International Journal of Home Science 2017; 3(2): 443-446

International Journal of Home Science

ISSN: 2395-7476
IJHS 2017; 3(2): 443-446

www.homesciencejournal.com
Received: 09-03-2017
Accepted: 10-04-2017

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Development of natural mosquito repellent cotton fabric using sweet lime peel

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Abstract
In this study an attempt has been made to approach of developing Mosquito repellency finishes using natural herbs. The herbal extracts of *sweet lime peel was* applied on cotton fabric directly by using pad dry cure method. The Mosquito repellency finishes of the finished fabric was assessed against mosquito. To enhance the durability of the finished fabric, wash durability test has been carried out and the results showed good efficiency of finishes even after 6 domestic washing cotton fabric. This paper described the textile materials selection, methods of imparting the repellent into the fabrics, repellency test of treated fabrics. The assessments used in the treated textile are summarized and conditions of the assessment of repellency relative to this discussion are presented.

Keywords: Anti-mosquito repellent, cotton fabric, pad dry cure method, sweet lime peel, wash durability

1. Introduction
Mosquito repellent textiles are one of the revolutionary ways to advance the textile field by providing the much-needed features of driving away mosquitoes, especially in the tropical areas. It protects the human beings from the bite of mosquitoes and thereby promising safety from the mosquito-borne diseases, such as malaria, dengue fever (DF), Nile fever, dengue hemorrhagic fever (DHF), chicken gunia and filariasis, are serious public health problems in tropical regions, especially in Africa and Asia. These diseases are transmitted to human beings through mosquito1. Most plants contain compounds that they use in preventing attack from phytophagous insects. These chemicals fall in to several categories, including repellents, feeding deterrents, toxins, and growth regulators2. “Natural” smelling repellents are preferred because plants are perceived as a safe and trusted means of mosquito bite prevention3.
So Cotton is the natural vegetable fiber of great economic importance as a raw material for cloth. It is the oldest and the most important fabric. It has been used for apparel purpose since centuries and known as white gold or the king of fabric. Cotton fiber is the background of the world textile these fibers are mainly known for its strength, high absorbency and good wearing qualities. Other features like excellent launder ability easy finish ability and good pliability in cotton fabric make it easy to produce a variety of organic mosquito repellent fabric.

2. Materials and Methods
2.1 Selection of fabric
Based on the properties like absorbency, bio-degradable, non toxic, high strength, non allergic, cool and softness. 100 percent cotton was obtained from Kanpur, U.P (India).

2.2 Selection of sources
Natural finishes have many advantages such as non- toxic, biodegradable, cost effective and availability. Orange peel *(Citrus sinensis)* was selected as a mosquito repellent agent.

2.3 Medium of dye extraction
Sweet lime peel was extracted in methanol medium and it was evaluated on the basis of optical density.

Fig 1: Dried and ground sweet lime peel

2.4 Selection of mordant
This natural finishing agent could not adhere into the fabric directly and require binder. The easily available source like citric acid was selected as a binder.

2.5 Optimization of Sweet lime peel mosquito repellent variable
A series of optimization of concentration of organic mosquito repellents, optimization of concentration of organic mosquito repellent extracts, Optimization of padding time. These variables were optimized based on optical density of the concentration mosquito repellent.

2.6 Method of Mordanting of orange peel mosquito repellent
Mordanting was carried out by using post mordanting. It was selected for mosquito repellency test and wash durability.

2.7 Preparation of final sample
Final samples were prepared from the selected mosquito repellent sources with orange peel mosquito repellent. Condition and optimized concentration of mordants and methods of mordanting. These samples were tested for the bending length, tensile strength, thickness, and crease recovery angle. Each sample was then evaluated for mosquito repellent finish test and wash durability test.

3. Results and Discussion
Mosquito repellent medium of methanol extract was selected as the best for Sweet lime peel. Optimizations of sweet lime peel concentration in methanol, mosquito repellent extract concentration time and padding time. In order to record optical density of organic mosquito repellent sources λmax of sweet lime peel was fixed 765 nm. density of five different concentrations i.e.; 25, 30, 35,40 and 45 per cent of Sweet lime peel powder was recorded at 765nm λ_{max} (Table.1).Optical density of 40g sweet lime peel powder in 100 ml of methanol gave highest value (0.93), therefore selected as optimum.

Table 1: Optical density of different concentrations of sweet lime peel mosquito repellent

S. No.	Sample code	Concentration (%)	$(\lambda)_{max\ (nm)}$	Optical density
1.	S.L. 1	25	765	0.78
2.	S.L.2	30		0.38
3.	S.L.3	35		0.85
4.	S.L.4 *	40 *		0.93*
5.	S.L.5	45		0.85

S.L. - Sweet Lime

3.1 Standardization of concentration of Sweet lime peel mosquito repellent extracts
Mosquito repellency of different concentration of extract of Sweet lime peel is presented in table.2. Sweet lime peel extract was taken in 40, 50 and 60 per cent. Data depicts that on increasing concentration from 40 to 60 per cent mosquito repellency also increases from 10 per cent to 80 per cent, therefore 60 per cent extract concentration of Sweet lime peel organic mosquito repellent was standardized for finishing of cotton fabric.

Table 2: Mosquito repellency of finished sample with sweet lime peel extract

Organic Mosquito Repellent	Optimized conc.	Extract conc. (%)	Padding time (minutes)	Mosquito repellency (%)
S.L.	40%	40	60	10
			90	20
			120	30
		50	60	40
			90	50
			120	60
		60*	60	70
			90*	80*
			120	80

S.L. - sweet lime

3.2 Standardization of padding time
Results are shown in table. 2. Data indicates that mosquito repellency of sweet lime peel samples increases with increasing time from 60 minutes to 120 minutes. Samples padded for 120 minutes with 60 per cent extract concentration showed 80 per cent mosquito repellency, therefore this time was selected for finishing of sweet lime peel samples.

3.3 Standardization of variables for after treatment of finished samples
Cotton samples were finished with standardized concentration of organic mosquito repellent extract of Sweet lime peel for optimized time**.** These samples were given after treatment with different concentration of citric acid for different time.

3.4 Standardization of concentration of citric acid and time

Wash durability and mosquito repellency of finished samples mordanted with 5 to 10 per cent concentration of citric acid for 30, 60, 90 minutes were checked side by side and result are shown in table 3.

Samples finished with orange peel mosquito repellent extract were also given after treatment with 5, 10 and 15 per cent concentration of citric acid for 30, 60 and 90 minutes and finding are presented in table 3. Results clearly reveals that mosquito repellency and wash durability after each laundering improves with increase of concentration from 5 to 10 per cent but decreased on furthers increasing of concentration from 10 to 15 per cent; therefore 10 per cent concentration of citric acid was finalized for after treatment of sweet lime peel samples. Wash durability of samples improves with increase of concentration of citric acid from 5 to 10 per cent after each laundering whereas it started decreasing with further increase in concentration of mordant from 10 to 15 per cent therefore 10 per cent concentration of citric acid was finalized for mordanting of samples finished with sweet lime peel extract.

Table 3: Mosquito repellency of mordanted finished samples with sweet lime peel after laundering

S. No.	S.c.	Ext. Conc.	Padding time	Mordt. Conc.	Time of after treatment	Mosquito Repellency (%)									
						1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1	S.L.	60%	90 MINS	5%	30MIN	40	30	20	10	5	-	-	-	-	-
					60 MIN	50	45	40	20	10	-	-	-	-	-
					90 MIN	55	50	45	25	15	-	-	-	-	-
				10%*	30MIN	70	70	60	50	20	10	-	-	-	-
					60 MIN	75	70	65	40	30	10	-	-	-	-
					90 MIN*	80	80	75	60	40	20	-	-	-	-
				15%	30MIN	60	40	30	20	10	5	-	-	-	-
					60 MIN	40	35	25	15	10	5	-	-	-	-
					90 MIN	40	30	20	10	5	-	-	-	-	-

3.5 Standardization of time for after treatment

Time for after treatment of finishing of samples with different sweet lime peel mosquito repellent i.e. sweet lime peel. Data (Table 3) reveals that after treatment for 90 minutes with 10 per cent concentration of citric acid produces best results hence this treatment optimized for mordanting of sweet lime peel samples. Mosquito repellency samples was checked after each laundering and observed that mosquito repellency decreases on increasing the time of after treatment from 30 to 90 minutes with 5 per cent and 10 per cent concentration of citric acid while it showed decreasing in trend with 15 per cent concentration. Mosquito repellency and washing durability upto 6^{th} laundering increases for after treatment from 30 to 90 minutes for 5 per cent concentration whereas mosquito repellency decreases with 15 per cent concentration on increasing time. Mosquito repellency of 15 per cent was observed upto 6^{th} laundering in samples treated for 90 minutes time with 10 per cent citric acid, therefore this time was optimized for mordanting of sweet lime peel samples.

3.6 Standardized Finishing Recipes

Recipes of organic mosquito repellent sweet lime peel for finishing of cotton fabric with standardized condition were given in (table 4) from the data it is clear that methanol extraction of 40 per cent of sweet lime peel powder was done and sample was padded with 60 per cent sweet lime peel extract concentration for 90 minutes. This sample was then dried at 90 °C for 5 minutes in hot air oven. After that finished sample was given after treatment with 10 per cent citric acid for 90 minutes and cured for 2 minutes at 120°C temperature. Findings clearly depicts that drying temperature and time were kept same for sweet lime peel organic mosquito repellent sources concentration of citric acid for after treatment of sample was also same and all sample were cured at same time and temperature. It was observed that wash durability and mosquito repellency was decreased in sample on increasing the concentration of citric acid.

Table 4: Standardized finishing condition for orange peel mosquito repellent finish for cotton fabric

S. No.	Organic mosquito repellents	Conc. Of o.m.r.	Extract Conc.	Padding time	Dry temp. & time	Curing conc.	After treatment	Curing temp. &time
1.	Untreated Cotton fabric	-	-	90 mins	90.C for 5 mins	-	60 mins	120° for 2 mins
2.	Sweet lime peel	40%	60%	90 mins	90°C for 5 mins	10%	90 mins	120° for 2 mins

4. Conclusion

The results proved that the selected natural mosquito repellent sweet lime peel was suitable for Mosquito repellent and fragrance finishing on Cotton fabric. The herbal finished fabric showed excellent repellency of mosquitoes. It protects the human beings from the bite of mosquito and there by promising safety from mosquito vector diseases and it is eco friendly, bio-degradable, non toxic, non irritant to the skin and low cost for vector control and can be used with minimum care. It shows good repellent property when applied on cotton fabric. It can be successfully utilized in apparels (night wear and accessories), mosquito net, window curtain and other home furnishings.

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