Development of Cost-Effective Menstrual Absorbent Pad with Eco-Friendly Antimicrobial Finish

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Abstract

Management of menstrual hygiene is a critical problem for Bangladeshi women and girls as the sanitary pads are expensive. Therefore, purchasing sanitary napkins for incredibly poor and middle-class families is very challenging. Many retail sanitary napkins are available on the local market, but most of them are costly. However, poor women's are unable to purchase or use high-quality sanitary napkins. Thus, a maximum of nine sanitary napkin pad samples with very cheap raw materials (natural fibres) have been produced in this study. Newly manufactured products even undergo antimicrobial treatment with natural antimicrobial agents such as Tulshi and Aloe Vera accompanied by a simple production process, which ultimately makes the product cheaper and safer for the consumer during use. A maximum of nine samples were produced and compared with commercial samples for cost analysis. The primary objective of this research is to develop such a kind of sanitary napkin that will be cheaper as well as user-friendly in contrast to commercial samples. More interestingly, poor women are not used to wear underwear, because of which they are not interested in using pads as commercial sanitary napkins; panty or other underwear is required. For this reason, an adjustable waistband support is used in this experiment to easily attach the sanitary napkin without any gum. Since menstruation is directly linked to the human reproductive process, it is important for women and girls to manage menstruation appropriately. In addition, the material (especially sanitary napkin core forming materials) used in commercial sanitary napkins is synthetic and may lead to accelerated growth of bacteria and germs by longterm use of the pad. The goal of this research was to construct an inexpensive sanitized pad that was treated with Aloe Vera and Tulshi extract. Tulshi and Aloe Vera modified non-woven fabrics incorporate antimicrobial activity against *Staphylococcus aureus (S. aureus)* and *Escherichia coli (E. coli)*. Therefore, as it can be used without undergarments, sanitary napkin is not only hygienic but also inexpensive and comfortable with effective protection against leakage. Findings demonstrate the newly developed prototype's substantial design and cost-effectiveness.

Keywords: Antimicrobial activity, Low-Cost Sanitary Napkin, Menstrual Management, Aloe Vera, Tulshi

Introduction

Cultural norms, parental influence, personal preferences, economic status and socio-economic pressures have influenced menstrual hygiene activities. Menstrual views relate to misconceptions or perceptions about menstruation within a specific culture or religion. Menstrual values, awareness, and behaviors wereall linked to menstrual hygiene management (Aniebue, 2010). Such norms are obstacles to better menstrual hygiene practices. Most women experience restrictions on cooking sexual intercourse, washing, worshiping, or eating other foods (Drakshayani Devi, 1994). Such restrictions are due to people's overall perception of menstruation because they consider it dirty and polluting (Jogdand, 2011).

Chakwana et al. (2014) revealed the way to develop a low-cost re-usable microfibre sanitary pad with good performance properties and low cost maintenance, affordable to poor women. The total cost of one re-usable microfibre sanitary napkin will be $2.40, which is eventually not suitable for Bangladeshi poor woman. Several attempts have been made for preparing the absorbent core for an ultrathin sanitary napkin using super absorbent fibre (SAF) and viscose fibre blends with varying SAF percentages and mass per unit area (g/m^2) but the researchers did not compare the cost effectiveness of developed product with the existing product (Das et al., 2008).

Most girls and women face difficulties in managing their periods safely. In addition to constant taboos, the ability of women and girls to manage their periods is affected by a number of other factors, including limited access to affordable and hygienic sanitary materials and disposal options, leaving many to manage their periods in an ineffective, uncomfortable and unhygienic manner. In some cases, natural materials such as mud leaves and dung and animal skins are used to control menstrual flow (Summer, 2013). Use of unclean rags, for example, particularly if they are inserted into the vagina, can induce or support the growth of unwanted bacteria that could lead to infection (Kirk and Sommer 2006). As a result natural and inexpensive antimicrobial agent such as Aloe Vera and Tulshi extract solution is used in this research to maintain consumer hygiene.

The direct contact of material with the skin induces the development of microorganisms. Sanitary napkins are such materials that are highly prone to bacterial infestation, contributing to diseases of the body in both immune compromised and normal people (Boryo DEA, 2013). Some bacterial and fungal organisms cause sanitary napkin-associated infections. There is therefore a strong need for a hygienic product for menstrual protection worldwide. To prevent infections in sanitary napkins, the fabrics should have antimicrobial activity. In the women's sanitary napkin industry, antimicrobial sanitary napkins may have their own place due to their preventing disease resistance properties (Sarika Mishra, 2016). Clothing and textiles are very good materials for the production of microorganisms (Sauperl O, 2016). These may serve as carriers for certain microorganisms, such as pathogenic bacteria, odor-generating bacteria or molds and fungi. Natural herbal extract finishes on fabrics have many benefits, such as non-toxic, non-irritant, biodegradable, cost-effective and easy availability. Finishing herbal extracts with antibacterial activity on fibres helps to reduce the growth of microbes. Therefore, the antimicrobial function of the fabrics can be accomplished by finishing the herbal extracts on the fibres. Bioactive substances in herbal extracts are responsible for antimicrobial action (Shabrin Farhana, 2018).

For example, findings from Bangladesh, where 80 per cent of factory workers were female, indicate that 60 per cent of them used menstrual fabric rags from the factory floor. These are extremely chemically modified and often newly dyed Infections are widespread, resulting in an average of 73% of women unemployed for six days a month. Women did not have a safe place either to buy fabric or pads or to change / dispose them. Women are paid per piece; those six days away are a major economic loss to them, but also to the supply chain for companies (Summer, 2013).

Moreover poor women are not used to wearing underwear because of which they are not interested in using commercial sanitary napkins although panty or other underwear is essential to use commercial sanitary napkin. A number of researchers have been reported about the development of low cost menstrual pad, which generally requires panty or undergarments during using sanitary pad (Barman et al., 2017) which is eventually not affordable to poor woman. Therefore, in this research, such a method is taken where any female can use pad conveniently without using a panty, as there will be an elastic waistband line where a pad can be added without any gum or undergarments.

Material and Methods

Materials

The research study was carried out using 100% cotton and 100% viscose fibre obtained from Square Textiles Ltd. White non-woven (90 per cent polyester and 10 per cent polypropylene) and black non-woven (95 per cent and 5 per cent polypropylene) fabrics, tissue paper (Bashundhara tissue paper), locally marketed and polyethylene were obtained from Bangladesh regional market. Antimicrobial activity of Aloe Vera and Tulshi treated non-woven tissue was investigated against *Staphylococcus aureus* (gram positive) and *Escherichia coli* (gram negative) collected from the Department of Microbiology, Primeasia University, Bangladesh. Those two bacteria have been chosen because they are commonly available in the human body. Analytical grade methanol from Zengzhou Sigma Chemical Company Ltd., China used to dissolve Tulshi. Analytical grade citric acid from Merck, India was used as a binder throughout the use of Tulshi extract on non-woven fabric. Whatman No. 1 filter paper was used during the extraction of Aloe Vera collected from the Department of Textile Technology, Primeasia University, Bangladesh.

Apparatus

Antimicrobial treatment of neem on non-woven fabric was performed by means of laboratory padding of Copower Technology Ltd, Taiwan. All the layers are sealed together by a heat-sealing system (Model PS-1000, 1000 mm, Impulse Heat Sealer, china). Eventually, all produced pad specimens were sterilized using a UV-treated sterilizer Model YTP280MT-1, UV, china).

Methods

Sample Preparation

For developing hygiene feminine products in this study finished non-woven fabrics were first treated with Tulshi and Aloe Vera extract solution, collected from freshly Tulshi and Aloe Vera leaves grown in National Botanical Garden, Bangladesh. At first Tulshi leaves were washed with distil water and leaves were dried under sunshade. The dried herbals are crushed into small pieces and extracted with 5% methanol for 12 hours in a soxhlet extractor. Methanol extracts of the herb were directly applied on non-woven fabric by pad-dry cure method. Various concentrations (10%, 25% and 50%) of Tulshi extract was applied on non-woven fabric along with 6% citric acid as cross linking agent by pad-dry cure method. Whereas, for Aloe Vera the spines of the leaf were chopped and the upper layer of the skin called rind was opened longitudinally to collect the gel. Then the gel was homogenized to make a crude paste and was used for extraction. Whereas, required amount of crude paste of Aloe Vera gel was soaked in 100 ml of distilled water for 24 hours with frequent mixing. This preparation was filtered using Whatman filter paper and the filtrate was concentrated at 100ºC in a water bath and various concentration (10%, 25% and 50%) of aloe-vera gel extract was applied on non-woven fabrics.

The treatment of non-woven fabrics with tulshi and Aloe Vera extract solution was carried out separately by using Laboratory Padding Mangle from Copower Technology Ltd, Taiwan. The Padding of fabric samples was performed at room temperature, 2 kg/cm^2 pressure, and squeeze to remove excess solution. After padding all the test samples were dried at 80^{0}C for 20 min followed by curing at 120^{0}C for 5 min. For the easier investigations all the test fabric sample were coded as shown in Table 2. The developed pad sample contains four layers. All of the layers were sealed together by heat-sealing machine (Model PS-1000, 1000mm, Impulse Heat Sealer, China). After that, the UV treated sterilizer (Model YTP280MT1, UV, China) sterilizes all created pad samples. Newly developed total of nine samples (sample 01 to sample 09) defined by different core forming materials as shown in Table 1. In addition, three commercial samples used in this experiment defined by commercial sample-01, commercial sample-02 and commercial sample-03 respectively.

Table 1. Design of Various Layer of Developed Pad Sample

Name of the sample	Top Layer or 1st Layer	Absorbent Layer / Core Layer / Middle Layer	Protective Layer or 3rd Layer	Bottom Layer
Sample-01	White Non-woven composed of 90% Polyester and 10% Polypropylene	100% Cotton fibre	Polyethylene	(95% polyester and 5% polypropylene) Black Non-Woven
Sample-02	White Non-woven composed of 90% Polyester and 10% Polypropylene	80% cotton and 20% viscose fibre	Polyethylene	(95% polyester and 5% polypropylene) Black Non-Woven
Sample-03	White Non-woven composed of 90% Polyester and 10% Polypropylene	50% cotton and 50% viscose fibre	Polyethylene	(95% polyester and 5% polypropylene) Black Non-Woven
Sample-04	White Non-woven composed of 90% Polyester and 10% Polypropylene	33.3% cotton, 33.3% viscose fibre and 33.3% tissue paper	Polyethylene	(95% polyester and 5% polypropylene) Black Non-Woven
Sample-05	White Non-woven composed of 90% Polyester	50% cotton 50% viscose fibre and	Polyethylene	(95% polyester and 5% polypropylene)

	and 10% Polypropylene	1gm sodium alginate powder		Black Non-Woven
Sample-06	White Non-woven composed of 90% Polyester and 10% Polypropylene	50% cotton 50% viscose fibre and 2gm sodium alginate powder	Polyethylene	(95% polyester and 5% polypropylene) Black Non-Woven
Sample-07	White Non-woven composed of 90% Polyester and 10% Polypropylene	50% cotton 50% viscose fibre and 1gm CMC powder	Polyethylene	(95% polyester and 5% polypropylene) Black Non-Woven
Sample-08	White Non-woven composed of 90% Polyester and 10% Polypropylene	50% cotton 50% viscose fibre and 2gm CMC powder	Polyethylene	(95% polyester and 5% polypropylene) Black Non-Woven
Sample-09	White Non-woven composed of 90% Polyester and 10% Polypropylene	50% cotton 50% viscose fiber,1gm CMC powder and 1gm sodium alginate	Polyethylene	(95% polyester and 5% polypropylene) Black Non-Woven

Evaluation Methods

Initially, non-woven fabrics are treated with Tulshi and Aloe Vera extract solution at different concentrations (10 per cent, 25 per cent and 50 per cent) in order to select the best-performing cloth for the further production of all sanitary napkins, which typically have excellent antimicrobial properties. The developed sanitary pad samples then performed a spray rating test to evaluate the ability of polyethylene to withstand blood or other menstrual fluid leakage. Eventually, the cost structure of the produced sanitary napkin was prepared and contrasted with commercial specimens.

Antibacterial Property Testing

The antimicrobial properties of Aloe Vera and Tulshi extract solution treated non-woven fabric (used to design sanitary napkin) were evaluated using ASTM E2149-01, which is a quantitative antimicrobial test method designed to evaluate the resistance of non-leaching antimicrobial treated specimens to the growth of the microbes under dynamic contact conditions. Antimicrobial activity was assessed against *S.aureus* (gram positive) and *E.coli* (gram negative). Each culture was suspended in a small amount of nutrient broth, spread on the nutrient agar plate, and incubated at 37^{o}C for 2 h. Two single colonies were picked up with an inoculating loop from the ager plate, suspended in 5 mL nutrient broth, and incubated for 18 hour at 37^{o}C. A final concentration of 1.5-3.0 X 10^5 colony forming units per millilitre (CFU/mL) was prepared by appropriately diluting each culture with a steric buffer solution (0.3 mM phosphate buffer, p^H 7.2) which was used as diluents in all experiments. These dilute culture solutions were used for the antimicrobial test.

For each Aloe Vera and Tulshi extract treated and one untreated sample, a 250 ml flask are prepared containing 50 mL of the working bacterial dilution (1.5-3 x 10^5 CFU/Ml) and non-woven fabric samples which are cut into small pieces (1cm x 1cm). All flasks were capped loosely, placed on a shaking incubator, were shaken at 37°C and 120 rpm for 1 hour. A series of dilutions were made using the buffer solution and each 0.1 ml of the dilution was placed in nutrient agar plate. The inoculated plates were incubated incubator (Binder from USA) at 37°C for 18-24 hour and surviving cells were counted. Safety cabinet (Clernair from Belgium) was used to carry out the preparation of bacteria culture and transferring to agar plate. The antimicrobial was expressed in terms of % reduction of the organism after contact with the test specimen compared to the number of bacterial cells surviving after contact with the control using equation-1 (Ferrero, 2012).

$$\% \text{ Reduction} = \frac{B-A}{B} \times 100 \ldots\ldots\ldots\ldots\ldots (1)$$

Where A and B are the surviving cells (CFU/ml) for the flasks containing test samples (Tulshi and Aloe Vera extract treated samples) and the control (blank samples) respectively after 1 hour contact time.

Table 2. Test for Non-Woven Fabrics Sample

Test Fabric Sample	Code
Non-Woven Fabric samples without any Tulshi and Aloe Vera extract solution treatment	U
Non-Woven Fabric samples treated with 10% Tulshi and Aloe Vera extract solution	A
Non-Woven Fabric samples treated with 25% Tulshi and Aloe Vera extract solution	B
Non-Woven Fabric samples treated with 50% Tulshi and Aloe Vera extract solution	C

Cost analysis of Developed Pad Sample

Cost analysis is a standardized process to determine the cost of each element. This plays a vital role in the process of product design. It is necessary to make and purchase decisions, to make alternative selections, to create a break-even analysis and to regain capital. The cost analysis shall assess the economic feasibility of the planned factory, sector or product.

There are several types of cost such as

* Direct material Cost.
* Labor cost.
* Factory overhead cost.

Water Spray Test: AATCC Test Method 22-2010

Water sprayed against the tight surface of the sample specimen under controlled conditions creates a wet pattern, the size of which depends on the relative repulsion of the fabric. Evaluationwas achieved by matching the wetted template with the objects shown in the standard chart.

Results and Discussion

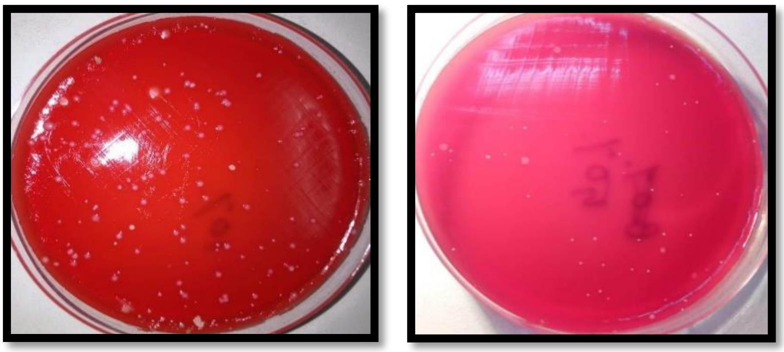
Antimicrobial Performance of Aloe-Vera Treated Non-woven Fabric

The main components of Aloe-Vera gels are glycoprotein, barbaloin, aloe-emodin, emodin, mannose-6-phosphate, polysaccharides, acemanan, aloesin, etc. The active ingredients of Aloe vera gel have wide range of activities such as moisturizing, anti-inflammatory, antibacterial, antifungal, antiviral agent, antiodor, etc. (Krinsky 2003; Lee et al. 2009).

The antimicrobial test result of the aloe-vera extract treated non-woven fabric against *S. aureus*are listed in Table 3 and results are summarized in Figure 1 and Figure 3.

Concentration of Aloe-Vera extract applied on non-woven fabric	Surviving cells after 1 hour contact time (CFU/mL)	Reduction (%)
0 (Untreated)	2.32×10^5[B]	
10%	57×10^3 [A]	75.43
25%	31×10^3 [A]	86.64
50%	14×10^3 [A]	93.97

Experimental results of Aloe-Vera treated non-woven fabric against *E. coli*are given in Table 4. and results are summarized in Figure 2 and Figure 3.



(a) **(b)**

Figure 2. Number of Surviving Cells (E. coli) after 1 hour Contact with Untreated Non-Woven fabric (a) and Non-Woven Fabric Treated with 50% Aloe-Vera Extract (b)

Table 4. Reduction of Microorganisms *(E. coli)* in Treated Non-Woven with the Increment of Aloe-Vera Extract Concentration.

Concentration of Aloe-Vera extract applied on non-woven fabric	Surviving cells after 1 hour contact time (CFU/mL)	Reduction (%)
0 (Untreated)	2.25×10^5 [B]	
10%	63.0×10^3 [A]	72
25%	34.0×10^3 [A]	84.88
50%	17.0×10^3 [A]	92.44

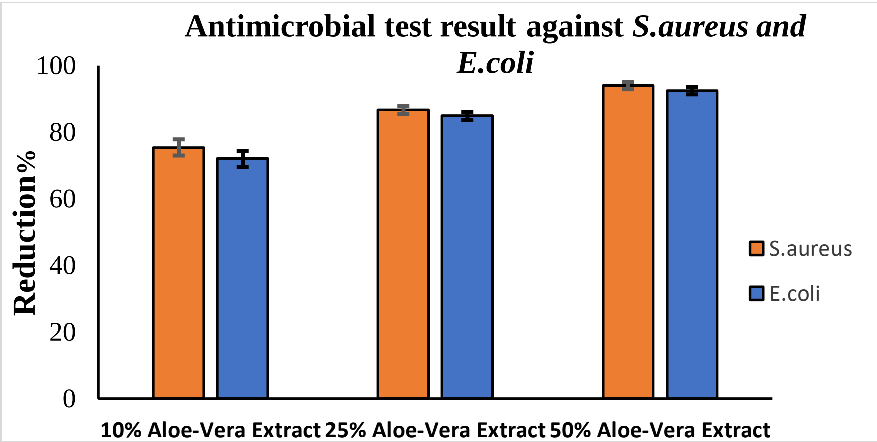


Figure 3. Results of Antibacterial Test against *S.aureus* and *E. coli*

The results have shown the excellent antibacterial efficacy of Aloe Vera treated non-woven fabrics. Untreated non-woven fabrics displayed no antibacterial activity against both (*S.aureus and E.coli*) where a significant improvement in antibacterial activity against both organisms was observed in all treated non-woven fabrics. The decrease of bacteria has been found to increase with an improvement in the amount of Aloe Vera extract solution. When the concentration was raised from 10% to 25%, antimicrobial resistance is also improved. Increasing the concentration from 25% to 50% has a significant effect on increasing antimicrobial resistance comparable to the commercial sample (Commercial Sample-01). Aloe gel polysaccharides and barbaloin are mainly responsible for their antimicrobial activity (Krinsky et al. 2003; Ramachandra and Rao, 2008). The antifungal and antibacterial effects of Aloe veracan can also be used for clinical fabric uses, such as wound dressing, suture and other bioactive textiles.

Antimicrobial Performance of Tulshi Treated Non-woven Fabric

Traditionally, Tulshi used in different forms; aqueous extracts from the leaves (fresh or dried as powder) are used in herbal teas or mixed with other herbs or honey to enhance the medicinal value. Traditional uses of Tulshi aqueous extracts include the treatment of different types of poisoning, stomach-ache, common colds, headaches, malaria, inflammation, and heart disease (Pattanayak et al., 2010). The antimicrobial test results of the Tulshi extract treated non-woven fabric against *S. aureus* are listed in Table 5 and results are summarized in Figure 4 and Figure 6.

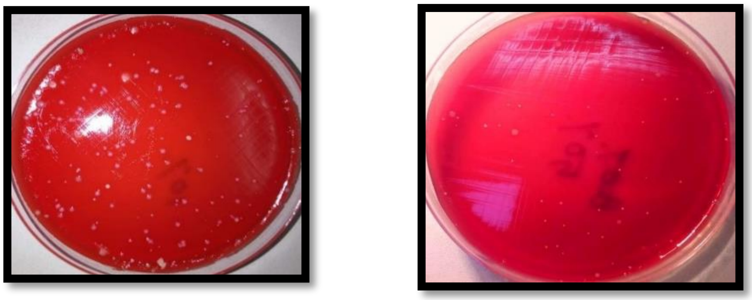
(a) (b)

Figure 4. Number of Surviving Cells (*S.aureus)* after 1 hour Contact with Untreated Non-Woven fabric (a) and Non-Woven Fabric Treated with 50% Tulshi Extract (b)

Table 5. Reduction of Microorganisms (*S.aureus*) in Treated Non-Woven with the Increment of Tulshi Extract Concentration

Concentration of tulshi extract applied on non-woven fabric	Surviving cells after 1 hour contact time (CFU/mL)	Reduction (%)
0 (Untreated)	2.32×10^5[B]	
10%	56×10^3 [A]	75.86
25%	33×10^3 [A]	85.77
50%	15×10^3 [A]	93.53

Experimental results of Tulshi treated non-woven fabric against *E. coli* are given in Table 6.and results are summarized in Figure 5and Figure 6.



(a) **(b)**

Figure 5. Number of surviving cells (*E. coli*) after 1 hour Contact with untreated non-woven fabric (a) and non-woven fabric treated with 50% Tulshi Extract (b)

Table 6. Reduction of Microorganisms (*E. coli*) in Treated Non-Woven with the Increment of Tulshi Extract Concentration

Concentration of tulshi applied on non-woven fabric	Surviving cells after 1 hour contact time (CFU/mL)	Reduction (%)
0 (Untreated)	2.25×10^5 [B]	
10%	64.0×10^3 [A]	71.56
25%	36.0×10^3 [A]	84
50%	19.0×10^3 [A]	91.55

The results clearly demonstrate the outstanding antibacterial efficacy of Tulshi extract treated with non-woven fabrics. Untreated non-woven fabrics displayed no antibacterial activity against both (*S.aureus and E.coli*) where a remarkable improvement in antibacterial activity against both organisms has been identified in all treated non-woven fabrics. The decrease of bacteria has been shown to improve with an improvement in the amount of Tulshi extract solution. When the concentration is raised from 10% to 25%, antimicrobial resistance is also improved. Improving the concentration from 25% to 50% has a significant effect on improving the antimicrobial protection compared to that of a commercial product.

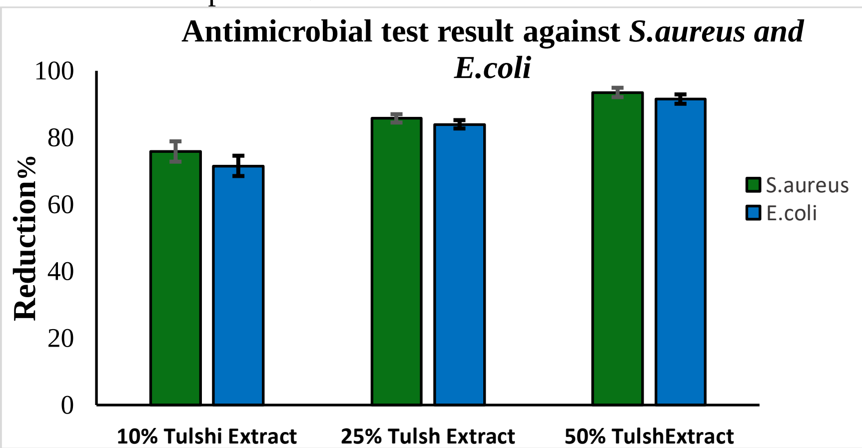


Figure 6. Results of Antibacterial Test against *S.aureus* and *E. coli*

Eugenol is the most prominent phytoconstituent in the Tulshi plant that may be responsible for antimicrobial action. Many research proposed the mechanism of bactericidal action of eugenol, alpha terpinol and gamaterpine, which are the major component of tulshi efficiently, work against test microorganism. The attached antimicrobial agent disrupts the cell membrane of the bacteria through the physical or ionic mechanism (Sarkar et al., 2003). When the cell walls are penetrated, the metabolite leakage occurs and other cell processes become disabled preventing the organism from functioning and reproducing.

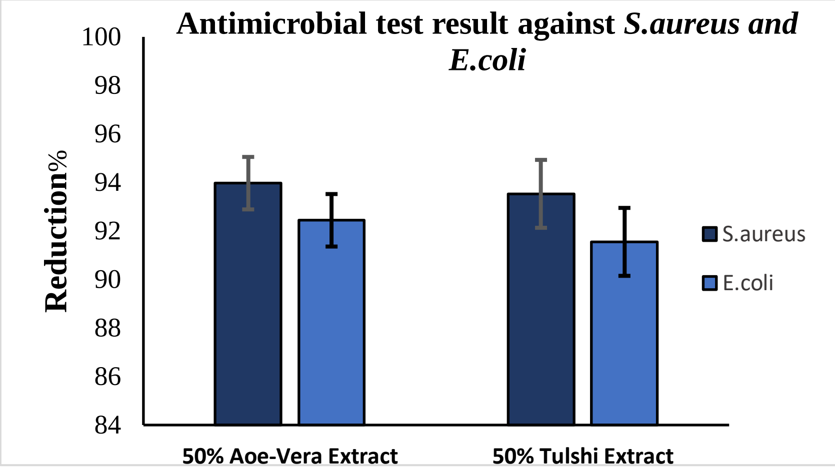


Figure 7. Comparison of Antibacterial Test Result of 50% Concentration of Aloe-Vera and Tulshi Extract Treated Non-Woven Fabric against *S. aureus* and *E. coli*

Figure 7 demonstrated a comparison of the antimicrobial properties of a particular amount (50%) of Aloe Vera and Tulshi extract solution added to non-woven fabrics. In this research, non-woven outer layer fabrics and pocketing fabrics were treated with various natural antimicrobial agents (Aloe Vera and Tulshi) to enable them both hygienic and user-friendly. For this reason, various amounts (10 per cent, 25 per cent or 50 per cent) are added to non-woven fabrics followed by padding. Among them, the 50 per cent concentration of Aloe Vera and Tulshi extract solutions are highly effective for rapid removal of bacteria as the reduction percentage increases with enhanced concentrations. The highest percentage of reduction against *S. aureus* and *E. coli*was observed for 50% concentration of Aloe Vera extract solution. As a result, non-woven fabrics treated with a 50 per cent concentration of Aloe Vera extract solution (outer layer fabrics and pocketing fabrics used to develop sanitary napkin) are chosen for the remaining of the other samples development (sample 01 to sample 09).

Developed Sample	**Commercial Sample-01**	**Commercial Sample-02**	**Commercial Sample-03**
			
Surviving cells after 1 hour contact time CFU/mL-0.12 x 103	Surviving cells after 1 hour contact time CFU/mL-0.1 x 103	Surviving cells after 1 hour contact time CFU/mL-0.13 x 10^3	Surviving cells after 1 hour contact time CFU/mL-2.06 x 10^3

Figure 8. Comparison of Bacterial Growth of Various Sanitary Napkin Pad Samples

Figure 8 reflects the final product (sanitary napkin) antimicrobial analysis in which both the sample developed and the commercial sample illustrates outstanding antimicrobial properties against bacterial growth. The excellent antimicrobial properties of the developed specimen were due to the treatment of non-woven fabric with a concentration of 50% of aloe-vera extract solution. After that, the fabricated sanitary napkin pad samples were sterilized with UV treated sterilizers. As a result, the antimicrobial potential of the final product is significantly enhanced by the accelerated killing rate of the bacteria. (Commercial sample-01) antimicrobial characteristics were highest among all samples shown in (Figure 8) although the reason behind this antimicrobial property is not revealed. (Commercial sample-02), antimicrobial properties are also good, although (Commercial Sample-03) shows poor antimicrobial properties. Hygiene is one of the major concerns for consumers of sanitary napkin especially for women as it plays a vital role in proper menstrual management to keep the reproductive system smother and healthier.

Costing of Developed Pad Sample

Table 7. Price of Various Raw Materials of Developed Sanitary Napkin

SL. No.	Materials used to develop a product	Cost (Taka)
01	Price of Cotton (surgical cotton)	120 per kg
02	Price of Viscose	200 per kg
03	Price of Nonwoven fabric	12 per yards
04	Price of Sodium Alginate	180 per kg
05	Price of CMC (Carboxy Methyl Cellulose)	210 per kg
06	Price of polyethylene	11 per yards
07	Price of Bashundhara Tissue paper (13 inch x 13 inch) 1 ply – 80 pieces	170 per kg
08	Elastic	12 per yards

The following items of plant and machinery are required for the project

Table 8. Cost Structure (Plant and Machinery)

Detail	Quantity	Value (Taka)
Core forming M/C	01	7000
Ultra Violet Treatment Unit	01	10000
Heat Seal	01	3000
Total		20000

Table 9. Other Accessories

Items	Quantity	Value (Taka)
Weighing Scale	02	6000
Work Table	02	2000
Plastic Buckets and trays	04	1000
Total		9,000

Table 10. Required Workers

Workers	Number of worker	Salary (Taka) per 25 working days	Labour cost per Napkin packet (taka)	Labour cost per piece (taka)
Semi-Skilled Labors (Daily Wages 200 Taka per Day for a single worker)	04	20,000	7.14	0.7

Table 11. Total Napkin Production per Day (minimum)

Number of Production per day	10 napkins per packet
140 x 8 hours = 1120 pieces	112 packets

Note: Four persons able to produce 140 pieces of sanitary napkin per hour.

Table 12. Monthly Administrative Expense / Overhead Cost

Expenses	Value (Taka)	Overhead cost per packet (per day) $\frac{\text{Daily Administrative Expenses (200 Tk)}}{\text{Number of production of Packet per day(112 packet)}}$	Overhead cost per piece (per day)
House Rent	2500	$\frac{200\ Taka}{112\ packets\ of\ Napkin}$ = 1.78	(Daily administrative expenses / Number of production of napkins per day) $\frac{200\ Taka}{1120\ pieces}$ = 0.18
Electricity Bill	2000		
General Administrative Expenses	500		
Total	5000 (200 per day)		

Table 13. Required Raw Material per Day (Sample-09: 50% Cotton + 50% Viscose + 1gm sodium alginate + 1 gm CMC)

Raw Materials	Unit (with 5% wastage)	Value (Taka)
Cotton	2.94 Kg	352
Viscose	2.94 Kg	588
Sodium Alginate	1.176 Kg	211
CMC	1.176 Kg	247
Non-woven (Top and Bottom layer, pocket)	140 yards	1680
Polyethylene	51.75 yards	569
Elastic	128 yards	1536
Packing Covers	112 packets	84
Total		5267

Table 14. Price Fixing per Napkin Packet (Sample-09: 50% Cotton + 50% Viscose + 1gm sodium alginate + 1 gm CMC)

Details	Value (Taka)
Raw Material per Napkin Packet	47
Wastage	0.10
Labour Cost per Napkin Packet	7.14
Overhead Cost per Napkin Packet	1.78
Cost Per Napkin Packet	56
Add Profit 30 %	17
Wholesale Price per packet	73
Add Whole Seller Profit Margin: 15%	11
Maximum Retail Price per Packet (MRP)	84
Maximum Retail Price per Piece (MRP)	8.4

Table 15. Maximum Retail Price per Piece (MRP) and Whole Sale Price of Developed Sample (Sample-01 to Sample-09)

Sample Name	Sample Details	Whole sale price per packet (Taka)	Whole sale price per piece (Taka)	Maximum Retail Price per Packet (MRP) (Taka)	Maximum Retail Price per Piece (MRP) (Taka)
Sample-01	100 % cotton	64	6.4	74	7.4
Sample-02	80% cotton + 20% viscose	65.82	6.6	76	7.6
Sample-03	50% cotton + 50% viscose	67.60	6.76	78	7.8
Sample-04	33.3% cotton + 33.3% viscose + 33.3% tissue paper	67.60	6.76	78	7.8
Sample-05	50% cotton + 50% viscose+1gm sodium alginate	70.20	7.02	80	8.00
Sample-06	50% cotton + 50% viscose+2gm sodium alginate	71.50	7.15	82	8.20
Sample-07	50% cotton + 50% viscose+1gm CMC	70.20	7.02	80	8
Sample-08	50% cotton + 50% viscose+2 gm CMC	74	7.40	85	8.5
Sample-09	50% cotton + 50% viscose+ 1gm sodium alginate+1gm CMC	73	7.30	84	8.4

Table 16. Sales per Month (sample-09: 50% Cotton + 50% Viscose + 1gm sodium alginate + 1gm CMC)

Details	Value (Taka)
Value of per Day required Raw Material	5267 x 25= 1,31,675
One Month (25 Working Days)	1,31,675
Per Day Napkin Production	1120 ÷ 10= 112 packets
One Month (25 Working Days)	25 x 112 = 2800 packets
Per Packet Whole Sale Price	73
Value of One Month Production	2800 x 73
One Month Sales	2,04,400
One Month Raw Material Expense	1,31,675
Total Profit	72,725
Labor Charge - Less from profit	20,000
Administrative Expenses - Less from profit	5,000
Net Profit per Month	47,725
Profit Margin On one Month Total Raw Material Value	36%

Table 17. Total Investment (Taka)

Investment Details	Value (Taka)
Advance for working Place	20,000
Machineries, Installation and training fees	80,000
Other Accessories	9,000
Running Capital for six Months	5,00000
Registration and Other Admin Expense	20,000
Total	6,29,000

Table 18. Net Profit per Year

Description	Value (Taka)
Profit per Month	47,725
Per Year profit	47,725x12 = 5,72,700
Interest for total investment @ 20 % (A)	125800
Depreciation of Machineries 10% (B)	8,000
A+B	133800
Net Profit Per year	5,72,700 – 1,33,800 = 4,38,900
Profit margin on Total Investment	69%

Comparison of Maximum Retail Price (MRP) of Developed Sample against Commercial Samples

Figure 9 and Table 19 demonstrate the maximum retail price (M.R.P) per piece of commercial and developed sanitary napkin. Among commercial samples, Commercial Sample-01 shows the highest MRP of 17.62 taka, the maximum of which is within three commercial samples, whether the lowest MRP is 10 taka among commercial samples (Commercial Sample-01 to Commercial Sample-03). On the other side, the maximum retail price (MRP) per piece of the developed sample is relatively inexpensive rather than commercial samples. As well as being cheap, the newly developed samples are designed with excellent performance. Among the developed sample, Sample-01 looks cheap, as its MRP is only 7.40 taka, although the quality of this pad (Sample-01) is not satisfactory. On the opposite, developed sample (Sample-09) offers good performance compared to commercial Sample-01, with a very reasonable (8.40 taka) maximum retail price (MRP) for consumers as viscose, cotton, sodium alginate, CMC (Carboxy Methyl Cellulose) were used to design core layer of a sanitary napkin. If the incorporation of sodium alginate and CMC increases, the performance of developed sample, (Sample-09) will be improved, but it will ultimately boost the cost of the product and make it uncomfortable for consumers.

Table 19. Comparison of Maximum Retail Price (MRP) of Developed Samples against Commercial Samples

Sample Identification	Maximum Retail Price per piece(Taka)
Commercial Sample-01	17.62
Commercial Sample-02	12.00
Commercial Sample-03	10.00
Sample-01	7.40
Sample-02	7.60
Sample-03	7.80
Sample-04	7.80
Sample-05	8.00
Sample-06	8.20
Sample-07	8.00
Sample-08	8.50
Sample-09	8.40

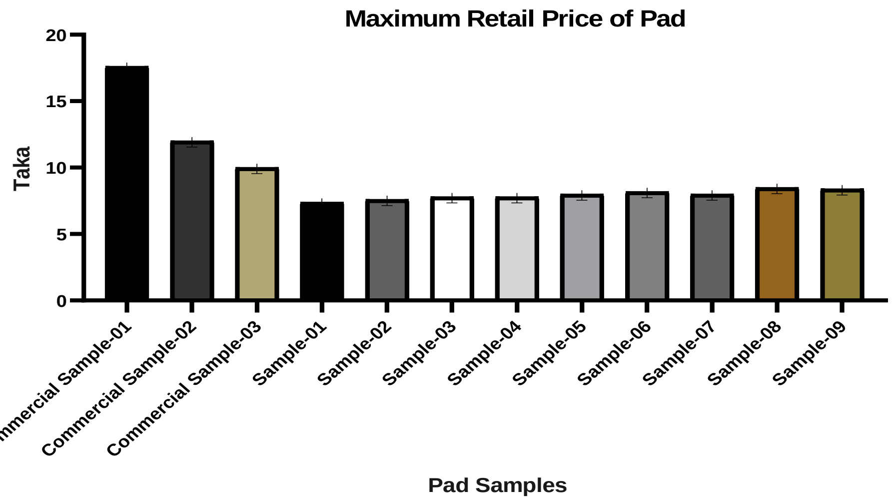


Figure 9. Comparison of MRP of Developed Sample against Commercial Sample

Spray Rating Test

The measurement of water spray rating of various components used to develop the samples was conducted by Accu Spray Tester (Model MAG-C1801, India) followed by AATCC Test Method 22-2010, known as water repellence test. At the end of the test, it is clearly visible that the barrier surface of the newly developed pad sample consists of polyethylene, indicating the average spray rating of 100 in Figure 10.

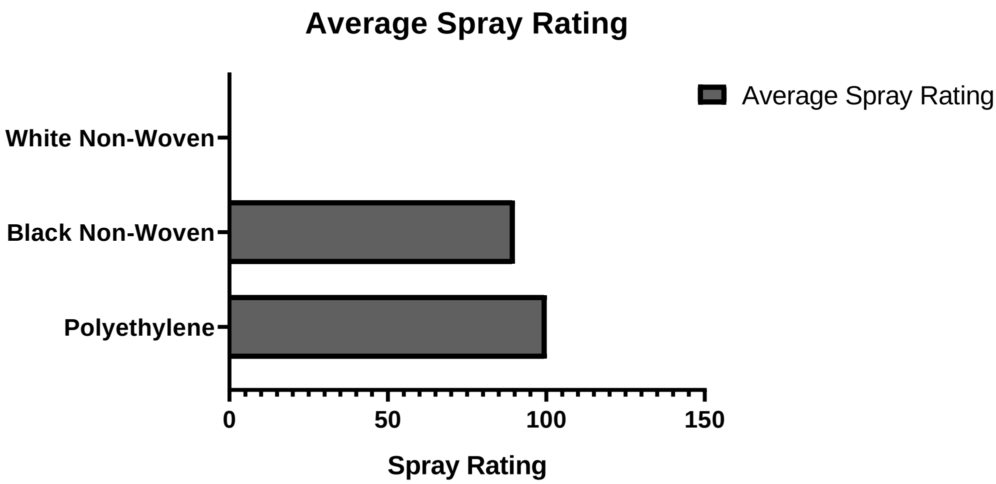


Figure 10. Average Spray rating of various samples

It ensures that it is waterproof as it prevents blood or other menstrual liquid from leakage. On the other finished non-woven (porous white non-woven) spray rating has been shown to be 0 which implies full wetting of whole upper and lower surfaces in order to improve the rapid absorption of menstrual fluid from the upper surface to the next layer of sanitary napkin. In comparison, black non-woven (stick / gummy layer) fabrics displayed a spray score of 90 that indicates a slight random sticking or wetting of the upper surface to establish a final blockade of menstrual fluid to protect against leakage during heavy menstrual fluid flow and thus allow users to keep themselves dry.

Conclusion

The detailed study has shown that designing a low cost menstrual absorbent pad will be the ultimate solution to enable poor women to use sanitary napkin during menstruation. In contrast, the application of Aloe Vera and Tulshi extract solution to the pad increases the antimicrobial properties, as they provides extra protection for human skin. The use of Aloe Vera and Tulshi in the pad often provides an additional advantage against pungent odor during menstruation. On the other side, most of the fabrics and chemicals used in the layout of the pads in this analysis are eco-friendly and easily disposed of to earth, which effectively make the product reusable. More notably, the production process of sanitary napkins is so simple and cost-effective that it will inspire girls and woman to use the product on a regular basis to manage their period with effectiveness. Developed sample, (Sample-09) offers good performance compared to commercial sample, (Commercial Sample-01) with a very reasonable (8.40) maximum retail price (MRP) for consumers as viscose, cotton, sodium alginate, CMC (Carboxy Methyl Cellulose) were used to design core layer of a sanitary napkin. Overall, a new path has been opened for the entrepreneur to initiate a plan to produce low cost sanitary napkins, which will potentially attract more men and women to support their families with additional income.

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