

Periodic Research

Mosquito Repellent Textiles Using Thyme Essential Oil with the Help of Covalent Bound β - Cyclodextrin



Monu

Research Scholar,
Deptt.of Fashion Technology,
B.P.S. Women University,
Khanpur Kalan, Haryana

Lalit Jajpura

Professor,
Deptt.of Fashion Technology,
B.P.S. Women University,
Khanpur Kalan, Haryana

Abstract

Textiles exhibiting character of repelling mosquitoes are called Mosquito-repelling textiles. Anti mosquito finish is applied to textiles which provide protection from the mosquitoes. In current era, use of eco-friendly and nature derived repellents products have received attention of large group of consumers for mosquito control. In this study, essential oil of thyme was evaluated for its repellency effects against malarial vectors using WHO Cone Test. Mosquito repellency was tested at different concentrations of thyme oil from 5 to 25% owf. β - Cyclodextrin was applied to fabric before oil applications as it is known for its hydrophilic as well as lyophilic affinity. Citric acid was used as cross-linking agent to bind the β - Cyclodextrin on the fabric substrate. The finding of the study shows that thyme oil has good mosquito repellency and application of β -Cyclodextrin increases effectiveness of mosquito repellency of textile material along wash durability.

Keywords: Textiles, Mosquito Repellent, Thyme oil, β - Cyclodextrin.

Introduction

Control of mosquitoes has become important for WHO Global Strategy and public health departments due to various mosquito borne diseases such as dengue, chicken guinea, malaria, etc. Various chemical advancements which release mosquito repellent chemicals in forms of coils, liquid vapourisers, gels, etc. are being used to control mosquitoes; still interest is growing towards nature derived products due to harmful toxic effects of aforesaid synthetic products on human health and environment. In ayurveda citation of many insect repellent natural herbs can be seen. Use of advance technology to bring nature-derived products to shop floor must be emphasised. Thus, there is need to develop durable mosquito repellent textile material with the help of these available renewable and sustainable traditionally known raw materials for protection against mosquito transmitted viral infections and diseases^{1,2}. It can protect the human beings from the bite of mosquitoes by inherent shielding as well as additional repellent phenomena and thereby promising safety from the mosquito-borne diseases.

"Natural" smelling repellents are preferred because plants are perceived as safe³ and trusted means of mosquito bite prevention⁴. The essential oils have many important properties, which motivate the researchers to deeply study them and start using them in different areas of wellbeing. Essential oils extracted from different families have shown high repellency against arthropod species⁵. The metabolites like the monoterpenes such as pinene, cineole, eugenol, limonene, terpinolene, citronellol, citronellal, camphor and thymol are the common constituents in a number of essential oils having mosquito repellent activity⁶. Oil used in present study (thyme) is reported to possess many medicinal properties and also insect repelling properties.

Thyme is integral part in recipes of Indian kitchen being numerous health related benefits. It is useful for ringworm, athlete's foot, thrush, and other fungal infections, as well as scabies and lice^{7,8}. It is also used to prevent hardening of the arteries, treatment of toothache, urinary tract infection and dyspepsia. It also expels fungus from stomach and intestine and it has ability to increase appetite because of its important component thymol, which has ability to kill bacteria and parasites⁹.

The present work focuses on the investigation of mosquito repellency effect of essential oil of thyme. The study explores the repellency properties of the various concentrations of the above herb on textile substrate against mosquitoes. Oils don't have affinity to cotton fabric,

E: ISSN No. 2349-9435

thus β - cyclodextrin was applied on cotton fabric. The outer part of the cyclodextrin molecules is hydrophilic and inner cavity is lyophilic in nature. The inner cavity can act as a host for hydrophobic guest molecules and can hold oil content inside. β -cyclodextrin is unreactive, several kind of binders and polyfunctional reagents have been used to link β -cyclodextrin on textile substrates with suitable durability¹⁰. In this work β -cyclodextrin was applied to cotton fabric with the help of citric acid as cross linking agent. Further, effect of β - cyclodextrin on the wash durability of oil was also explored.

Experimental

Materials

The cotton fabric used in present work was procured from local market. Essential oil of thyme was procured from the "Kazima Perfumers, Delhi" and was used as it is without further purification. β -Cyclodextrin, Sodium hypophosphite hydrate (SHP) and citric acid (CA) were procured from HIMEDIA, CDH and Fisher Scientific, respectively. All the other chemicals used were of laboratory grade

Methods

Pretreatment of Fabric

To remove any finish or dirt and dust particles cotton fabric was soaped at mild condition by treating the fabric with 1gpl Lissapol N for 30min at 60°C. After soaping, fabric was thoroughly rinsed and dried.

Methods of Application of β - Cyclodextrin and Essential oil on Fabric

The research was performed in following two steps:

1. Application of β - cyclodextrin on fabric with the help of citric acid as cross linking agent.
2. Application of essential oil of thyme on fabric via spray method.

Application of β - Cyclodextrin

β - Cyclodextrin does not form bonds with cotton fabric by own. So, β -Cyclodextrin was applied to cotton fabric by exhaust method with the help of citric acid as cross linking agent and sodium hypophosphite hydrate as catalyst. The concentration of β -Cyclodextrin was varied to find the optimized β -Cyclodextrin concentration. The optimisation is done on the basis of add on % and absorbance values. Higher add on % and lower absorbance value means more amount of β - Cyclodextrin is present on fabric. The recipe for application of β - Cyclodextrin on fabric is shown in Table 1.

Table 1: Conditions for application of β -Cyclodextrin onto cotton fabric

| | |
|-------------------------------|----------------|
| β - Cyclodextrin (%owf) | 10, 30, 50, 70 |
| SHP (%owf) | 15 |
| Citric acid (%owf) | 20 |
| Time of exhaust (min) | 45 |
| Temperature of exhaust (°C) | ~35 |
| MLR | 1:20 |

Application of Oil on Fabric

After cross-linking of cyclodextrin with optimized concentration, essential oil was applied on fabric. Spray method was used to apply essential oil on fabric samples. Ethanol was used as solvent for varying the concentration of thyme oil. Various

Periodic Research

concentrations of oil were taken to make the solution for the optimisation of oil concentration. The recipe for finishing the fabric by spray method is given in Table 2. The solvent and oil mixture was directly sprayed on fabric samples then samples were dried at room temperature to evaporate ethanol. It was assumed that only ethanol evaporates from samples leaving behind oil on fabric during the drying operation.

Table 2: Recipe for Finishing the Fabric by Spray Method

| | |
|--|-------------------|
| Concentration of Essential oil (% owf) | 5, 10, 15, 20, 25 |
| Solvent | Ethanol |
| Temperature | Room temp. |
| MLR | 1:10 |

Assessment of Various Properties of Finished Fabrics

Presence of β - Cyclodextrin on Fabric

Presence of β - Cyclodextrin on fabric was checked by phenolphthalein method. Decrease in colour of the phenolphthalein molecule in alkaline pH solution due to presence of β -Cyclodextrin is measured at 552 nm with spectrophotometer. Solution of 2 ml of 4 mM phenolphthalein and 8 ml of ethanol was added in to 200 ml of 125 mM sodium carbonate solution. β - Cyclodextrin applied cotton fabric was added (cut in circular form with 3.8 cm in diameter) in 10 ml of the aforesaid prepared solution after uniform mixing. Then absorbance of the solution was checked after 5 min¹¹

Wash Durability of β - Cyclodextrin on fabric

The β - Cyclodextrin applied fabrics were subjected to washing, after washing fabrics were weighed again and their absorbance values were also checked in order to investigate the durability of β -Cyclodextrin on fabric after washing.

Assessment of Mosquito Repellency

The finished samples were assessed for mosquito repellent activity by the standard WHO cone test. For calculating mortality rate, 5 mosquitoes were caught in transparent nylon cone for each fabric sample. The number of mosquitoes knocked-down in 3 minutes was noted to check the effectiveness of the finish. The percentage mortality was calculated by using the following Abbott's formula:¹²

$$\text{Mortality Rate} = \frac{\text{Number of dead mosquitoes}}{\text{Number of mosquitoes introduced}} \times 100$$

Assessment of Wash Durability of Oil on Fabric

The finished fabrics were subjected to washing and then again tested for its mosquito repellency efficiency using the WHO Cone test in order to investigate the durability of finished fabrics after washing.

Results and Discussion

In this study essential oil was applied on cotton fabric to impart mosquito repellency to it. Concentration of oil was optimised on the basis of mosquito mortality rate. Essential oils are not durable on cotton fabric so to enhance the durability β -Cyclodextrin was applied on cotton fabric before application of oil. The concentration of β - Cyclodextrin was optimised and then oil was applied.

E: ISSN No. 2349-9435

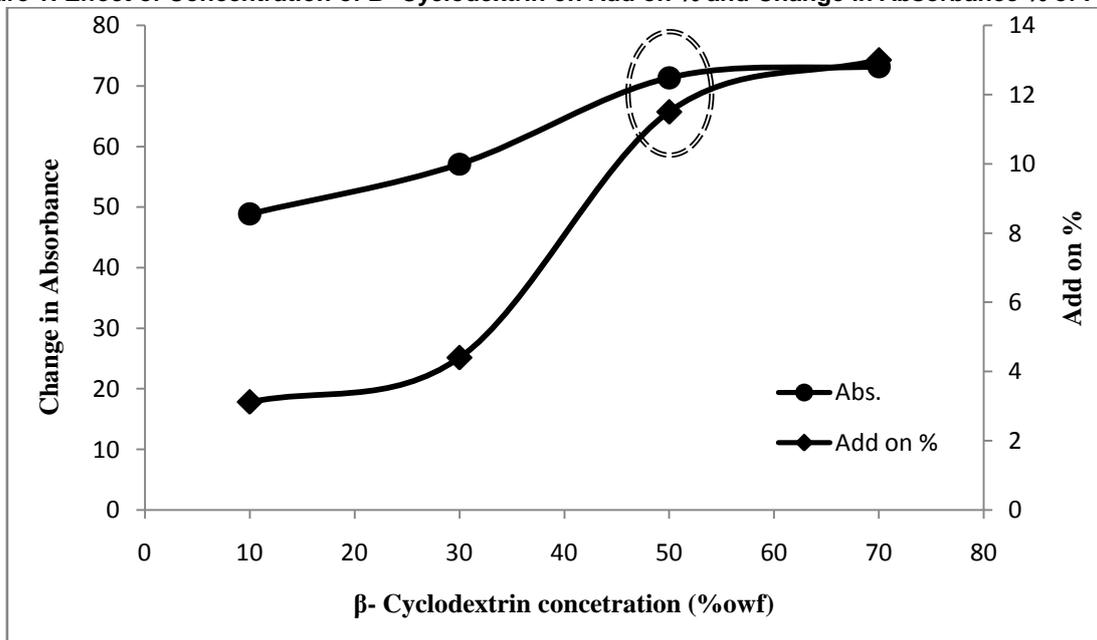
Periodic Research

Application of β - Cyclodextrin

To check the optimised β - Cyclodextrin concentration, the conditions were kept constant as SHP (15%owf), Citric Acid (20%) and Time 45 min

taking MLR 1:20 and carrying out the exhaust process at room temperature. The effect of applied concentration of β - Cyclodextrin on add on % and absorbance is shown in Figure1.

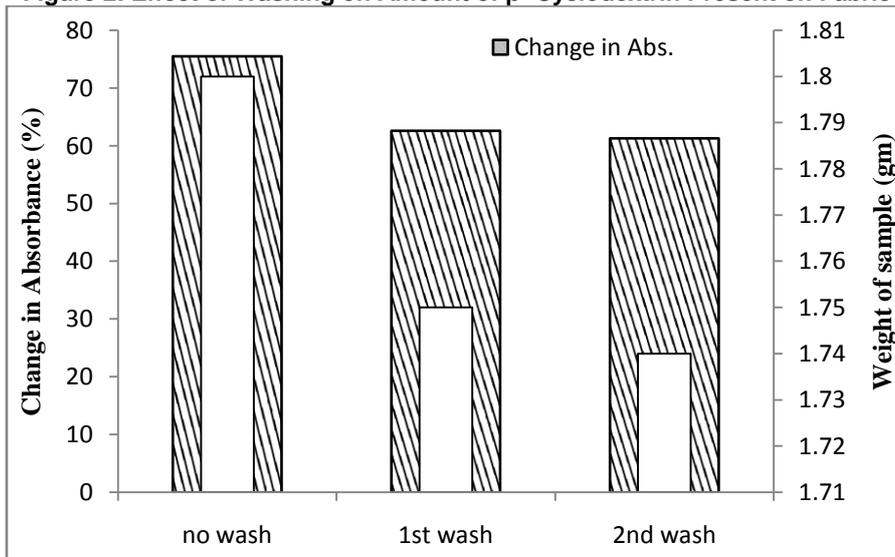
Figure 1: Effect of Concentration of B- Cyclodextrin on Add on % and Change in Absorbance % of Fabric



As the applied concentration of β -Cyclodextrin was increased from 10% owf to 30% owf, add on % and change in absorbance % increases significantly but at slower rate. Both add on % and change in absorbance values show sharp increase when applied concentration of β -cyclodextrin was increased from 30% to 50%. There after with increase in applied β - cyclodextrin there was increase in add on % was observed but at slower. Add on % and change in absorbance values were

found maximum when concentration of β -Cyclodextrin was 70% owf but applications were carried out using 50% owf concentration as the increase in add on % beyond this concentration was marginal. Samples on which 50% owf fabric β -Cyclodextrin was applied were also subjected to washing upto two washes to check the durability of β -Cyclodextrin. The results of washing are shown in Figure 2.

Figure 2: Effect of Washing on Amount of β - Cyclodextrin Present on Fabric



It is clear from Figure 2 that both weight of fabric and change in absorbance value show same trend for washed samples. It can be observed that with 1st wash there is sharp decline in both the values as the physically adhered β - cyclodextrin molecules

were washed away. But after 1st wash there is less decrease in absorbance and weight which shows that after first wash the molecules of β - cyclodextrin present on cotton fabric are more chemically bonded to the fabric.

E: ISSN No. 2349-9435

Application of Oil on Fabric

As discussed earlier the research was performed in following two steps:

1. Application of β - cyclodextrin on cotton fabric
2. Application of essential oil on fabric via spray method.

After completion of first step i.e. optimisation of β - cyclodextrin application oil was applied on cotton fabric. Application of essential oil on fabric is done via spray method by varying oil concentration from 5 to 25% owf.

The results of the mosquito mortality test of cotton fabric treated with different concentrations of essential oil of thyme are presented below in Table 3.

Table 3: Mosquito Mortality Test Results of Cotton Fabric Samples Treated With Different Concentration of Thyme Oil

| Conc. of oil on fabric (% owf) | Without Cyclodextrin | With Cyclodextrin |
|--------------------------------|--------------------------------|--------------------------------|
| | Mosquito Mortality Rate (in %) | Mosquito Mortality Rate (in %) |
| 5 | 0 | 0 |
| 10 | 0 | 40 |
| 15 | 40 | 60 |
| 20 | 80 | 100 |
| 25 | 100 | 100 |

It can be analysed from the Table 3 that initially at lower concentrations of oil without β -cyclodextrin on fabric no mosquito was knocked down. Samples not treated with β - cyclodextrin started to show mosquito repellency only at concentration of 15% owf. Thereafter, mosquito mortality rate increases with increase in oil concentration. The result of oil treated fabric samples shows that mortality rate is higher in samples treated with β - cyclodextrin. The β -cyclodextrin treated samples containing the oil appropriately with lyophilic cavities thus shows more efficacy in mosquito repellence.

The mosquito mortality rate of the treated fabrics might be attributed with the strong odours of thyme clove oil present in the treated fabric surface. The high mortality rate of thyme oil is due to presence of terpenes, polyphenolic acid (oleanic acid, rosmarinic acid, triterpene and caffeic acid).

Wash Durability

The samples having high concentration of oil showed good mosquito repellency thus samples having higher oil concentrations of 20 and 25 % owf were assessed for wash durability. The results of the wash durability are shown in Table 4.

Table 4: Effect of washing on mosquito mortality rate of cotton fabric samples treated with essential oil

| Oil | Conc. | Mosquito Mortality Rate % | | | |
|-----------|-------|-------------------------------|------------|----------------------------|------------|
| | | Without β -cyclodextrin | | With β -cyclodextrin | |
| | | Before Wash | After Wash | Before Wash | After Wash |
| Thyme oil | 20 | 80 | 40 | 100 | 80 |
| | 25 | 100 | 40 | 100 | 80 |

The wash durability test results from data in Table 4 reveals that the mosquito mortality rate of finished cotton fabric without β -cyclodextrin decreases

Periodic Research

after washing when compared with the unwashed samples. It was observed that β -cyclodextrin treated samples shows higher mortality rates and its durability was found higher than without β -cyclodextrin treated samples.

Conclusion

This study reveals that herbal plants can be a good alternative to protect ourselves from mosquitoes. In the study oil is used with or without cyclodextrin on cotton fabric. The results showed that herbal plant thyme is capable to repel mosquitoes. The finding shows that application of β -cyclodextrin not only increases effectiveness of mosquito repellency but also enhances wash durability of oil applied on to the fabric.

References

1. R. Anitha¹, T. Ramachandran¹, R. Rajendran² and M. Mahalakshmi³: Microencapsulation of lemon grass oil for mosquito repellent finishes in polyester textiles ,Anitha et al./ Elixir Bio Phys. 40 (2011) 5196-5200]
2. LalitJajpura , ManjuSaini* , Abhilasha Rangji , Kalpana Chhichholia.: A review on mosquito repellent finish for textiles using herbal extracts, International Journal of Engineering Sciences & Management Research, Vol.2(8) August, 2015], ISSN. 2349-6193
3. M. Sumithra¹ and N. Vasugi Raja²: Mosquito repellency finishes in blended denim fabrics, International journal of pharmacy and life sciences [Sumithra& Raja, 3(4): April, 2012] CODEN (USA): IJPLCP ISSN: 0976-7126
4. Casas A., Valiente-Banuet A., Viveros J.L., Caballero J., Cortes L., Davila P., Lira R. and Rodriguez I. (2001): Plant resources of the Tehuacan-Cuicatlan Valley, Mexico, Econ Bot., 55:129-166.]
5. R V Geetha¹, AnithaRoy²: Essential Oil Repellents- A short Review, ijddr Int. J. Drug Dev. & Res | April - June 2014 | Vol. 6 | Issue 2 | ISSN 0975-9344]
6. Brown, M., Hebert, A.A.: 1997 Insect repellents: an overview, J. Am. Acad. Dermatol. 36, 243–249
7. Rey, C.: Selection of thyme for extreme areas (of Switzerland), Acta Horticultural, 306: 66–70.
8. Runham, S.: A review of the potential uses of plants grown for extracts including essential oils and factors affecting their yield and composition, ADAS Ref F 602/001.
9. HinaJaved, ShaziaErum, SobiaTabassum, Farhan a Ameen.: An overview on medicinal importance of thymus vulgaris, Journal of Asian Scientific Research, 2013, 3(10):974-982
10. Prof Bojana Vončina, Yohann Lachette.: Application of Cyclodextrin on Textile for Cosmetic Purpose April-June 2010]
11. Goel, A.; Nene, S. N. Starch-Starke 47(1995) 399-400
12. Ramanibai, A. Madhavarani and M. Boomilingam.: Larvicidal Efficacy of Leucas Aspera (Willd) Extracts against the Mosquito Larvae of Culex Quinquenotatus, Journal of Pharmacy Research, 2011, 4(12), pp. 4424-442