RESEARCH PAPER

Cotton based Fragrance Packet for Well-being Applications

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Abstract

A well-being fragrance packet based on cellulosic fibres has been developed. This pack contains three layers of cotton nonwoven (250 gram per square meter) as core material. Optimized quantity of natural essential oil (citronella oil) based fragrance has been incorporated in the middle non-woven layer of the cotton. Paper sheet having 2300mL/min permeability has been used as sheath material. Volatile active species of the essential oil infused in the cotton non-woven, slowly diffuse through the upper and lower non-woven layers in the surrounding atmosphere through the pores of the paper sheath material. As per feedback from users, fragrance released from the packet is satisfactory up to seven days in the 25-30 square feet area. Aroma released from the packet was also found to repel mosquitoes. Standard cone test showed that the smell release from the pack was sufficient to repel mosquitoes (100%) up to three days after opening the pack.

Keywords : Cellulose fibre, Fragrance, Essential oil, Mosquito repellency, sheath and core material

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Introduction

Scientific research has shown the positive effect of pleasant smell on creating good mood and positive mental function (Leffingwell, 2003). It makes the human beings feel better and relaxed, reduces the brain stress level and rejuvenates the body and its positive effect on concentration, memory, pain, mood, anxiety, sleep disorder etc. have been documented by Warrenburg (2005). Some fragrances ease migraine and headaches and assist to sleep. Overall pleasant smells have certain well-being effect on human beings and it is beneficial to incorporate these in places used in our day to day life such as living room, car, office, bed room, washroom etc. In the market, various synthetic essential oil based (lavender, jasmine etc.,) fragrance packets are available for the pleasant smell (Sowndhararajan and Kim, 2016). A reputed company has marketed the fragrance pouch containing synthetic fragrance trapped inside a gel in a paper packet. Another company has marketed a fragrance pouch in which fragrance infused powdered material is kept inside a porous polypropylene packet. Some research groups have tried to use activated charcoal granules, talc material etc. to entrap the fragrance for slow release action. Most of the packs are made with synthetic material and synthetic aroma oil and are not easily bio-degradable. Till date, very little work has been reported on the sustainable fragrance technology which is durable for longer time period. Researchers have tried to explore newer biomaterials and methods for extraction of flavours and fragrances. Extraction of bio-flavours and fragrances *via* fungi and their enzymes has been reported by Vandamme (2003). Vandamme and Soetaert (2002) have used fermentation and biocatalysis technology for extraction of fragrance and flavor from the biomaterials. Vankar (2004) has compiled a good review on the extraction of essential oils and fragrance from various natural resources. Various researchers have attempted to prepare aroma textiles by applying natural essential oil based fragrances to textiles by finishing to provide soothing pleasant smell to users with varied durability. Singh *et al.*, (2017) reported a method for sustainable fragrance and antimicrobial finishing of cotton fabric by using natural lavender oil. The treated fabric showed fragrance for three days. Thilagavathi and Kannaian (2010) could get up to 10 days durability of geranium oil based fragrance on cotton textiles by micro-encapsulation technique. However, according to the reported documentation, till date no cellulosic fibre based fragrance packet for use in living spaces is available in the market where cotton fibres will assist in slow release of fragrance.

On the other hand, dealing with mosquito menace is an important concern of our society. Every year many people in our country die because of the deadly diseases like Malaria, Dengue, yellow fever, Japanese B encephalitis, etc. caused by mosquito bites. According to the UNICEF reports, every year around 1200 children die worldwide due to mosquito bites (Raja *et al*., 2015). Due to the rapid urbanization, climate change and other important factors, ill effects of the mosquito bites are increasing day by day. Different types of synthetic lotions, coils, synthetic oils and insecticide coated mosquito nets have emerged in the commercial market for getting mosquito repellency. These protect the human beings from mosquito bites and save many lives from deadly diseases. Therefore, mosquito repellent action is also an important well-being aspect of our society. However, most of the synthetic products used for mosquito repellency are harmful to human beings in terms of causing irritation, breathing problems, etc. Moreover, some of them are effective against mosquitoes only for few hours as reported by Naseem *et al*., (2016). Most of the products available in the market as mosquito repellent need burning (mat, coil, agarbatti, etc.,) and repellency gets hampered after few hours. Apart from it, some popular companies have marketed spray, body lotions, etc. which require direct skin contact which may cause skin rashes, breathing problem, allergies, etc., Since past one decade, researchers have used different plant based extract like lemongrass, tulsi, peppermint, lavender, neem, etc., for making mosquito repellent textile products as reported by Samanta and Basak (2014), Samanta and Basak, (2017) and Basak *et al*. (2018). However, in most cases, mosquito repellent effect lasted only for few hours and intense irritating pungent smell came out from the product. Therefore, mosquito repellent action by soothing, non-irritant pleasant smell is an important concern for the researchers of this field. As discussed in this section, both the functionalities (pleasant fragrance and mosquito repellence) have well-being effect on the human society. However, till date no literature has been reported on the preparation of cotton or other natural fibre based well-being pouch capable to deliver pleasant fragrance and also repel mosquitoes for a few days.

In the present study, natural fibre based well-being packet has been prepared. Cotton based core material, paper based sheath material and citronella essential oil has been explored for making the well-being pack. Mosquito repellency and the fragrance release behavior of the pack have been measured qualitatively and quantitatively by using various techniques.

Materials and Methods

Material

Non-woven cotton material 250 gsm and standard punching density (40 needles/sq. inch) was prepared at SASMIRA (Synthetic and Art Silk Mills' Research Association), Mumbai, India. In addition jute and paper material (GSM 200) were also collected for experiment. Citronella essential oil was purchased from the local market of Mumbai, India. Handmade papers from the porosity range 700-2500mL/min and gm/m^2 range from 140-160 were collected from ICAR-CIRCOT, Mumbai and also from the local market and used for the experiment. Plastic coated aluminium foil was also purchased from the market for packing.

Experimental Methods

Three layers of non-woven were used as core material or as essential oil holding material in the core. Citronella based natural essential oil was incorporated uniformly in the middle cotton non-woven layer by using micro pipette. Thereafter, oil infused non-woven fabric was guarded with other non-woven layers (same specification) on up and down side. Henceforth, the total sponge like non-woven arrangement was packed inside the natural fibre made handmade paper as shown in **Fig 1.** In the total arrangement, cotton non-woven has acted as core material and the handmade paper of different porosity has acted as sheath material. Thereafter, packet was packed in aluminium foil and labeled with proper technical parameters of the pack. The technical steps involved in well-being pack preparation, has been represented in **Fig 1.**

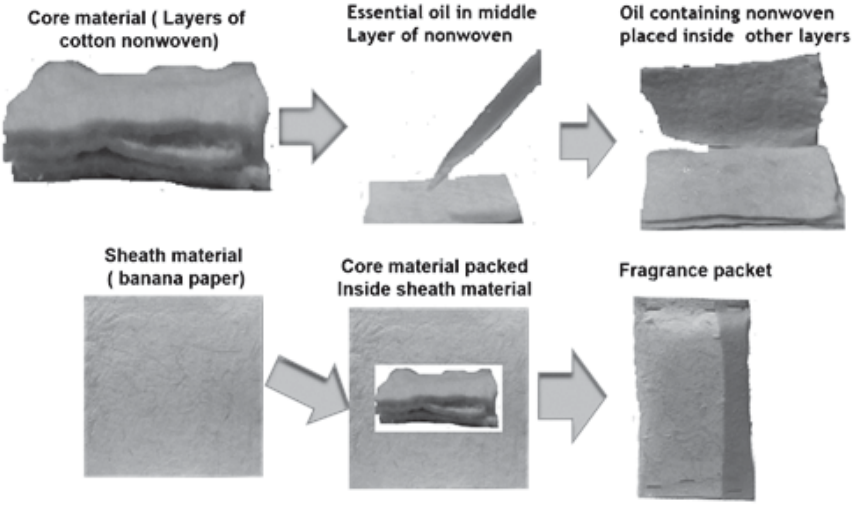

Fig. 1: Technical steps for the preparation of cellulosic fibre based well-being material

Characterization methods

Porosity and thickness of the sheath and core material

Porosity of the sheath and core materials was examined in smoothness and porosity tester (BENDTSEN, Universal, Saharanpur, India). Thickness of the sheath and core material was examined in thickness tester (Universal Engg, Saharanpur, India).

Air permeability analysis

Air permeability of the sheath materials was examined by using Kawabata KES-F8-AP1. It gives the results of resistivity, permeability and porosity of the material.

Mosquito repellency test

A test chamber measuring 20cmsx20cms with flip opening for release of mosquitoes was used for the experiment. The test chamber was connected to another escape chamber for mosquitoes to escape. A window having a diameter of 6 cm was provided for escaping of the mosquitoes. Fragrance packet was kept inside the chamber at the time of evaluating repellency.

Subjective evaluation of the efficacy

Natural fibre based fragrance packs were distributed to various persons and information about the effective duration for fragrance release, mosquito repellency and other technical observation parameters was obtained from them.

Results and Discussion

Optimization of Core material

Two different types of grey cotton non-woven, a jute non-woven and a paper board material were used as core material (three layers of each material) of the fragrance pack as represented in **Fig. 2.** Size of all core materials was maintained constant (9cmx6cm) for testing. Physical specifications (porosity, weightage and thickness) of the mentioned materials are presented in **Table 1.** As per earlier discussion, core material was used to hold the essential oil and release the active ingredients of the fragrance in controlled manner. 4 mL of essential oil was incorporated uniformly in all the afore-selected core materials. From the experimental analysis, it was observed that jute non-woven was not capable to hold the oil and most of the oil incorporated in it had leached out and made an "oil mark" or impression on the outer sheath material. This "oil impression" is not desirable in terms of end use and attractiveness of the pack. Moreover, this phenomenon also reduces the life time of the fragrance pack. On the other hand, paper pad material being thick, hard and having more material was capable of absorbing more oil molecules. However, the main disadvantage was that the concerned material was not releasing the fragrance in normal conditions. Indeed, most of the active ingredients had got trapped inside the paper pad. Some heating arrangement might be needed to release the fragrance form it. Out of the two types of cotton non-woven materials tested, it was observed that low thickness cotton non-woven material has satisfactory slow release property but the material was not sufficient to absorb 4 mL oil as some part of it came out and made "oil impression" on the sheath material. However, cotton non-woven B of weight 250 gsm, thickness 0.12cm and porosity level 2200mL/min showed good result in terms of oil holding and the concerned material was also capable of releasing fragrance in the surroundings. It means that at a time it has both oil absorbing and fragrance releasing capability. Thus cotton nonwoven B was selected for the further experiments.

Table 1: Physical specifications of the experimental core materials

Materials used	Porosity (mL/min)	Weightage (gm/m^2)	Thickness (cm)	Observations after testing
Jute non-woven	3000	350	0.22	Half of the oil had leached onto the outside sheath material
Cotton non-woven A	2200	175	0.09	Oil leaching onto the outside sheath material
Cotton non-woven B	2200	250	0.12	Satisfactory and no leaching problem
Paper pad	2000	155	0.17	Absorbed oil but did not release fragrance in surroundings

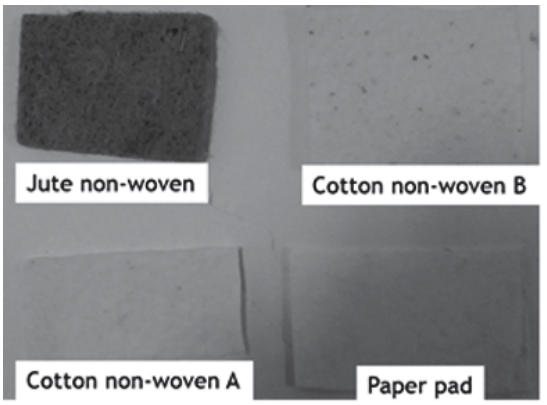

Fig. 2 : Core materials used for the experiment

Optimization of the sheath material

Different natural cellulosic paper materials of 140-160 GSM (differing in porosity and thickness) as shown in **Fig. 3** were explored to prepare the sheath material for the fragrance packet. Physical specifications of these materials have been presented in **Table 2.** In these experimental trials core materials remained exactly same (cotton non-woven B) and in all cases, 4 ml oil was used as in earlier experiments on optimization of core material. As per observations on fragrance release, paper material having porosity of 2000 ml/min or more provided satisfactory diffusion of fragrance in the surroundings. It is known from the manufacturing process of the paper that porosity of the paper depends on the length of the fibre used for paper making. If the length of the fibre is more than the porosity of the paper is also more. Therefore, depending on the porosity level, sheath material was finalized and further experimentation was performed.

The packs made of different sheath materials were further sealed in plastic coated aluminium foil to stop fragrance loss before use and were given to various persons for evaluation of fragrance release performance and its duration.

Table 2: Physical specifications of the sheath material

Materials used	Porosity (mL/min)	Resistivity [R] (KPa S/m)	Permeability (1/R) m/ KPa S	Observations on fragrance release
A (white handmade paper)	1500	20.63	0.05	Smell entrapped inside the pack
B (pink blotting paper)	2000	9.97	0.10	Slow diffusion
C (white handmade paper)	2300	4.20	0.24	Satisfactory diffusion and no leaching problem
D (blue blotting paper)	2500	6.41	0.16	Satisfactory diffusion

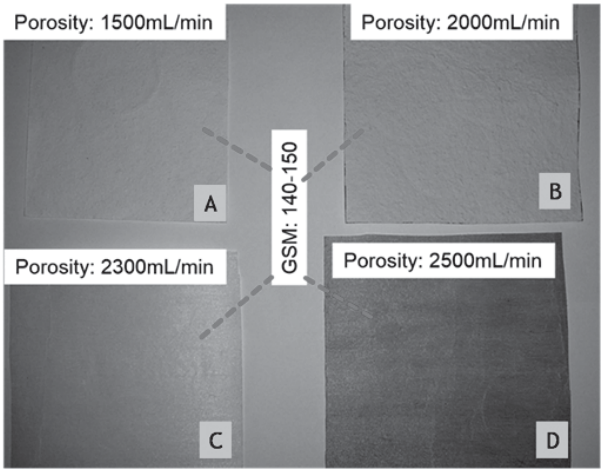

Fig. 3 : Sheath materials of different porosity used for the experiment

The above four different kinds of papers of varying porosity and a newspaper material having low porosity were used as sheath material and user feedback on their performance for fragrance release over time was obtained and has been reported in **Table 3.** Due to varying porosity level, diffusion flow rate of the each sheath material was different. Diffusion flow rate is the amount of fragrance material diffused through the pack per unit time and is directly proportional to the net difference of the concentration of the fragrance inside and outside the packet. Depending on the feedback report, diffusion flow rate of the sheath material having porosity of 2000mL/min or more was satisfactory to enable fragrance release. Fragrance pack made with sheath materials like newspaper (porosity: 700mL/min) or white handmade paper (porosity: 1500mL/min) was not capable to diffuse the fragrance from the pack at satisfactory level. Indeed, fragrance got trapped inside the packet. It means diffusion flow rates of the sheath materials having porosity range lower than 2000mL/min are less. On the other hand, sheath material made with pink blotting paper was adequate in terms of porosity. However, grammage was more which interrupted diffusion of fragrance. White handmade paper (C) had higher porosity and lower grammage hence showed good diffusion of fragrance. Blue colour blotting paper had more porosity and the diffusion flow rate was also higher compared to the pink blotting paper. As a result, life time of the pack was less and the end users felt irritated with the intense fragrance of citronella.

Table 3: Feedback report of the fragrance pack made of citronella essential oil

Paper used for sheath material [core material same for all packs]	Porosity level (mL/min)/ grammage/ thickness	Feedback parameters		
		Area covered by fragrance	Durability of fragrance observed	No. of days after which fragrance could not be observed
Newspaper	700/ 100/ 0.02	Low diffusion flow rate	Fragrance trapped inside the packet	-
White handmade paper (A)	1500/ 140/0.04	10 sq feet area cover	Slow diffusion of fragrance in the surroundings	-
Pink blotting paper (B)	2000/160/0.11	25-30 sq feet area	Satisfactory level of diffusion	60
White paper (C)	2300/140/0.04	25-30 sq feet area	Good diffusion	40
Blue blotting paper (D)	2500/ 140/ 0.04	30 sq feet area	Rapid diffusion and irritating smell	30

Note: *Each Result is the average of ten feed-back reports*

Mosquito repellency test of the fragrance pack

The prepared natural fibre based fragrance pack was also capable to repel mosquitoes. As per earlier mentioned procedure, natural fibre based fragrance pack was opened and kept in the test chamber and approximately 50 nos. of mosquitoes were released at a time. Periodically, observations were made on death/ migration of the mosquitoes to the untreated chamber. Observations were made initially, and then after ten minutes and half an hour to see if there was any long standing effect on mosquitoes in terms of moving away/ death etc. Test was repeated two times for constant observation. For knowing the longevity and the effectiveness of the prepared pack, the fragrance pack was kept open and the concerned test was conducted on day 3 and day 5 of opening the pack. Detailed test report has been represented in **Table 4.** It was observed that the concerned pack is 100% effective against mosquitoes up to 3 days. Then the repellency effect has decreased a little and at the end of 5 days, it showed 90% repellency. As per literature, mosquitoes search for carbon dioxide, lactic acid scents. Actually, active ingredients present in the citronella oil (geraniol, citronellal) coming out from the pack as fragrance may mask the smell of carbon di oxide and lactic acid in the surroundings. As the intensity of fragrance release gradually comes down after a few days, its effectiveness in repelling mosquitoes also comes down.

Table 4: Mosquito repellent behavior of the natural fibre based fragrance pack

Sample parameters	No. of mosquitoes released in treated chamber	No. of mosquitoes escaping to nest chamber	No. of mosquitoes dead/ unable to fly	Percentage mosquito repellency
After opening (10 minutes)	50	50	00	100%
After opening (30 minutes)	50	50	00	100%
3 days after opening (10 minutes)	50	50	00	100%
3 days after opening (30 minutes)	50	50	00	100%
5 days after opening (10 minutes)	50	38	00	90%
5 days after opening (30 minutes)	50	45	00	90%

Conclusion

Fragrance pack has been prepared by using cotton nonwoven, paper and natural citronella essential oil which is totally eco-friendly and easily biodegradable. The product is suitable to provide rejuvenating and refreshing fragrance up to seven to eight days (using 24 h everyday) in its surrounding atmosphere, after opening the package. Moreover, the concerned fragrance pack can also repel mosquitoes up to four to five days. Grey cotton nonwoven acts as physical barrier for quick leaching of fragrance from the pack and the fatty and waxy matter, pectin, etc. present in the grey cotton assist to hold the hydrophobic essential oil and slowly release it in the surroundings. Prepared product may be effectively used in office, washroom, bed room, living room, car, etc. It may also be equally useful to remove the bad smells if placed in wardrobes, cupboards, drawers, travel bags, etc.

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Cotton Facts: Physiology (ICAC, 2003)

Photorespiration: The cotton plant releases a considerable amount of CO_2 during the photosynthesis process, a phenomenon known as *photorespiration.* Plants that photorespire belong to the group called C_3 plants. Photorespiration, which is virtually absent in C_4 plants, confers little or no benefit to the cotton plant. The rate of oxidation of photosynthetic products by photorespiration is about five times the rate of dark respiration. The respiration rate depends on temperature. High yielding cotton varieties have a lower rate of photorespiration than the less productive varieties. It is estimated that the cotton plant can lose about 30% of its assimilated carbon in photorespiration.

Cutout: In cotton, vegetative and reproductive phases can go side by side: a plant grows and forms bolls at the same time during most of its life. Cutout is the cessation of vegetative growth and fruit formation. *Cutout* is a stage determined by the cessation of growth due to the development of boll load sink and the resulting demand for available nutrients and photosynthate resources.

Cutout can be physiological, a stage beyond which no more productive bolls will be formed; or seasonal, a natural cutout; and premature. Premature cutout, which can happen due to stress, i.e., drought, pest damage, etc., can be corrected to put the plant into a productive stage again.

Why does cutout occur? A complete change from the vegetative to the reproductive phase occurs when the rate of dry matter accumulation equals the growth rate of the crop. At this stage, all photosynthates are channeled toward the existing bolls and new fruit forms are shed.

Cutout in cotton is always temporary. The cotton plant has the potential to get out of all kind of stress, terminate the cutout and start its regrowth and fruit formation again.