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**Neenu Poonia**

Department of Textile & Apparel  
Designing, I.C. College of Home  
Science, CCS HAU, Hisar,  
Haryana, India

**Dr. Saroj S Jeet Singh**

Department of Textile & Apparel  
Designing, I.C. College of Home  
Science, CCS HAU, Hisar,  
Haryana, India

## Insect repellent fabric

**Neenu Poonia and Dr. Saroj S Jeet Singh**

### Abstract

Mosquitoes are a serious threat to public health transmitting several dangerous diseases for over two million people in the tropics. Worldwide, however, mosquitoes transmit disease to more than 700, 000, 000 people annually and will be responsible for the deaths of 1 of every 17 people currently alive. To avoid such sort of disease transmission to humans can be avoided using mosquito repellent fabrics. A textile fabric with the mosquito repellent is one of the revolutionary ways and the much needed feature of driving away the mosquitoes. It protects the humans from the bite of mosquitoes and thereby promising safety from the mosquito borne diseases.

**Keywords:** Mosquito, disease, fabric, repellent

### Introduction

From centuries men has always concerned about his protection which led to number of developments in every field with regards to textiles. After fabricating the mansions of fashion and comfort, Textiles are moving towards high-tech era of performance, which brought up diversification and expansion of technologies. To ensure our security and safety from the future hazards, we need to equally development the technology for our protection. Protective textiles are among one such smart application of smart technology in textiles. Protective textiles refer to those textile products which have a functionality of giving protection from something in some or the other sense. With regard to textiles, the protective textile field of the smart textiles has to fulfill this requirement. Insect repellent textiles are one of the revolutionary ways to advance the textile field by providing the much-needed features of driving away insects, especially in the tropical areas.

**Insect:** Any animal of the class Insecta, comprising small, air breathing arthropods having the body divided into three parts (head, thorax, and abdomen), and having three pairs of legs and usually two pairs of wings.



**Insect Groups (Orders):** The Insects (Class Insecta) are divided into a number of Orders. These are grouped together into two sub-classes called the Apterygota (wingless insects) and the Pterygota (winged insects). In addition to the Class Insecta there are three other classes of invertebrates that have six legs, these three classes are known as non-insect hexapods.

### Diseases associated with insects

1. Viruses (chikungunya virus, yellow fever, dengue fever, etc.)
2. Bacteria (Lyme disease, plague, etc.),
3. Parasites (malaria, sleeping sickness, filariasis, etc.)



**Corresponding Author:**

**Neenu Poonia**

Department of Textile & Apparel  
Designing, I.C. College of Home  
Science, CCS HAU, Hisar,  
Haryana, India

### Impact of Insect borne disease

- Economic loss
- Illness and death
- Deforestation
- Loss of biodiversity
- Introduction of alien species
- Climate change

### Insect Attack

A female mosquito feeds on blood to acquire protein that allows the development of her eggs (Figure 1). When she bites, she releases saliva into the area where she is feeding. Her saliva contains proteins that may cause some people to have an allergic reaction, such as itchy red bumps and swollen hives. For those with increased sensitivity to bites, a blister, bruise, or large inflammatory reaction may occur. If a mosquito is harboring a pathogen, such as a virus, a protozoan, or a nematode worm, it is possible that she can transmit the pathogen to humans through her saliva.

**Protective measures:** The right insect repellent and other preventive actions can discourage mosquitoes, ticks and other biting insects from landing on people and harming them.

#### 1) Avoiding Infested habitats

- Eliminate standing water in rain gutters, old tires, buckets, plastic covers, toys, or any other container where mosquitoes can breed.
- Empty and change the water in bird baths, fountains, wading pools, rain barrels, and potted plant trays at least once a week to destroy potential mosquito habitats.
- Drain or fill temporary pools of water with dirt.
- Keep swimming pool water treated and circulating.

#### 2) Use Structural Barriers

- Cover all gaps in walls, doors, and windows to prevent mosquitoes from entering.
- Make sure window and door screens are in good working order.

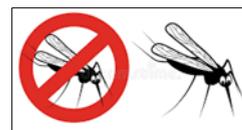
**3) Wear appropriate clothing:** Travelers can minimize areas of exposed skin by wearing long-sleeved shirts, long pants, boots, and hats. Tucking in shirts, tucking pants into socks, and wearing closed shoes instead of sandals may help reduce risk. Application of repellents or insecticides, such as permethrin, to clothing and gear can provide an added layer of protection.



**4) Bed nets:** Bed nets provide essential protection to travelers staying in accommodations lacking adequate window screens and air conditioning. Bed nets that do not reach the floor should be tucked under mattresses. Treating bed nets with a pyrethroid insecticide helps maximize their efficacy.

**5) Check for ticks:** Peoples should inspect themselves and their clothing for ticks during outdoor activity and at the end

of the day. Prompt removal of attached ticks can prevent some infections. Showering soon after leaving a tick-infested area may prevent ticks from attaching or facilitate detection of recently attached ticks.



**6) Insecticides and spatial repellents:** Active ingredients in these products, metofluthrin and allethrin, provide protection from insect over a wide area. Spray aerosols can clear rooms or areas of mosquitoes; coils, vaporizing mats, and spatial repellents repel insects from a circumscribed area. Use insecticides and repellent products with caution, avoiding direct inhalation of spray or smoke.



**Protective textiles:** It is defined as textile products which having a functionality of giving protection. This type of textiles help in protection from the species that are prone to cause damage in some or other manner.

**Insect Repellent:** is any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest. (Mitigating means reducing the effect of something).



**How insect repellent works does:** Humans attract mosquitoes and other blood feeding insects by their breath and skin odors. The insect is attracted to the carbon dioxide in a human's breath. Repellents are effective only at the skin area and close to the treated surface, so mosquitoes may still be seen flying nearby. An insect repellent also commonly called "bug spray" is a substance applied to skin or clothing which produce a vapor layer that has an offensive smell or taste and makes a person unattractive for feeding and therefore repels the insect from landing or climbing on that surface. Insect repellents help to prevent and control the outbreak of insect-borne diseases such as malaria, Lyme disease, dengue fever and West Nile fever. Repellents with higher concentrations (percentages) of active ingredient usually provide longer-lasting protection.

#### History of Insect Repellent

- 484BCE-425BCE:** The plant species (*O.dorsovittatus*) contain the insect repellent chemicals called benzoquinones and it was hypothesized that the anointing behaviour was designed to deter biting insects.
- 4<sup>th</sup> century:** Rubbing a concoction of Vinegar, manna and oil on the body to repel insects.

- **17<sup>th</sup> century:** Burning of plants such as neem to repel biting insects.
- **18<sup>th</sup> century:** burning fish, shell, various bones generated a thick smoke that have some repellent effect
- **1890:** Pyrethrum which is natural plant oil incorporated into the mosquito coil to repel insects.
- **1929:** The first chemical repellent to be developed was dimethyl phthalate (as a fly repellent).
- **1953:** Deet is the most important in the evolution of repellants, the most effective repellent use in today-more than 50years after its discovery.
- **1975:** IR3535 and many modern synthetic long lasting repellent were introduced to repel insects.

### Classification of insect repellent

**Natural insect repellent:** Those repellants which are derived from plant based ingredients are called natural insect repellents. These are obtained from various parts of plants such as leaf, stem, roots, weeds and peels etc.

<b>Leaf:</b>	Basil Catnip Bay leaves Neem
<b>Flower:</b>	Alliums Marigold Vanilla Clove
<b>Weed:</b>	Pineapple Wormwood
<b>Peels:</b>	Orange Lemon

**Clove:** Botanical name of clove is *Syzygium aromaticum* and its native place are Bangladesh, Indonesia, India, Pakistan etc. It is mainly used in fever reduction and prevent premature ejaculation. Cloves are used as a carminative. It also repel various type of insects such as Ants, housefly, moth and mosquito. The essential oil found in cloves kills insects on contact, which makes it an excellent ingredient for use in homemade insecticides. Whole, dried cloves can be used as an insect repellent, because, though the oil has dried, the pungent odor of the cloves is repulsive to pests such as ants, flies and moths. Nentwig G *et al.*, (2017) <sup>[10]</sup> Studies have found that undiluted topical clove oil is active against mosquitoes. The studies concluded that it's effective for nearly four hours. However, like thyme oil, clove oil should not be applied undiluted to skin as it can be absorbed and result in adverse effects. Gupta (2014) converted plain woven cotton fabric into mosquito repellent fabric by application of clove extract. For treatment using 7 and 14 percent concentration of clove extract at room temperature for 30 minutue. Then the fabric samples were tested for mosquito repellency as per the standard test method (Cage tests). Both the untreated cotton fabric and treated fabric were placed inside the mosquito cage containing mosquito for 2hours. The effectiveness of the finish was evaluated by the presence of number of mosquitos on the sample and the bites.



**Citronella:** Citronella is a well-known natural mosquito repellent. The oils from the plant are used to make lotions, sprays, and candles. In some studies, citronella-based repellents have been found to be as effective as DEET. The main problem with this old standby is that it can evaporate within two hours, depending on the formula, Wong (2017). Newer findings have discovered that combining it with vanillin can slow down the evaporation. Those citronella candles, which people have long used on patios and when camping, aren't as effective as skin applications. Candles, which offer continuous evaporation of the oil, have been shown to reduce mosquitos by just 50%. Muller *et al.*, (2008) stated that the repellency rate of 5% citronella candles against mosquito was 29.0%, of 5% linalool candles was 71.1% and 5% geraniol candles was 85.4%. The candles with geraniol were about twice as effective as those with linalool and were about 5times as effective as citronella candles. The repellency rate of 5% citronella candles towards sand flies was 24.7%, of 5% linalool candles was 55.2% and of 5% geraniol candles was 79.7%. A geraniol candle was almost 5 times as effective as a citronella candle and about twice as effective as a linalool candle in protecting a person from being bitten indoors by sand flies.



**Basil:** The botanical name of basil is *Ocimum tenuiflorum* and its native place is India. It is used mainly in treating cough, syrup, bronchitis and asthma. Many people chew tulsi to get relieves from cold and flu. It is also used to make an insect repellent spray due to its medicinal properties. Basil came in wide variety but among various variety cinnamon basil, lemon basil and Peru are the best because they have a very strong aromatic property. The insect repellent made from basil are mainly used to repel flies and mosquitoes.



**Garlic:** The botanical name of garlic is *Allium sativum* and its native places are North Eastern Iran and Central Asia. It is used as a seasoning or condiments. It helps to prevent cancer, common cold, cardiovascular diseases. It also helps to control nematocidic and insecticide such as aphids, fleas, Japanese beetles, and spider mites.



**Snowbrush:** It is also called as red roots and its botanical name is *Ceanothus velutinus*. It is used to treat colds, fevers, and Influenza. Helps to prevent dandruff and repel insects such as Ants, flies, cockroach.



**Pennyroyal:** It is also known as mint. The botanical name of pennyroyal is *Mentha pulegium* and its native places are Europe and North Africa. It is used in flavoring of teas drinks and foods and mainly present along walkways, house entrances, foundations, and near pet quarters. Mint is also used as a insecticide and pest repellent due to its various properties such as abortifacient, culinary, insecticide and pest repellents thus repel ants, white cabbage moths, aphids, and flea *Betteles*.



**Marigold:** The botanical name of marigold is *Calendula officinalis*. and its native place are South-western Asia & Western Europe. It is used in eye, genital, skin infection treatment and Immune boosting formula. It also prevent serious skin conditions like psoriasis, eczema. Marigold have inherent properties such as anti-inflammatory, antispasmodic and antifungal due to which it repel insects such as mexican bean beetles, squash bugs, thrips, tomato hornworms, and whiteflies. Rana, M (2016) [13] conducted an experiment to give mosquito repellent finish to cotton and P/C blend using different techniques, marigold and nirgundi plant material was selected among 8 plant because these have mosquito repellent efficacy. They found that direct application technique has better efficacy after treatment and durability was found better with microencapsulation and combination technique with both plant extract on both the fabric as compared to treated fabric.



**Nirgundi:** The botanical name of nirgundi is *Vitex negundo* and its native place is India. It is mainly used to treat Inflammatory swellings of joints and Catarrhal fever. It is also used as bio-pesticide or insecticide and help to repel mosquito. Nirgundi have inherent properties such as anti-inflammatory, anticatarrhal, analgesica and antimicrobial. Mohanraj *et al.*, (2012) explained *V.negundo* is an effective bio-control agent, antibacterial, antifungal, antifilarial, antiviral and mosquito repellent. Every part of plant is useful

in many ways such as leaves are anti-inflammatory, roots are tonic. Roots, fruits, flowers, leaves and bark have great medicinal value and are used for medicinal and insect repellent purposes. Ramasamy *et al.*, (2014) [12] synthesized nanoparticles loaded with *V.negundo* leaf extract using ionic gellification method. Repellent textiles were achieved by padding cotton fabrics with nanoparticle loaded with *V.negundo* leaf extract using conventional pad-dry method. The finished fabric were analyzed using mosquito repellency behavioural test and showed 100% mosquito repellency efficiency and fabrics retained their activity until 15 washes.



**Neem:** The botanical name of neem is *Azadirachta indica* and its native places are India, Nepal, Pakistan & Bangladesh. It is used for its medicinal purpose and to control pest and disease. It has several properties such as antifungal, antidiabetic, antibacterial and antiviral. It prevent mosquito, fleas, tick & ants. It is helpful in preparation of polymeric resins and cosmetics.



**Castor Oil:** The botanical name of castor oil is *Ricinus communis*. Castor oil has been used as a natural insect repellent as far back as Greek antiquity. Castor oil have antihistamine and anti-inflammatory properties. It has long been used on the skin to prevent dryness. It is used as insect repellent. Tseghai (2016) [15] concluded that Sample treated with Castor oil was effective on mosquito repellency property. The wash fastness was poor so it is recommended not to wash the treated fabric or retreat it after washing by spraying. The strength of the treated fabric was better than the untreated hence the finish didn't degrade the fabric. The finish showed slight shrinkage but no increase in the stiffness was observed.



**Synthetic insect repellent:** Those repellent which are obtained from chemical ingredients and prepared by chemists in laboratory. The various type of synthetic repellents are Deet, IR3535, benzaldehyde, picaridin, ethylhexanediol and metaflorin etc.

**Deet:** *N, N*-Diethyl-*meta*-toluamide, also called DEET or diethyltoluamide, is the most common active ingredient in insect repellents. It is a slightly yellow oil intended to be applied to the skin or to clothing and provides protection against mosquitoes, ticks, fleas, chiggers, leeches and many biting insects. A slightly yellow liquid at room temperature, it can be prepared by converting *m*-toluic acid (3-methylbenzoic acid) to the corresponding acyl chloride using thionyl chloride (SOCl<sub>2</sub>), and then allowing that product to react with diethylamine. Yoon *et al.* (2015) [7] test the efficacy and complete protection times (CPTs) of three representative mosquito repellents: *N,N*-diethyl-3-methylbenzamide (DEET), citronella, and fennel oil. The repellency of citronella oil decreased over time, from 97.9% at 0 h to 71.4% at 1 h and 57.7% at 2 h, as did the repellency of fennel oil, from 88.6% at 0 h to 61.2% at 1 h and 47.4% at 2 h. In contrast, the repellency of DEET remained over 90% for 6 h. The CPT of DEET (360 min) was much longer than the CPTs of citronella (10.5 min) and fennel oil (8.4 min).



**IR3535:** It is also known as Ethyl butylacetylaminopropionate. It is derivative of beta-alanine and used as an insect repellent, has no killing action and does not give rise to selection pressure or development of resistance. It is a colorless and almost odorless oil and is intended to be applied to the skin of humans and animals. It has a broad efficacy against various insects like mosquitoes, ticks, lice, and other bugs. Ethyl butylacetylaminopropionate is safe for use on infants, pregnant and breastfeeding women. It is biodegradable and completely degraded in the environment within a very short time. Carroll (2008) [3] revealed that the three IR3535 formulations provided unusually long-duration protection against mosquitoes and blacklegged ticks, even at comparatively low doses. Complete protection times ranged from 7.1 to 10.3 h for mosquitoes and from 9.1 to 12.2 h for blacklegged ticks. Long protection duration resulted in many cases being truncated by darkness or eventual subject withdrawal, which suggests that actual protection times were probably greater.

#### Reasons for using plant based repellent

- Plant-based repellents are safer than synthetic because they are natural.
- Plant based repellents are better for the environment than synthetic molecules.
- Natural insect repellent does not contain dangerous chemicals like allethrin.
- Plant-based insect repellent is used because of user acceptability. People tend to favor natural products over synthetics.
- Plant-based active ingredients are also thought by some to pose fewer risks to users.

- Insect repellents derived from plants can be an inexpensive.
- Plant-based repellents are ethically sourced and produced then they can bring trade to developing countries and are less damaging to the environment," said Dr. Moore.
- Plant-based repellents distillation requires biomass energy, extraction commonly uses organic solvents that must be disposed of carefully, growing the plants uses agrichemicals, such as fertilizers and pesticides.

Pattanayak *et al.*, (2015) [11] studied plants having mosquito repellent activity. Plant-derived repellents usually do not pose hazards of toxicity to humans and domestic animals and are easily biodegraded. Compared to synthetic compounds, natural products are presumed to be safer for human. As Malaria is very common in most of the tribal dominated areas, development of low cost herbal mosquito repellents will save the precious life of many poor people.

#### Application of Herb on fabric

- 1) **Extraction from the Herb:** The selected sources were cleanly and safely collected from both living area and the forest area that were grown under optimal environmental condition that is free from disease and contamination. Fresh leaves dried under shadow and the leaves were grinded.
- 2) **Filtration:** Required amount of dry powder is mixed with methanol; the container was closed and kept overnight. After overnight incubation, the extract was filtered through filter paper.
- 3) **Evaporation/condensation:** After filtering the herb extract, methanolic solvents were evaporated using the soxhlet method and thus the herb extract were condensed.
- 4) **Techniques used for application:** There are four main techniques to achieve the method of repellent textile which are absorbed, incorporation, polymer coating and microencapsulation.

- a) **Absorption Technique:** comprises the method of spraying, dipping or pad dry cure method.

**Dipping method:** In this method fabrics is immersed in the solution for effective formation of the material. Once the material is deposited then the substrate can be removed by evaporation which will result the thickness of the layer are unique. The major forces that are used for the dip coating process are gravitational force and surface tension. Kumar *et al.*, (2007) treated cotton and nylon with chrysanthemum oil by padding and exhaust method using direct and microencapsulation techniques. It was found that both methods were quite effective, particularly the exhaust method with direct technique which showed satisfactory performance with both nylon and cotton. The major disadvantage associated with this finish was slight yellowing problem but possessed good wash fastness whereas in micro encapsulation technique, release of plant oils has been found to be significantly decreasing the bites per minute in test boxes.

**Pad Dry cure method:** The textile is passed through a water-based solution bath containing the finishing chemicals. The textile is then dried and cured using heat and/or pressure.

- b) **Incorporation technique:** This techniques is mainly used during the manufacturing or dyeing process.

- c) Polymer coating:** In this technique a layer of polymers coated onto the textiles fibre thus finish taken place.
- d) Microencapsulation:** It must be in capsule form that mixed to binding solution. The plant essential oils were microencapsulated to prevent the easily evaporation process. The textile treated with microencapsulated performed the higher and longer lasting protection against insects compared to sprayed fabric with ethanol solution of essential oil. Gupta and Gupta (2010) [5] revealed that most finish on textiles use micro-capsulation to deliver active ingredient like moisturizer, therapeutic oil, body lotions, creams or insecticides through the clothes onto the skin directly where they were absorbed by the dermis.

#### Application of Insect repellent finish

**Clothing:** Jacket, Netting Jacket, Headnets, Vests, T-shirt, Trousers, Bands and Ankles.

**Upholsteries/Outdoor:** Detachable patches of fabric (Velcro strips, press buttons or adhesive stickers), Hammock, Curtain, Bed-Sheets, Bed-Curtains, Mosquito netting (rectangular netting, circular netting, wedge shaped netting & baby netting (self supported)).

#### Advantage

- 1) Generally very safe to use.
- 2) Natural fragrance.
- 3) Environmentally friendly and fully biodegradable.
- 4) Acceptance due to long history use
- 5) Less expensive
- 6) Fewer side effect- compatible with all types of skin.
- 7) They don't create any by-product.
- 8) Botanical products are rich source of vitamin, antioxidants, essential oils and other bioactive compounds.

#### Disadvantage

- 1) Some have shorter residual action or protection times.
- 2) Costs may be higher than synthetic compounds.
- 3) Evaporative loss
- 4) Destroy ecosystem.

Maia and Moore (2011) [8] studied "Plant based insect repellent" they stated that it is a valuable resource for the development of new natural mosquito repellent products. Commercial repellent products containing plant based ingredients have gained increasing popularity among consumers and perceived as safe in comparison to long established synthetic repellent.

#### Future

- 1) All plant species are medicinally important.
- 2) Phytochemical analysis of plant species shows the presence of starch, protein, tannin, saponin, flavonoids and alkaloids etc. and it can be used in multidisciplinary research.
- 3) The use of green plants or their products has been effective in controlling several plant pathogens.
- 4) It gives rise to sustainable agriculture and maintenance of a clean environment to our descendants in the future.
- 5) Natural herbs as a viable alternative to synthetics and pave the path forward for the industry to make in-roads into sustainable manufacturing.

- 6) Insect repellent finishes are used to achieve effective and long lasting insect repellent properties in an ecofriendly manner.
- 7) It's aiming at improving the formulation of essential oil to increase their longevity through the development of nanofibers, micro-encapsulation, sol-gel doping and entrapping in cyclodextrins etc.
- 8) Insect repellent textiles should be multifunctional combining the repellent character with other functionalities like UV Protection, Flame retardant, Water repellency etc.
- 9) It can be used as a repellent in home to kill rats, mosquitoes, flies, bug etc.

#### Conclusion

Natural plant based insect repellent can be used as viable functional finishes for imparting antibacterial and insect repellent to different textile substrate like wool and cotton fabric etc. Thus they protect the people from the bite of insect and thereby provide safety from insect borne diseases. Many of the textile material treated with insect repellent have potential to provide protection against insect vectors but lack the residual activity necessary to achieve prolonged effect or cost effective. Some promising technique for improving their longevity includes the microencapsulation pretreatment that has a positive effect on the final characteristics of fabrics. Natural products can serve as effective alternative materials to synthetic organic compounds, and therefore could be highly useful for the society as well as to the environment as a whole. With the necessity to reduce environmental burden it is important for the textile industry to develop green processes and products for improving health and protect the environment.

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