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Development of Eco-Friendly Sanitary Napkins using Sansevieria trifasciata Fibres coated with Rosa damascena Extracts

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Abstract

The present paper highlights the issue of non biodegradability of commercial sanitary pads and importance of using Sansevieria trifasciata plant fibres as biodegradable and eco friendly absorbent core in sanitary napkin. Commercial pads are non biodegradable causing accumulation of menstrual waste and degradation of environment. A study estimated that on an average 335 million menstruating women dispose 432 million pads every month. These sanitary pads are non-biodegradable and remain in the landfills for about 800 years. Wood pulp is the major raw material which is used as absorbent core in feminine hygienic product. But over usage of these natural resources will lead to deforestation. Commercial sanitary napkins contain chemicals which affects the health status of women. The best alternative for these synthetic materials are agricultural and plant based fibers as they are abundant, non toxic, environmental friendly and bio degradable. The purpose of the research work focuses on preliminary testing of Sansavieria trifasciata plant fibers to develop sanitary napkin with antimicrobial finishes. Sansevieria trifasciata fibers were extracted from the leaves of the plant which was subjected to pre-treatment such as scouring and bleaching to enhance the absorption property of fibers. Microencapsulation with Rosa damascena extract was applied to impart antimicrobial function to fibers. The present research work concludes that the microencapsulation of Sansevieria trifasciata fibers possess antimicrobial properties against different microorganisms such as Escherichia coli, Pseudomonas sp. and Candida sp. Thus Sansevieria trifasciata plant fibers could be an ideal substitute for absorbent core used in sanitary pads.

Keywords: **Microencapsulation, plant fibres, *Rosa damascena, Sansevieria trifasciata*, sanitary napkin.**

1. Introduction

Menstruation is a physiological phenomenon of regular discharge of blood and mucosal tissue (menses) from the lining of uterus through the vagina at an interval of 28 to 35 days from puberty till menopause. Absorbent materials called sanitary napkin is used to absorb the menstrual discharge (Anuradha *et al*, 2017). The primary requirement of feminine hygiene product are absorbency, odour free, stop leakages, retention of menstrual fluid, aesthetic appearance, stay in place , and provide with a feel of comfort and enhance every women's health and lifestyle (Dhinakaran *et al*, 2017). Materials used in sanitary pads are derived from natural sources such as petroleum based which cannot be reused or compost and over exploitation of these resources need to be stopped as nothing will be left for future generation (Barman *et al*, 2017). The major raw material in the absorbent core of feminine hygiene products are wood pulp. But over usage of wood pulps from natural resources such as trees leads to deforestation and adverse environmental effects (Dhinakaran *et al*, 2017). Sanitary napkins generally comprise multilayer structure with top sheet, absorbent core and bottom sheet each with specific functions to perform. The absorbent core material is made up of Super Absorbent Polymer which is known to cause skin irritation and toxic shock syndrome and cancer. The fluff pulp of the absorbent core consists of dioxins which are toxic and environmental persistent organic pollutants (Jihyun bae *et al*., 2018). Plant fibres possess desirable properties and an ideal substitute for conventional wood pulp and can be harnessed into sanitary pad making. These plant fibres are environmentally friendly compared to the commercial sanitary pads since they contain fewer chemicals. Sanitary napkins have been already developed from natural fibres such as banana fibres, jute fibres, water hyacinth fibres, bagasse pulp (Bhawana, 2016). Plant fibers are obtained from leaves, stems and seeds and are classified into hard fiber obtained from hardened wood core and soft fiber obtained from stem or bast portion of plant called bast fibre. Natural plant fibres such as coir, cotton, banana, hemp, sisal, jute, bamboo, kenaf, flax are more environmental friendly than synthetic fibres in terms of low cost, abundance, renewability and biodegradability (Ragoubi *et al*, 2010). Bio fibres are agro-based fibres which finds application in composite, biofuels, textile, pulp and paper manufacture because of their properties, structure and composition. Major sources of agro-based bio fibres include sugarcane, banana, pineapple, corn, wheat, sorghum, barely and coconut (Michelin *et al*, 2015). Length, strength, elasticity, pliability, absorbency, abrasion resistance and various surface properties of the fibres can be exploited for commercial purposes.The major constituents of plant fibres include alpha cellulose, hemicelluloses and lignin. High content of alpha cellulose and low content of lignin of the plant fibres are necessary properties for its textile application (Das *et al*, 2010).[1-8] The water absorption behaviour of plant fibres are due to the presence of polar groups present in cellulose, hemicelluloses, pectin and lignin (Celino *et al*, 2013). *Sansevieria trifasciata* also called Snake Plant is a perennial tropical plant native to India, Africa and Indonesia. Leaves are yellow or dark green in color ranging between 70-90 cm long and 5-6 cm wide. *Sansevieria* plants are known to act as good purifiers by removing various toxins such as formaldehyde, toluene, xylene from the air and converts CO_2 into O_2 at night time (Rita *et al*, 2013). Fibers of the *Sansevieria* plants are used for making bowstrings because of the strong, flexible and durable property of the fibres. These fibres also find application in making ropes, fishing lines and fishnets. The lignocelluloses content of *Sansevieria trifasciata* plant fibres consists of 56% cellulose, 34% hemicelluloses and 6% lignin (Mardiyati *et al*., 2016). Due to the high content of cellulose and low content of lignin, *Sansevieria* fibres finds potential application to be used as absorbent core in the sanitary napkins. Garments which are in direct contact with the body offer an ideal environment for microorganisms to grow. Antimicrobial finish on textiles prevents these microorganisms causing diseases to the humans. There are many natural products which harbour various antimicrobial properties in their leaves, stem, seeds, and flowers. Microencapsulation is one of the novel method and more advantageous when compared to conventional method of applying antimicrobial finish on textiles (Sathianarayanan *et al*, 2009). Direct exposure of the skin to sanitary pads result in the growth of microorganisms and the skin is prone to microbial infestation. Sanitary napkins need to have antimicrobial activity to avoid infections (Voyich *et al*, 2005). [9-16]*Rosa damascena* is an important species belongs to Rosaceae family flowers. It is an ornamental plant with several pharmacological properties besides perfuming effect. Various pharmacological properties include anti-HIV, antibacterial, antioxidant, antitussive, hypnotic, ant diabetic and relaxant effect on tracheal chains (Mohammad Hossein *et al*, 2011). Decoction of flowers is used for treatment of abdominal pains, chest pains, menstrual bleeding and digestive ailments. Rose water used as antiseptic agent for eye washing and mouth disinfectant. Rose petals cooked with sugar or honey is used for cooling the mind and body in Iranian traditional medicine (Mohaddese, 2016). The present work is aimed to test the effectiveness of *Sansevieria trifasciata* fibres to develop eco friendly sanitary napkins with antimicrobial finish on them. There is a great necessity to develop natural and sustainable raw material for sanitary napkins with antimicrobial function to enhance the health and hygiene status of women and to safeguard the Mother Nature. In this study fibres were pre-treated to enhance the absorption property. Herbal finishing was given to the fibre to impart antimicrobial function to the fibres. *Rosa* *damascena* plant extract was applied to the fibres by microencapsulation techniques.[17-27].

2.Materials And Method

2.1Collection of Sansevieria trifasciata plant

The leaves of the *Sansevieria trifasciata* plants were collected from in and around areas of Vadavalli region, Coimbatore, Tamil Nadu. The soil sample was collected from the house garden with the help of a clean spatula in a clean dry polythene bag.(Fig 1)

Fig.1 Sansevieria trifasciata plant leaves

2.2 Primary isolation of soil organisms

One gram of soil sample was dispensed into 100 ml of sterile water in a conical flask. Serial dilution was performed and plated onto nutrient agar by spread plate technique to get isolated colonies. The plates were incubated at 37^0C for 24 hours. The isolated colonies were subjected to further study.

2.3 Examination of isolates

The organism from the soil sample was identified by following the standard method (Cappuccino manual, 1983).

2.4 Fiber extraction of Sansevieria trifasciata plant by water retting method

The fibres were extracted from the leaves of *Sansevieria trifasciata* plant by water retting method. The leaves were immersed in water and a loop full of inoculums isolated from the soil sample was added into the retting tank. It was left for 10-15 days during which the microbial degradation of leaves takes place. The extracted fibres were thoroughly washed with running water to remove the impurities adhering to the fibres. The fibres were then dried in sunlight for 5-7 hours to remove the moisture. (Rita *et al*, 2013; Mohammad Myser Ali, 1957)

2.5 Pre-treatment of fibers

2.5.1 Scouring of plant fibers

*Sansevieria trifasciata*fibers were treated with Sodium hydroxide solution with ratio 1:200 to enhance fiber texture and luster. 5 grams of fiber was treated with various concentration of NaOH (1%, 3%, 5%, and 10%) and boiled in 100ºC for 2 hours. The treated fibers were then filtered and washed with distilled water and dried in room temperature.(Mardiyati *et al*, 2015)

2.5.2 Bleaching of plant fibers

10 grams of plant fiber were treated with different concentration of hydrogen peroxide (0.3%, 0.4%, 0.5%, 0.6%, and 0.7%) for 1 hour. Hydrogen peroxide removes the natural coloring matter from the substrate. (Harizi*et al., 2013*)

2.6 Water absorption test for *Sansevieria trifasciata* fibres

The fibres were cut into small pieces and soaked inside the beaker containing 30 ml of water for 5 minutes. The time of the fiber being immersed is recorded with the help of a stop watch. After 5 minutes the fibers were taken with the help of a tweezers. The remaining water present in the beaker is measured using glass measuring jar. The amount of water absorbed by the fiber was calculated by subtracting the remaining amount of water present in the beaker from 30 ml. The same process was carried out after pretreatment of fibres to know the efficiency of scouring and bleaching processes in enhancing the water absorption property of fibres. (Raji lal, 2012)

2.7 Antimicrobial finish on Sansevieria trifasciata plant fibers

2.7.1 Preparation of herbal extract

Rosa damascena flowers were collected from the garden area. The petals were removed from the flower and shadow dried and ground into fine powder. The powder was then mixed with aqueous solution at room temperature in the ratio of 1:5 for 3 days. After 3 days the aqueous extract was filtered and the solution is extracted. (Anuradha *et al*, 2017)

2.7.2 Microencapsulation of *Sansevieria trifasciata* plant fibers with Rosa damascena flower extract

In microencapsulation method, the prolonged bioactivity is observed due to the slow diffusion of antimicrobial agent out of the polymer. Herbal extract was used as core material and gum acacia as wall material. In 100 ml of hot water, 10 grams of acacia powder was added and allowed to swell for 15 min. 50 ml of hot water was added to this mixture and stirred for 15 minutes maintaining the temperature between 40^0C and 50^0C. One and half gram of herbal extract as core material was slowly added. Stirring process was continued for a period of another 15 minutes and 10 ml of 20% sodium sulphate and 6 gram of citric acid was added. Microcapsules were developed by freeze drying the mixture in a freezer. The fibres were then immersed in the microcapsule solution and dried at 80^0C for 5 minutes. (Sathianarayanan *et al*, 2009)

2.7.3 Antimicrobial activity test

Antimicrobial activity of the microencapsulated fibres was carried out using agar diffusion test. Test was carried out against gram positive bacteria (*Staphylococcus*sp,), gram negative bacteria (*E.coli*, *pseudomonas*sp,), and Fungi (*Candida* sp,). Microencapsulated fibers were placed on the agar plate with test bacteria and incubated for 24 h at 37^0C. After incubation the zone of inhibition was measured. (Anuradha *et al*, 2017)

3 Results and Discussion

3.1 Examination of isolates

By following the standard protocol of Cappuccino manual, the isolated colony obtained was identified as Bacillus sp.

Results of biochemical tests were shown in table 1

Table.1. Biochemical test results of isolated colony

Biochemical tests	Results
Indole	-
Methyl Red	-
VogesProskaeur	+
Citrate	+
Oxidase	-
Catalase	+
Gelatin	+
Urease	-

(+)= Positive(-) = Negative

The isolated colony showed positive result for Voges proskaver, Citrate, Catalase and gelatin test. The colony showed negative result for Indole, Methyl red, Oxidase and Urease test.

3.2 Fiber extraction of *Sansevieria trifasciata* plant

After the retting period, the fibres were removed from the leaves and washed in running water and dried. Long white uniform fibres were obtained. Water penetrates to the central stalk portion and swells the inner cells and bursts the outermost layer. This increases the absorption of both moisture and decay-producing bacteria. The time taken for retting need to be monitored carefully as under retting and over retting will lead to poor quality of fibres. Retting is a microbial process allowing easy separation of individual fibres from lignocellulosic biomass without damaging the fiber cellulose (Ashish Hulle *et al*, 2015). The microbes produces enzymes such as pectinase, xylanase, hemicellulaseetc, which act on the non-fibrous cementing material mainly pectin and hemicelluloses and destruct intercellular adhesive substances. Microorganisms soften and degrade the pectinous substances that bind fibers with other plant tissues. After fermentation the fibres can be separated from the leaves easily. (Manimekalai *et al*, 2017).

3.3 Pretreatment of Sansevieria trifasciata fibers

3.3.1 Scouring of plant fibres

Effect of different concentration of sodium hydroxide on plant fibers was studied. 5 grams of fiber with 3% of sodium hydroxide treatment gave optimal scouring condition. Similarly, Mardiyati *et al.*, 2015 reported that 3% of sodium hydroxide gave optimal scouring condition for *Sansevieria trifasciata*fiber. Alkaline treatment is the standard method used in the paper and pulp industry for lignin removal in which lignin can be dissolved in sodium hydroxide solution and cellulosic fibres can be obtained (Deshpande *et al*, 2000). During this process lignin gets broken into smaller fragments. Sodium hydroxide acts as a swelling agent and increases dissolution of lignin with other non cellulosic materials present in the fiber (Cai *et al*, 2005; Khuhwaha *et al*, 2009). Fibres softened and water absorption property of fibers increased after alkali treatment with sodium hydroxide.

3.3.2 Bleaching of plant fibers

Effect of different concentration of Hydrogen peroxide on plant fiber was studied. 5 grams of fiber treated with 0.3% hydrogen peroxide gave optimal bleaching condition. Similarly Harizi *et al,* reported that 0.3% of hydrogen peroxide gave optimal bleaching condition of *Sansevieria trifasciata*fibers. Hydrogen peroxide removed the coloring matter present in the fiber with minimum degradation of the fiber (Abdul *et al,* 2013). Whiteness of the fiber increased without causing more weight loss of the fibres. Further water absorption property of the fibres was also increased after the bleaching process.

3.4 Water absorbency test for *Sansevieria trifasciata* fibers

The water holding capacity of *Sansevieria trifasciata*fibers was calculated by using the following formula.

Water absorbency= Initial volume of water- Final volume of water

Water absorbency= 30-25

Water absorbency = 5

The water holding capacity of *Sansevieria trifasciata*fibers is 5 ml

The water holding capacity of *Sansevieria trifasciata*fiber before pretreatment with scouring and bleaching is 5 ml. The study revealed that the scouring and bleaching of fiber increased the water absorption capacity of the fiber. Pretreatment of fibres removed the impurities present in fibres and enhanced the absorption property of fibers. Water absorption value of fibres after scouring and bleaching were represented in table 2.

Table.2 values for water absorbed by the fibers after scouring and bleaching

Treatment	Amount of water absorbed by fiber at optimum condition (3%)
After scouring	6 ml
After bleaching	6.3 ml

3.5 Assessment of Antimicrobial activity test

The antimicrobial activity of *Rosa damascena* petals were evaluated by qualitative agar diffusion method. The results showed that the treated fibres showed good antimicrobial activity against the test pathogens. From the study maximum zone of inhibition was observed for *E,coli* (10 mm) followed by *Candida* (9 mm) and *Psudomonas*(8 mm). No zone of inhibition was observed for Staphylococcus sp. Untreated natural fiber was used as the control and showed no zone of inhibition against any of the test pathogen. Similar results were observed by Mohamed Shohayeb *et al*, 2014. He observed that aqueous extract of rose petals showed good activity against *E.coli*, *Pseudomonas* sp, and *Candida* sp. Thus the treated fiber showed good antimicrobial activity against the test pathogens. Antimicrobial activity of the treated fibers against different microorganisms was represents in table 3.

Table.3 Zone of inhibition against test pathogens

Zone of inhibition (in mm)		
Organisms	**Control (Untreated fiber)**	**Treated fiber**
Staphylococcus sp.	-	-
Pseudomonas sp.	-	8
E.coli	-	10
Candida sp.	-	9

Conclusion

From the present study it may be concluded that *Sansevieria trifasciata* fibres posses desirable properties to be used in feminine hygiene product such as sanitary pads because of its eco friendliness and biodegradable nature. The quality of the fibres improved after pretreatment with sodium hydroxide and hydrogen peroxide. Further fibres treated with *Rosa damascena* extract by microencapsulation technique showed good antimicrobial activity against *Pseudomonas* sp. *E.coli*. and *Candida* sp. Thus using *Sansevieria trifasciata* fibers will be a promising alternative in the future for developing eco friendly sanitary napkins to improve the health and hygiene status of women.

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