

ORIGINAL RESEARCH ARTICLE

An essential oil-derived mosquito repellent renewable finish for fabrics

SHIVANI SRIVASTAVA^{1*} • SANGITA SRIVASTAVA²

Article History

Received: December 15th, 2019

Revised: March 06th, 2020

Accepted: April 4th, 2020

Key Words

Citronella

Essential oil

Menthol mint

Mosquito repellent fabric

ABSTRACT

Essential oils derived from aromatic plants like mint species, lemongrass, palmarosa, citronella, vetiver, geranium etc are finding extensive usage in perfumery, flavoring, cosmetics and pharmaceutical industries. Some of these essential oils also possess strong mosquito repellency feature that make them potential candidates for utilization in the huge market of insect repellents and insecticides. In this context, the oils obtained from the hydro-distillation of mint, citronella and lemongrass leaves are in high demand for making herbal formulations/products used in house-hold hygiene and for mosquito repellency. Mosquito borne diseases such as dengue, malaria, filariasis and chikungunya have plagued the public health scenario, especially for the homeless people who live on roadsides and are under constant threat of mosquito bite. According to 2011 Census data about 449761 families in India are roadside dwellers. In the present study we have prepared an organic mosquito repellent renewable fabric finish using citronella oil as the base. Application of this product on fabrics has been found very effective in repelling the mosquitoes. Our study suggests that mixed or intercropping of mint species with citronella can be a profitable venture for farmers because of extra income that citronella oil can fetch for preparing above product.

© CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow-226015

INTRODUCTION

Essential oils are secondary plant metabolites synthesized in different parts of medicinal and aromatic plants, such as leaves, flowers, stems, roots and seeds etc. There are some best known essential oils such as mint, palmarosa, vetiver, geranium, basil, lemongrass and citronella oils that are not only aromatic but are also known to have various other biological activities, including insect repellency and anti-microbial effects etc. Essential

oils have biological active compounds that can be also used as raw material in high grade perfumes, spices, food and pharmaceuticals (Suzane and Salva, 2018). Essential oils are therefore used in different areas, from aromatherapy to aroma therapeutic finishes for textile materials. The essence of oil can impart medicinal effect separate from the aroma but, more often they are intertwined (Buchbaur and Jirovetz, 1994). Nowadays herbal drugs are prescribed widely even when their

*Corresponding author; Email: shivanisrivastava25@gmail.com

¹Department of Home Science, University of Allahabad, Senate House, University Road, Old Katra, Prayagraj -211002 (India), ²Prof. Rajendra Singh (Rajju Bhiya) University, Prayagarj -211002 (India)

Doi: <https://doi.org/10.62029/jmaps.v42i2.Srivastava>

biologically active compounds are unknown because of their effectiveness, minimal side effects, and relatively low cost (Valiathan, 1998). The aroma therapeutic finishing of textile is one of processes which enhance the value of the product by adding aroma as well as other beneficial factors.

Mosquitoes are the most harmful vectors for the deadly diseases such as Dengue, Malaria, and Chikungunya in millions of people every year worldwide (Maheshwaran et al., 2008). Mosquito repellent textile is one of the most effective solutions for avoiding life threatening diseases because it protects the human being from mosquito bite thereby promising the safety from these diseases (Rajendran et al., 2014). Natural herbal aromatic plant based repellents are now preferred and perceived as safe and also trusted means of mosquito bite prevention. These plants may also contain phytochemicals which act as larvicides, insect repellent and have deterrent activities (Aarthi and Murugan, 2010). The present investigation is focused on development of an eco-friendly mosquito repellent finish using blending of natural plant oil extract of citronella (*Cymbopogon winterianus*) with other essential oils.

Wool is a linear keratin protein polymer made of amino acids joint together by polypeptide bond, cross linked by cysteine and salt linkages (Gohl and Vilensky, 1987). The surface content of keratin is almost derived from the amino acids cysteine and methionine. This cross linkage is also responsible for wool resilience. Salt bonding is ionic bonds, linking amino and carboxylic acid groups. These groups also account for amphoteric nature of wool as it unites and reacts towards both acid and base. The wool polymer is composed of twenty amino acids linked together by polypeptide bond. The wool fiber polymer contains inter-polymer forces of attraction such as van der Waals forces and hydrogen bonds that are very weak force of attraction. Hydrogen bond between hydrogen and nitrogen atom are weaker than that of hydrogen and oxygen because nitrogen is less electronegative than oxygen. This inter-polymer bond breaks easily as the fiber absorb water. Water molecule enters

in fiber polymer system and contributes to tensile strength of the fiber. Wool is hygroscopic in nature, as it attracts water molecules. Cross linked disulfide linkages are very strong and contributes to the elastic nature and tenacity of wool fiber. In wool, the amino acid chains have helical configuration that account for the high degree of elasticity, elongation resilience, crease resistance and abrasion resistance of wool fabrics (Stout, 1965). The wool fiber therefore, is said to be only fiber that possesses all the desirable property of a textile fiber.

MATERIALS AND METHODS

Selection of raw material

Selection of fabrics

In the present study pure Marino wool fabric was chosen for application of essential oil finish. Selection of fabric was done keeping in mind the properties of the textile fibers. Every fabric takes up essential oil and releases its particular aroma differently. Correct choice of fabric and the concentration of the renewable finish are important factors to elicit the desired results. In the literature so far there is no evidence/record about the correct choice of right material. Therefore when the microencapsulation process is done, the textile products require extra handling because the capsules can be destroyed during packaging/shipping, limiting its effect and the process requires high cost (West and Annett-Hitchcock, 2014).

Selection of aromatic plant oils

On the basis of an extensive literature search on aromatic plant essential oils and their therapeutic effect, citronella plant was chosen in the present study for preparing the fabric finish. The essential oil was extracted by hydro distillation method with the help of Clevenger apparatus. The hydro distillation process has advantage that by this process the original composition and quality of essential oil largely remains unaffected. Fresh leaves of citronella plant were collected and cut into small pieces. The cut leaves were put into Clevenger apparatus with material to liquor ratio 1:3 and completely immersed in water. At first the

temperature of heating mantle was set at 100°C and when boiling started the temperature was decreased to 60°C. After 4 hours, the essential oil was collected in a glass container. Oil samples were subsequently analyzed for determining their qualitative and quantitative composition using Gas Chromatography (GC).

Preparation of fabrics for finishing

Preparation of fabric is a necessary step to ensure the complete impregnation of the essential oil. The fabric must be free from other finishing process and impurities which can interfere with the aroma impregnation. To remove all impurities before finishing of fabrics, scouring method were done. The term scouring means removal of impurities such as oil, grease, dirt, gum etc. Scouring enables the fiber to be hydrophilic and absorb dyeing and finishing materials evenly. It is the first step of processing wool. It increases the absorbency of the wool fabric. Scouring process was done by soaking the fabric in a solution of sodium carbonate and a mild soap followed by boiling at 60° C for 60 min. After the completion of the process, the fabric was rinsed thoroughly under running tap water to remove any residue, followed by drying.

Preparation of renewable finishing solution and application on fabric

A 10% (v/v) mixture of essential oil was prepared in 80% ethyl alcohol. For impregnation of the essential oil suspension on the fabric, a spray method was used. The finishing solution was fed into spray bottle and spraying was done manually followed by drying and curing.

Olfactometry analysis

Olfactometry analysis is a kind of sensory evaluation used to assess the aroma intensity and aroma durability. The samples were smelled for a period of one month. Coffee beans were sniffed between the evaluations to avoid mixing of aroma intensity with other. Twenty five respondents were selected for evaluation of aroma intensity. The samples were smelled on every 5th day for a period of one month. The average aroma intensity was

recorded at five point quantum scale. The aroma intensity was categorized into different attributes and following weightage was given (Table 1).

Table 1. Aroma attributes and weightage

Rating	Weightage
Very strong	5
Strong	4
Medium strong	3
Weak	2
Very weak	1

The weighted mean was calculated by multiplying the frequency of each rating with the respective weightage. A range was found for final rating on the basis of weighted mean score (Table 2).

Table 2. Weighted mean score rating range

Weighted mean score	Rating
5.0-4.8	Very strong
4.8-4.0	Strong
4.0-3.0	Medium strong
3.0-2.0	weak
2.0-1.0	Very weak

Assessment of mosquito repellent activity

The efficacy of mosquito repellency of treated samples was assessed by mosquito repellent test using standard cage method (Prabha and Vasugi, 2012). A specially designed wooden cage was employed to measure the repellent activity of mosquitoes (Fig. 1). The wooden outer chamber measures 35 cm x 30 cm x 30 cm. The box is composed of a door which opens in front. The treated and controlled samples were placed inside



Figure 1: The repellency cage used in the study

the cage. The treated sample was placed at one facet of the box and controlled sample was placed at opposite facet of the box. 20 mosquitoes were exposed and number of mosquitoes rest on treated and controlled sample were noted at every 10 minutes intervals for 40 minutes. The repellency was calculated using the following formula.

$$\text{Mosquito Repellency \%} = \frac{\text{number of mosquitoes on controlled sample}}{\text{number of mosquitos exposed in the cage}} \times 100$$

Treated sample was also assessed for repellent activity after washing. The washing was done using laboratory launder-O-meter. The test was performed as per recommendation of IS: 3361-1979. The efficacy of mosquito repellent activity was assessed after 10 wash cycles. Again mosquito repellency % was calculated by using above given formula.

RESULTS AND DISCUSSION

The present study was undertaken to prepare an aroma therapeutic renewable finish and also to identify suitable fabric for the application of finish. The renewable finish was developed to meet the consumer needs with reference to mosquito bites. The findings of this research work have been illustrated below. All the studies were performed on the basis of following data categories.

Quality analysis report of essential oil

Under the present study Gas chromatography was used for the quality/purity checking of the essential oils (Table 3). The quality and major constituent of the oils of citronella were analyzed using plotted chromatogram (Fig.2). Qualitative data of the citronella oil indicated that the bulk of the oil (~70%) was represented by 34.5% citronellal, 23.9% geraniol and 10.1% citronellol. The other detectable constituents were limonene (3.2%), neral (0.5%), geranial (1.2%), citronellyl acetate (2.2%), geranyl acetate (4.2%) and elemol (4.1%).

Olfactometry analysis

The olfactometry analysis was done to record average aroma intensity of impregnated fabric. Table 4 shows the average aroma intensity from the 5th day till 30th day. It can be seen from the table

Table 3: Major components of citronella essential oil estimated by GC-FID analysis.

Compound	(%)
Limonene	3.2
Citronellal	34.5
Citronellol	10.1
Neral	0.5
Geraniol	23.9
Geranial	1.2
Citronellyl acetate	2.2
Geranyl acetate	4.2
Elemol	4.1

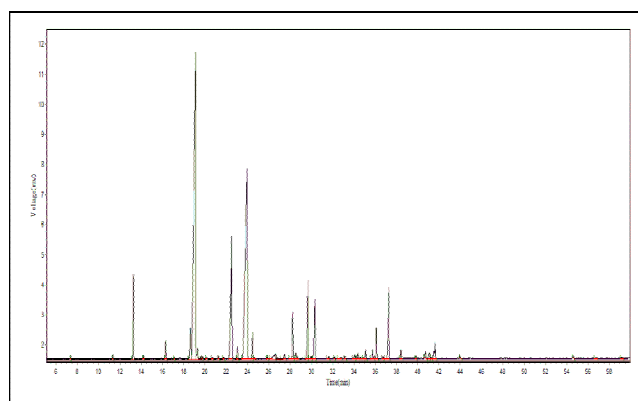


Figure 2: Gas chromatogram of citronella oil

that aroma intensity on 5th day of evaluation was observed very strong (W.M.S.-5.0). On the 10th day the aroma intensity was again very strong (W.M.S.-4.88). From the day 20th to 30th day the aroma intensity was recorded strong (W.M.S.-4.60-4.32). The aroma intensity of wool fabric was still felt strong as reported by the respondents. It is evident from Table 5 that the mosquito repellency of sample treated with citronella oil was 90 to 95 percent.

Efficacy of mosquito repellent activity after washing

Treated sample was assessed for mosquitoes repellent activity after washing. The data regarding repellency % after washing is presented in Table 6. The samples were subjected to 10 wash cycles and mosquito repellent activity was recorded. It can be seen from the data that, the repellency was 95 % before washing, and after 5, 10 wash cycles it was observed to be 76% and 60 % respectively.

Table 4: Weighted Mean Score (W.M.S.) for aroma intensity of wool fabric treated with citronella oil

Essential oil	Evaluation day	Aroma attributes					
		VS	S	MS	W	VW	W.M.S.*
Citronella	5 th	25	0	0	0	0	5.0
	10 th	24	1	0	0	0	4.96
	15 th	23	1	1	0	0	4.88
	20 th	21	1	1	1	1	4.60
	25 th	20	2	1	0	0	4.4
	30 th	18	1	1	2	3	4.32

*W.M.S rating follows the order, Very Strong: 4.8-5.0, Strong (s):3.8-4.7, Medium Strong (Ms):2.8-3.7, Weak (W): 1.8-2.7**, Very Weak (VW): 1.0-1.7. (No. of respondents, n=25)

Table 5: Analysis of efficacy of mosquito repellent renewable citronella oil finish on wool fabric

Time of observation (min)	Citronella		Repellency %
	CW	TW	
10	18	2	90
20	18	2	90
30	18	2	90
40	19	1	95

*Number of mosquitoes exposed in the cage = 20; CW= number of mosquitoes rest on the controlled wool sample; TW= number of mosquitoes rest on the treated wool sample

Table 6. Assessment of wash durability of mosquito repellent renewable finish on wool fabric

Type of essential oil	Wash cycles	Durability to washing (Repellency (%))
Citronella	0	95
	5	76
	10	60



Figure 3: The finished product-a woolen stole impregnated with essential oil blend

Final Product development

On the basis of overall results of this study wool fabric was chosen for final product development. A woolen stole was developed (Fig. 3) using spray finishing technique for essential oil blend impregnation that could repel mosquitoes.

REFERENCES

- Aarthi N, Murugan K. 2010. Larvicidal and repellent activity of *Vetiveriazizanioides* L, *Ocimum basilicum* Linn and themicrobial pesticide spinosad against malarial vector. *Anopheles stephensi*liston (Insecta: Diptera: Culicidae). *J Biopesticides* – Special Issue 199 - 204.
- Buchbaur G, Jirovetz L. 1994. Aromatherapy-use of fragrance & essential oil as medicaments. *Flavour Fragr J* **9**: 212-222.
- Gohl EPG, Vilensky LD. 1987. The protein Fibres (Textile Science), CBS Publishers and Distributors.
- Maheshwaran R, Sathish S, Ignacimuthu S. 2008. Larvicidal activity of *Leucasaspera* (wild) against the larvae of *Culex quinquefasciatus*

- Say. And Aedesaegypti L. *Int J Integ Biol* **2**: 214 – 217.
- Prabha R, Vasugi RN. 2012. Filarial repellent finish using medicinal plants. *Ind J Sci* **1**:74-76.
- Rajendran R, Radhai R, Rajalakshmi V. 2014. Development of mosquito repellent fabrics using *Vitex negundo* loaded nano particles. *Malaya J Biosci* **1**: 19-23.
- Stout EE. 1965. *Introduction to Textiles*. Jhon Wiley and Sons, Inc.
- Suzane AK, Salva LR. 2018. Recent progress in photochemical reaction on main components of some essential oils. *J Saudi Chem Soc* **22**: 855-875.
- Valiathan MS. 1998. Healing Plants. *Current Sci* **75**: 1122-1126.
- West and Annett-Hitchcock. 2014. A critical review of aroma therapeutic application for textile & apparel. *J Textile Appar Tech Mgmt* **9**: 1-14.