdom	*Plantae*
Division	*Magnoliophyta*
Class	*Magnoliopsida*
Order	*Sapindales*
Family	*Meliaceae*
Genus	*Azadirachta*
Species	*Indica*

FTIR analysis of botanicals

The botanicals used in the study were first characterized through FTIR spectra. The investigations of botanicals are shown in figures 5 to 7. FTIR (Fourier Transform Infrared Spectroscopy) were recorded at Department of Chemistry, Aligarh Muslim University Aligarh. IR spectra were recorded on a FTIR model Shimadzu 8400S grating infrared spectrophotometer in KBr pellets and wavenumbers were measured in cm^{-1}. FTIR analysis of *Syzygium aromaticum* essential oil is indicated by figure 5. The peak nearly 3400-2800 cm^{-1} represents OH group vibrations, the peak around 1600-1500 cm^{-1} shows C-H finger printing and C-C stretching vibrations respectively. While peaks nearly 1400-1200 cm^{-1} shows C=H bending vibrations of the present organic compounds.

By Figure 6 the FTIR spectra of *Nigella sativa* essential oil have assigned the existence of a variety of sharp, strong, and weak peaks as well as crucial functional groups that correspond to C-H, $-CH_2$, CH_3, C=O, C-O, and C=C, suggesting the presence of these groups in the given oil. FTIR spectrums in Figure 6, which represent the absorption peak at nearly 3300 cm^{-1} indicated the presence of O-H stretching vibrations of the vinyl group. Meanwhile, another important strong band is observed at 1600-1700 cm^{-1}, which can be attributed to the C=O stretching vibrations of ester as well as ketone groups, a band at 1100 cm^{-1} owing to the C-H bending vibrations. These results indicate the fact that FTIR is a powerful technique in determining the structure of organic materials.

The intense bands occurring nearly 3400.00 cm^{-1} and 2900.00 cm^{-1} shows the O-H and C-O stretching vibrations of the present compound, nearly 2300.00 cm^{-1} shows N-H bonding , 1600.00 to 1300.00 cm^{-1} represents OH group, and peak nearly 1000.00 cm^{-1} shows C-H bonding, the vibration peak nearly 500.00-600.00 cm^{-1} indicated the C=O stretching vibrations through these peaks it is indicated the presence of alcohol, phenol, amines, amides, carboxylic group, ester, ether, amino acids group in the oil of *Azadirachta indica* essential oil, which is clearly shown in following Figure 7.

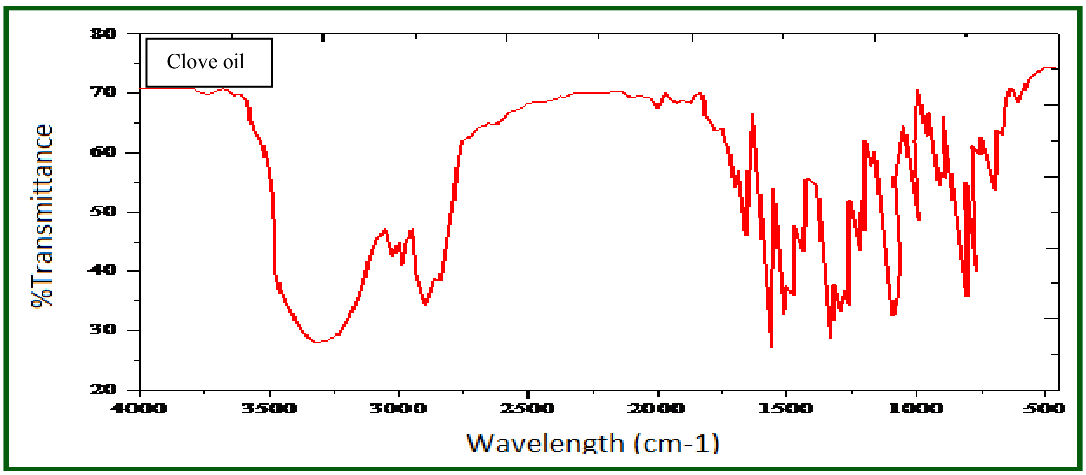


Figure 5. Represents the FTIR spectra of *Syzygium aromaticum* essential oil.

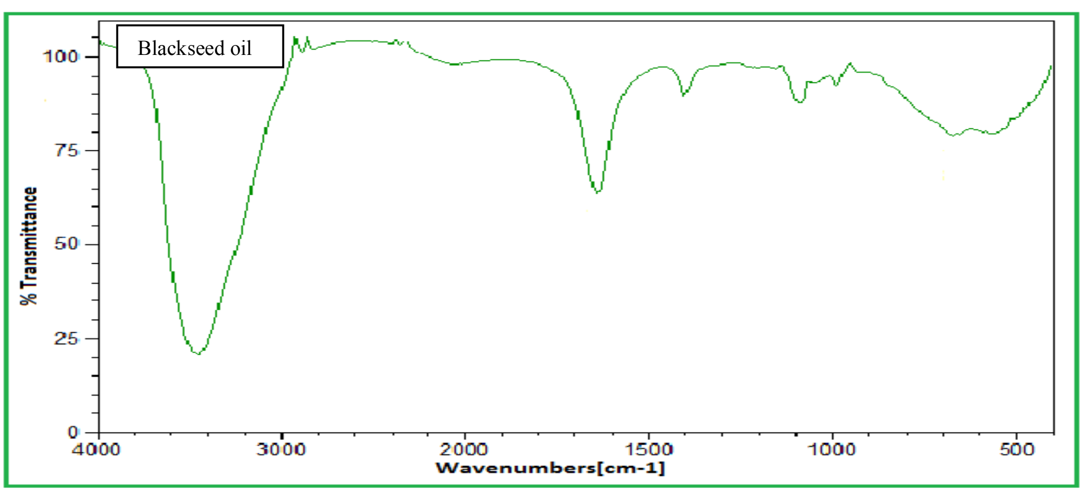


Figure 6. Represents the FTIR spectra of *Nigella sativa* essential oil.

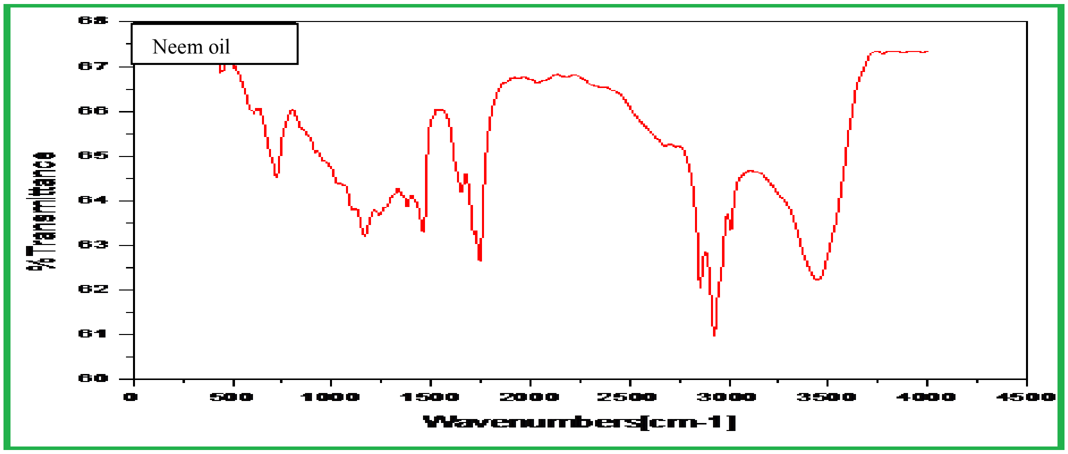


Figure 7. Represents the FTIR spectra of *Azadirachtin indica* essential oil.

Collection of test organism

The initial source of beetles culture was a infested "bull horn", which was collected from the natural history collection of MUSA Dakri museum of the Aligarh Muslim University, India, indicated by figure 8. These beetles were identified on the basis of their morphological characters in entomology section of zoology department, Aligarh Muslim University.

Identification of test organism

The rearing beetles were species of *Anthrenus verbasci.* It was identified based on the morphological characters in the entomology section of zoology department, Aligarh Muslim University.

Taxonomic position of Varied carpet beetle	
Kingdom	***Animalia***
Phylum	***Arthropoda***
Class	***Insecta***
Order	***Coleoptera***
Family	***Dermestidae***
Genus	***Anthrenus***
Species	***verbasci***

Rearing of insect culture

During the month of April 2014 these identified beetle along with the infested bull horn was kept in rearing box covered with muslin clothes in dark storage area. The culture of insects was carried out in the rearing box (48cmx27cmx34cm) in order to obtain a homogeneous and sufficient population of *Anthrenus verbasci* larvae for various biological tests, shown in Figure 9.

Bioassay for repellency test

The repellent effect of the botanicals against the larvae of *Anthrenus verbasci* was evaluated using the method of the preferred area in the dry preservation insect box described by McDonald et al. in 1970 [70]. The three insect boxes (25.5cm×14.5cm×7.5cm) A, B, C respectively were used to confine insects during the experiment shown in following Fig.10. The concentrated essential oils were prepared in distilled water as per required concentration of solution (v/v). In case of clove oil, dose of 0.31 ml/cm^3, 0.63 ml/cm^3, 1.25 ml/cm^3 were taken, in case of blackseed and neem oils dose of 0.5 ml/cm^3, 1.0 ml/cm^3, 2.0 ml/cm^3 were taken respectively. Then the blotting sheet of 25.5cm×14.5cm area was used for this purpose were cut into two equal portions each having a surface of 92.44cm^2. These dilutions were then applied on the half area of each blotting paper and half area remain as same, then they are allowed to dry for 30 minutes in each cases of oils. The treated blotting papers were fitted in the repellent boxes. The larvae of *A. verbasci* were released at the center of each blotting sheets in each boxes. Later, the data was examined after a knockout period of 4 hours to assess repellency percentage (RP%) and repellency classes (RC). The entire experimental set up and the controls were arranged in a laboratory with temperature fluctuating between 25 ± 2ºC and 60 ± 2 % RH in a Completely Randomized Design (CRD). Four replications were conducted for each dose. The larvae on untreated /controlled area and larvae on treated area are shown in each case of oils below in Table 1 to 3.

Figure 8. Demonstrating a "bull horn" infested by adult and larvae of *Anthrenus verbasci.*

Figure 9. Demonstrating the rearing box covered with muslin cloth.

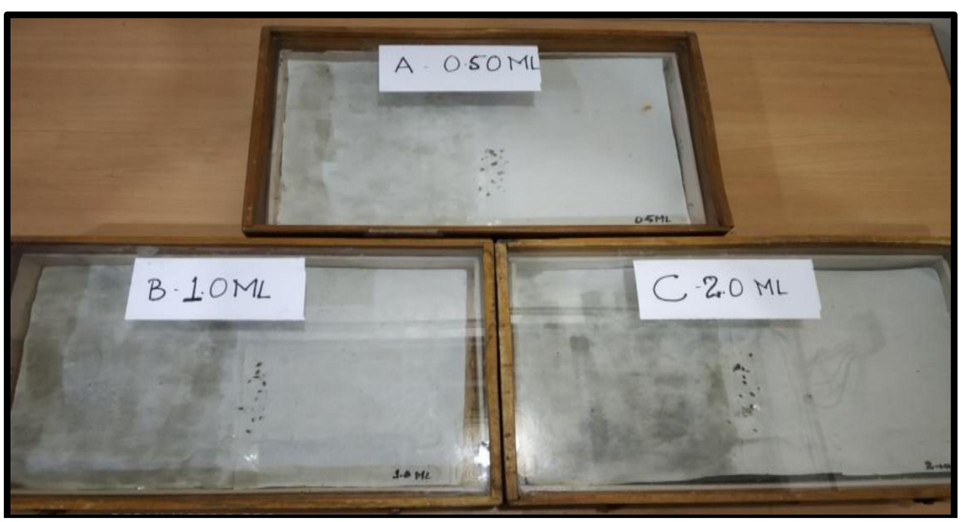


Figure 10. Demonstrates the experimental setup for evaluating repellency activity of botanicals.

Table 1. Represent the repellent effect of *Nigella sativa* essential oil against *A.verbasci* larvae at 4 hours of exposure.

Dose (ml/cm³)	Larvae on untreated /controlled area	Larvae on treated area
A (0.5ml)	1	9
B (1.0ml)	3	7
C (2.0ml)	4	6

Table 2. Represent the repellent effect of *Syzygium aromaticum* essential oil against *A. verbasci* larvae at 4 hours of exposure.

Dose (ml/cm³)	Larvae on untreated /controlled area	Larvae on treated area
A (0.31ml)	4	6
B (0.63ml)	7	3
C (1.25ml)	10	0

Table 3. Represent repellent effect of *Azadirachtin indica* essential oil against *A. verbasci* larvae at 4 hours of exposure.

Dose (ml/cm³)	Larvae on untreated /controlled area	Larvae on treated area
A (0.5ml)	2	8
B (1.0ml)	5	5
C (2.0ml)	7	3

Result and discussion

The repellent activity of *Nigella sativa, Syzygium aromaticum* and *Azadirachtin indica* essential oil was further analyzed on the basis of above results. Further, the percentages of the repulsion of the various doses of all botanicals were investigated, which are summarized in Table 4. The repulsion rate of the test insects was assessed using the formulae given below. It shows that after four hours of exposure, the various doses of the different botanicals have respectively caused different repellency rate against the larvae of *Anthrenus verbasci,* shown in Figures 11-13. The percentage of repulsion was calculated by using the following formulae.

$$\text{Percentage of Repulsion (PR\%)} = \frac{Nc-Nt}{Nc+Nt} \times 100$$

Where, Nc = Number of insect on controlled/untreated area, Nt = Number of insects on treated area

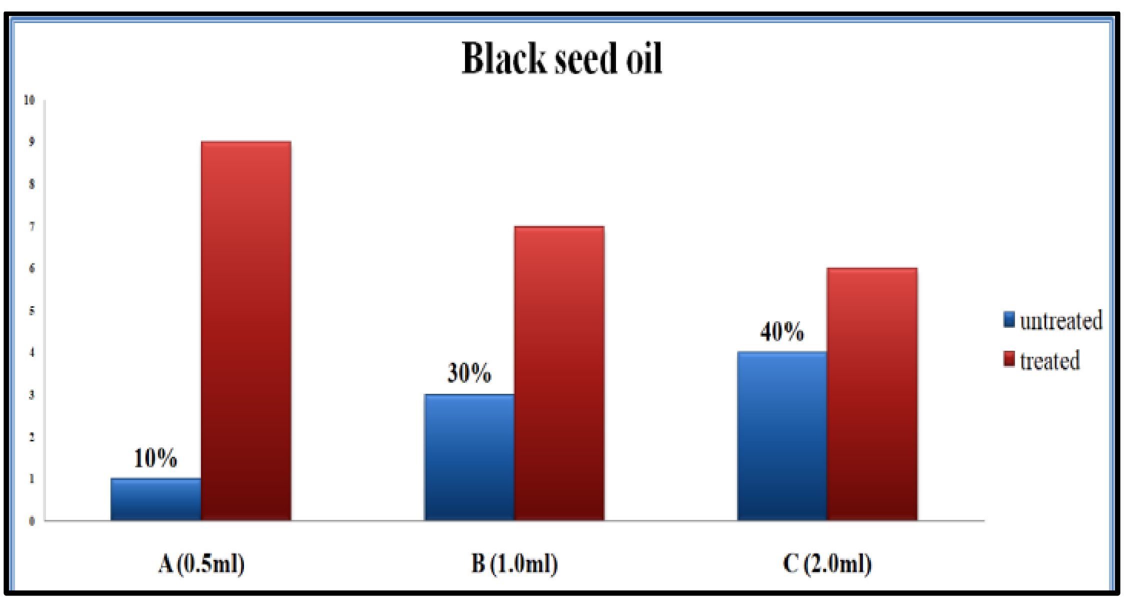


Figure 11. Represent the percent of larvae *of A. verbasci* controlled with *Nigella sativa* (blackseed) essential oil after 4 hours of exposure.

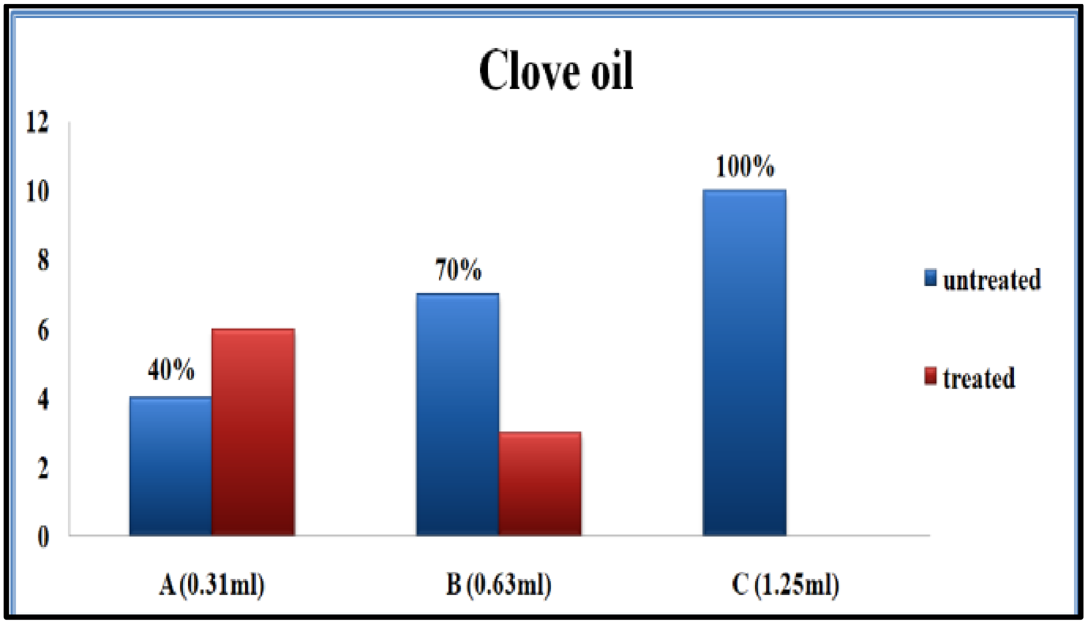


Figure 12. Represent the percent of larvae *of A. verbasci* controlled with *Syzygium aromaticum* (clove) essential oil after 4 hours of exposure.

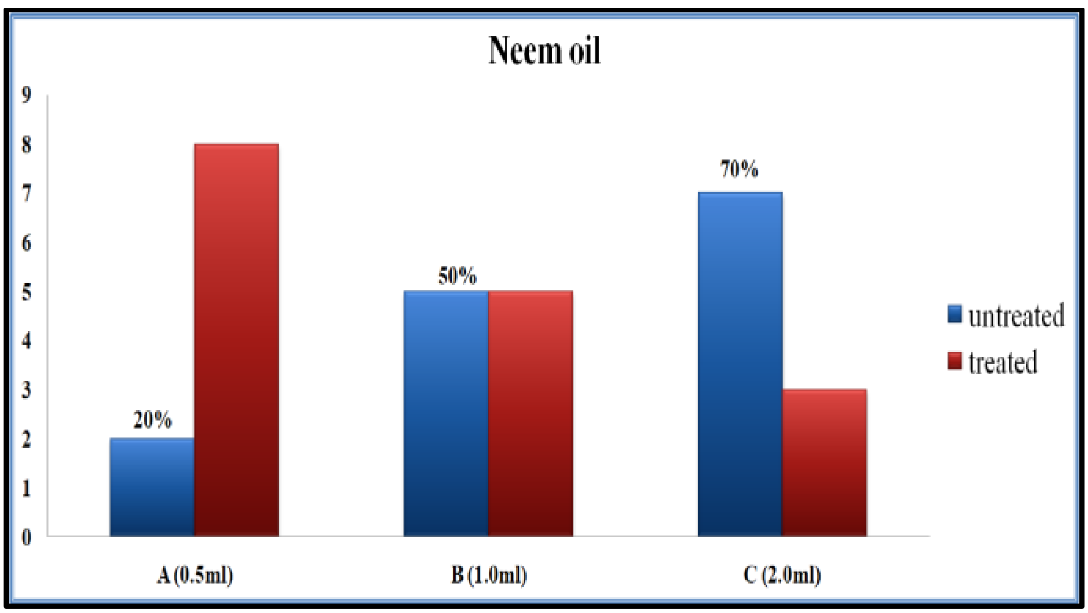


Figure 13. Represent the percent of larvae *of A.verbasci* controlled with *Azadirachta indica* (neem) essential oil after 4 hours of exposure.

In cases of *Syzygium aromaticum* (clove) essential oil, repulsion rate was observed highest against larvae of *Anthrenus verbasci.* Whereas, in *Nigella sativa* (Blackseed) and *Azadirachta indica* essential oils have comparatively lower repulsion rates than *syzygium aromaticum* after 4 hours of exposure against the larvae of *A. verbasci*, which is shown clearly in following Table 4.

The repulsion rates of the various doses of *syzygium aromaticum* (clove) essential oil are summarized in below Table 4. It shows that after four hours of exposure, the different doses of the essential oil of clove 0.31ml/cm^{3}, 0.63 ml/cm^{3}, 1.25 ml/cm^{3} have respectively caused -20.0%, 50.0%, 100% of repulsion against larvae of *A. verbasci.* While with treatment with *Azadirachta indica* (neem) essential oil, result was found sparsely effective. It shows after 4 hours of exposure of different doses of neem essential oil 0.5 ml/cm^{3}, 1.0 ml/cm^{3}, 2.0 ml/cm^{3} have respectively observed -60.0%, 0.0%, 50.0% of repulsion rate. While applying same doses as neem oil with *Nigella sativa* oil against larvae of *A. verbasci* result was not upto that mark. The repulsion rate at various doses after 4 hours of exposure was found to be -80.0%, -50.0%, -20.0%. This can also be seen in Table 4.

Table 4. Represent the Repellency rate (RP%) and Repellency class (RC) of black seed, clove and neem essential oils against *A. verbasci* after 4 hours of exposure.

Insecticide Mode of action	Name of Botanicals	Concentrations	Repellency Rate % RP%= (Nc - Nt ÷Nc + Nt)×100	Repellency Class (RC)
Repellents activity	Black seed oil	0.5ml/cm³	-80%	0
		1.0ml/cm³	-50%	0
		2.0ml/cm³	-20%	0
	Clove oil	0.31ml/cm³	-20%	0
		0.63ml/cm³	50%	Ⅲ
		1.25ml/cm³	100%	V
	Neem oil	0.5ml/cm³	-60%	0
		1.0ml/cm³	0%	0
		2.0ml/cm³	50%	Ⅲ

In the light of above results, it can be noticed that the essential oils of *Syzygium aromaticum* (clove) has shown strongest repellent activity against the larvae of *Anthrenus verbasci*. On the basis of McDonald *et al.* [70], they belong to the repulsive class V with an average of repellency 100%. Whereas in case of blackseed oil and neem oil, the repellency classes (RC) were 0 and Ⅲ on the basis of repellency rate (RP%), which was -20% and 50% respectively. The average percentage of different botanicals repellency were also calculated and assigned according to following scale (McDonald *et al.*) [70].

Class	Repellency Rate
0	>0.10
I	0.1 -20%
Ⅱ	20.1 - 40 %
Ⅲ	40.1 - 60%
Ⅳ	60.1 - 80%
V	80.1 - 100%

Conclusion

The skins and hides have been used for making utilitarian and decorative objects since prehistoric times. Skin and skin products are contain by a large part of art, history, ethnography, anthropology and natural history collections. As the compositions of these collections are organic in nature so they can be easily susceptible to pest damage. The accumulative effects of this damage can ultimately destroy museum's valuable objects. Therefore, it is important to constantly monitor collections for evidence of pest activity. Museum pests are biological agents that can cause damage to museum collections. The toxic and repellents effects of different botanicals may relies on its chemical composition and the level of insect sensitivity. Therefore, the botanicals are first characterized by FTIR analysis for evaluating their important bioactive constituents.

The repellent effect in case of *Nigella sativa, Syzygium aromaticum* and *Azadirachtin indica* essential oils, repellency rates of *Syzygium aromaticum* oil was found maximum and their repellency classes was also highest comparatively to other essential oils and extract used in the study against the larvae of *A. verbasci* after 4 hours of time period. At the dose of 1.25 ml/cm3 conc. of *Syzygium aromaticum* essential oil, highest repulsion rate was achieved for controlling target insects after 4 hours of exposure. Hence on the basis of repulsion rate, *Syzygium aromaticum* essential oil was considered in the V class of repellency.

In addition, the natural plant products have been traditionally used for insect control of animal based products. Furthermore it is suggested that, there is a need to identify the active molecules from promising plant sources and evaluate them for application at the commercial level. The effective constituents of the herbal pesticides can be separated by infra-red spectroscopy so that the high concentrated compounds can be easily extracted and used in controlling the pests, and also in future it must be integrated in the IPM of museums as well.

The factual information required is in this study, and the materials needed to control and prevent biodeterioration are simple and affordable. But the attitude and the institutional capabilities needed to make these solutions effective are far more difficult to achieve. Therefore, it is recommended that, there is utmost need for professionals to reintroduce the indigenous methods of pest control and to integrate that traditional methods and materials into development of conservation strategies.

Acknowledgement

The author is gratefully acknowledged to Prof. Abdurahim K, Department of Museology AMU Aligarh for providing necessary research facilities like samples, reagents, analysis chamber instruments, glass wares etc. We are also thankful to UGC for providing financial assistance to complete my research work.

References

1. Sullivan AM. Cultural Heritage & New Media: A Future for the Past. J Marshall Rev Intell Prop L. 2015; 15:604.

2. Logan WS. Closing Pandora's box: human rights conundrums in cultural heritage protection. Cultural heritage and human rights: Springer; 2007; 33-52.
3. Arinze EN. The role of the museum in society. Museums, Peace, Democracy and Governance in the 21st Century–Post Conference Workshop, Georgetown, Guyana Retrieved from http://www maltwooduvic ca/cam/activities/past_conferences/1999conf/CAM1999.
4. Coremans P. Climate and microclimate, in the conservation of cultural property with special reference to tropical conditions. Unesco. 1968; 11:27-39.
5. Anupan S. Indigenous Methods and Manuscript Preservation India (Samraksika Series). Madras: DkPrintworld. 2006.
6. Bisht A. Control of biodeterioration in museums: a study of problems. Biodeterioration of cultural property Proceedings of the International Conference, February 20-25, 1989, Lucknow, India Edited by OP Agrawal and Shashi Dhawan1991; 98-103.
7. Nair S. Biodeterioration of museum materials in tropical countries. Conservation in the tropics1972; 150-8.
8. Querner P. Insect pests and integrated pest management in museums, libraries and historic buildings. Insects 2015; 6(2):595-607.
9. Pinniger D, Harmon J. Pest management, prevention and control. Care and Conservation of Natural History Collections Butterwoth Heinemann, Oxford. 1999:152-76.
10. Allsopp D, Seal KJ, Gaylarde CC. Introduction to biodeterioration: Cambridge University Press; 2004.
11. Rajendran S, Parveen KH. Insect infestation in stored animal products. Journal of Stored Products Research 2005; 41(1):1-30.
12. Imura O. Herbivorous arthropod community of an alien weed Solanum carolinense L. Applied Entomology and Zoology 2003; 38(3):293-300.
13. Nair S. Biodeterioration of museum collections by dermestid beetles, with particular reference to tropical countries. Biodeterioration 6: papers presented the 6th International Biodeterioration Symposium, Washington, DC, August 1984; 337-43.
14. Pinniger D. New developments in the detection and control of insects which damage museum collections. Biodeterioration Abstracts 1991; 125-30.
15. Linsley E. Natural sources, habitats, and reservoirs of insects associated with stored food products. Hilgardia. 1944; 16(4):185-224.
16. Iftikhar A. Insect pests of museum materials: their deleterious effects and method of control. Journal of Indian museums 1983; 39:142-59.
17. Nair S. Certain observations on the biodeterioration of museum materials. Journal of Indian Museums 1969; 25:74-5.
18. Chomchalow N. Protection of stored products with special reference to Thailand. Assumption University Journal of Technology 2003; 7(1):31-47.
19. Orlita A. Biodeterioration of leather materials especially book-leather bindings and parchments. Recent advances in biodeterioration and biodegradation Volume I: biodeterioration of cultural heritage 1993; 259-99.
20. Waterhouse DF. Wool digestion and moth proofing. In: Metcalf, R.L. (Ed.),. Advances in Pest Control Research 1958; Vol. II (Interscience Publishers, Inc., New York) :207–62.
21. Baker J. Amylase/proteinase ratios in larval midguts of ten stored-product insects. Entomologia experimentalis et applicata. 1986; 40(1):41-6.
22. Bell C. A review of diapause in stored-product insects. Journal of Stored Products Research 1994; 30(2):99-120.
23. Viscardi P. Natural history collections-why are they relevant. The Guardian https://www theguardian com/science/punctuated-equilibrium/2011/apr/12/2. 2016.
24. Linnie MJ. Integrated pest management: A proposed strategy for natural history museums. Museum Management and Curatorship 1996; 15(2):133-43.
25. Allmon WD. The value of natural history collections. Curator: The Museum Journal 1994; 37(2):83-9.
26. Rajendran S, Parveen KH. Insect infestation in stored animal products. Journal of Stored Products Research 2005; 41(1):1-30.
27. Veer V, Prasad R, Rao K. Taxonomic and biological notes on Attagenus and Anthrenusspp (Coleoptera: Dermestidae) found damaging stored woollen fabrics in India. Journal of Stored Products Research 1991; 27(3):185-98.
28. Pavela R. Larvicidal effects of various Euro-Asiatic plants against Culexquinquefasciatus Say larvae (Diptera: Culicidae). Parasitology research 2008; 102(3):555.
29. Pirali-Kheirabadi K, da Silva JAT. Lavandulaangustifolia essential oil as a novel and promising natural candidate for tick (Rhipicephalus (Boophilus) annulatus) control. Experimental Parasitology 2010; 126(2):184-6.
30. Koul O, Walia S, Dhaliwal G. Essential oils as green pesticides: potential and constraints. Biopesticides International 2008; 4(1):63-84.
31. García M, Gonzalez-Coloma A, Donadel OJ, Ardanaz CE, Tonn CE, Sosa ME. Insecticidal effects of Flourensiaoolepis Blake (Asteraceae) essential oil. Biochemical Systematics and Ecology 2007; 35(4):181-7.
32. Qin W, Huang S, Li C, Chen S, Peng Z. Biological activity of the essential oil from the leaves of Piper sarmentosumRoxb.(Piperaceae) and its chemical constituents on Brontispalongissima (Gestro)(Coleoptera: Hispidae). Pesticide Biochemistry and Physiology 2010; 96(3):132-9.
33. Jbilou R, Amri H, Bouayad N, Ghailani N, Ennabili A, Sayah F. Insecticidal effects of extracts of seven plant species on larval development, α-amylase activity and offspring production of Triboliumcastaneum (Herbst) (Insecta: Coleoptera: Tenebrionidae). Bioresource technology 2008; 99(5):959-64.
34. Ranjan G.Nature's Medicines: Traditional Knowledge and Intellectual Property Management. Case Studies from the National Institutes of Health (NIH), USA, Curr Drug Discov Technol. 2005; 2(4): 203–219.
35. Stanley E, McCann M. Technical reports on pesticides used in museums. Pest control in museums: a status report, (1980)/compiled and edited by SR Edwards, BM Bell, ME King, with additional contributions by R Beauchamp[*et al*]. 1981.
36. Shaheen FaSD. Natural plant products: a safe preventive measure against. In Biodeterioration of cultural property. Proceedings of the International Conference National Research Laboratory for Conservation of Cultural Property , Lucknow, India Edited by OP Agrawal and Shashi Dhawan 1991 1989, February 20-25.
37. K FFaA. Toxic Effect of Myristica Fragrans Essential Oil Against The Museum Pest Anthrenus Verbasci (Coleoptera: Dermestidae) To Control Biodeterioration of Animal Collections. Journal of Bio Innovation 2019; 8(5):554-71.
38. Isman MB. Plant essential oils for pest and disease management. Crop protection 2000; 19(8-10):603-8.
39. De Saravia SGG, de la Paz Naramjo J, Guiamet P, Arenas P, Borrego SF. Biocide activity of natural extracts against microorganisms affecting archives. Boletinlatinoamericano y delcaribe de plantasmedicinales y aromaticas. 2008; 7(1):25-9.
40. Bhatia SK. Traditional herbal remedies in the preservation of museum objects in India. Indian Science Cruiser. Institute of science, education and cultures 2001; 15:31-7.
41. Xie Y, Fields P, Isman M. Repellency and toxicity of azadirachtin and neem concentrates to three stored-product beetles. Journal of Economic Entomology 1995; 88(4):1024-31.
42. Tripathi AK, Upadhyay S, Bhuiyan M, Bhattacharya P. A review on prospects of essential oils as biopesticide in insect-pest management. Journal of Pharmacognosy and phytotherapy 2009; 1(5):52-63.
43. Stoll G. Natural Crop protection in the tropics: Letting information come to life: MargrafVerlag. 2000.
44. Kong Q, Song Y, Zhang L, Chen L, Li Q. Natural antifungal compounds from {\slSyzygiumaromaticum}(L.) Merr. et Perry. Shanghai NongyeXuebao. 2004; 20(3):68-72.
45. Han Q, Luo Q, Chen G, Huang S, Chen J. Lethal effects of Syzygiumaromaticum on the eggs and larvae of Triboliumcastaneum. Plant protection 2006; 32(3):60-3.
46. Lou X, Li X, Zhang A, Ding H, Gao J. Study on Antimicrobial components of the clove oil. Acta Agriculturae Boreali-occidentalis Sinica. 2006; 15:91-3.
47. Shang J, Cai J. Inhibiting action of clove extract on mildews in stored grains. Journal of Henan University of Technology (Natural Science Edition). 2007; 28:12-4.
48. Asgarpanah J, Kazemivash N. Phytochemistry and pharmacologic properties of Myristicafragrans Hoyutt.: A review. African Journal of Biotechnology 2012; 11(65):12787-93.
49. Nguyen P, Kang H, Le T, Chae J, Kim S, Kwon K, et al. Simple process for the decrease of myristicin content from myristicafragrans (nutmeg) and its activity with amp-activated protein kinase (ampk). Journal of Food Biochemistry 2011; 35(6):1715-22.
50. Milind P, Deepa K. Clove: a champion spice. Int J Res Ayurveda Pharm. 2011; 2(1):47-54.
51. Choi CY, Park K-R, Lee J-H, Jeon YJ, Liu K-H, Oh S, et al. Isoeugenol suppression of inducible nitric oxide synthase expression is mediated by down-regulation of NF-κB, ERK1/2, and p38 kinase. European journal of pharmacology 2007; 576(1-3):151-9.
52. Diego C-rF, Wanderley OP. Clove (Syzygiumaromaticum): a precious spice. Asian Pacific Journal of Tropical Biomedicine. 2014; 2:90-6.
53. Zheng G-Q, Kenney PM, Lam LK. Sesquiterpenes from clove (Eugenia caryophyllata) as potential anticarcinogenic agents. Journal of natural products. 1992; 55(7):999-1003.

54. Pitasawat B, Champakaew D, Choochote W, Jitpakdi A, Chaithong U, Kanjanapothi D, et al. Aromatic plant-derived essential oil: an alternative larvicide for mosquito control. Fitoterapia. 2007; 78(3):205-10.
55. Choi W-S, Park B-S, Lee Y-H, Yoon HY, Lee S-E. Fumigant toxicities of essential oils and monoterpenes against Lycoriellamali adults. Crop Protection. 2006; 25(4):398-401.
56. Tang G, Yang C, Xie L. Extraction of Trigonellafoenum-graecum L. by supercritical fluid CO 2 and its contact toxicity to Rhyzoperthadominica (Fabricius)(Coleoptera: Bostrichidae). Journal of pest science. 2007; 80(3):151-7.
57. Mahfuz I, Khalequzzaman M. Contact and fumigant toxicity of essential oils against Callosobruchusmaculatus. University Journal of Zoology, Rajshahi University. 2007; 26:63-6.
58. Islam M, Hasan MM, Xiong W, Zhang S, Lei C. Fumigant and repellent activities of essential oil from Coriandrumsativum (L.)(Apiaceae) against red flour beetle Triboliumcastaneum (Herbst)(Coleoptera: Tenebrionidae). Journal of Pest Science 2009; 82(2):171-7.
59. González-Coloma A, Martin-Benito D, Mohamed N, Garcia-Vallejo MC, Soria AC. Antifeedant effects and chemical composition of essential oils from different populations of Lavandulaluisieri L. Biochemical Systematics and Ecology. 2006; 34(8):609-16.
60. Nathan SS, Hisham A, Jayakumar G. Larvicidal and growth inhibition of the malaria vector Anopheles stephensi by triterpenes from Dysoxylummalabaricum and Dysoxylumbeddomei. Fitoterapia. 2008; 79(2):106-11.
61. Isikber A, Alma M, Kanat M, Karci A. Fumigant toxicity of essential oils from Laurusnobilis and Rosmarinus officinalis against all life stages of Triboliumconfusum. Phytoparasitica. 2006; 34(2):167.
62. Adil B, Tarik A, Kribii A, Ounine K. The study of the insecticidal effect of Nigella sativa essential oil against Tutaabsoluta larvae. Int J SciTechnol Res. 2015; 4(10):88-90.
63. Khan FZA, Sagheer M, Mansoor-ul-Hasan M, Najam-ul-Hassan MF, Rahman A. Bioactivity of Nigella sativa, Syzygiumaromaticum and Trachyspermumammi extracts against Triboliumcastaneum (Herbst.) (Coleoptera: Tenebrionidae). Journal of Entomology and Zoology Studies. 2014; 2(3):103-5.
64. Stoll G. Natural Crop Protection Based on Local Farm Resources in the Tropics and Sub-tropics, Third Edition. Weikersheim, Margraf Publishers Scientific Books, Germany. 1988:188.
65. Vietmeyer N. Neem: a tree for solving global problems. Report of an ad hoc panel of the Board on Science and Technology for International Development, National Research Council: National Academy Press; 1992.
66. Keeler CM. Control of Dermestesmaculatus (Coleoptera: Dermestidae) in an interior storage situation with neem, Azadirachtaindica: McGill University Libraries; 1999.
67. D.F. Waterhouse, 1958. . . Wool digestion and moth proofing. In: Metcalf, RL (Ed), Advances in Pest Control Research, Vol II Interscience Publishers, Inc, New York, 1958, pp. 207-262.
68. Bennett SM. Tachypodoiulusniger. http://wwwthe-piedpipercouk/th11b(1)html. 2000.
69. Rathnagirl P, Krishnan G, Nayudamma Y. On the nature & significance of cuticular lipids of larvae & adults of leather beetle Dermestesmaculatus. Indian journal of experimental biology. 1981.
70. McDonald LL, Guy RH, Speirs RD. Preliminary evaluation of new candidate materials as toxicants, repellents, and attractants against stored-product insects: US Agricultural Research Service; 1970.