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Development of Eco-friendly Herbal Sanitary Napkins using Cotton and Kenaf Fibres

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Abstract

Menstrual hygiene and awareness has been the need of the hour for women's physical and mental health. Use of ashes, rages, leaves and other unsafe material have been a practice before the evolution of napkins. Advent of napkins has been from early 19th century and the study still thrives for betterment. Modern era has led women's from using commercially available sanitary napkins made of synthetic and non-biodegradable materials. Use of synthetic and non-biodegradable napkin results in skin irritation, itches, rashes and complicated diseases like cervical cancer on prolonged usage. In this paper, efforts are made in replacing synthetic materials used in sanitary napkins with cotton and kenaf fibres with additional herbal finish. The developed napkins provide better skin protection and are also eco-friendly due to its bio-degradable nature.

1. Introduction

Menstruation is the process where women undergo blood discharge from the lining of uterus at an interval between 28 to 35 days [1]. Over centuries, women have used various adsorbent materials like fabric, leaves, etc., in order to absorb the blood discharge. Usage of such materials highly impacts menstrual hygiene. Evolution of sanitary napkins from 19th century has slowly replaced the use of old fabrics, leaves etc., during menstruation [2]. Consumption of such sanitary napkins by women in highly populated developing countries like India has already reached the market value of $550 Million in the year 2020 and the market is expected to grow by 12.2% during 2021-2026 [1], [3].

The most of the commercially available sanitary napkins are made up of synthetic material and super adsorbent polymers (SAP) [3]. These materials are non-biodegradable in nature and adds to pollution load due to improper disposal and waste management [4]. These synthetic non-biodegradable materials are not only a threat to the environment but also a serious threat to the user itself. Use of such sanitary napkins is also one of the identified risk factor for the reason behind cervical cancer [5]. The raw materials used in commercial sanitary napkins focuses mainly on absorbing blood fluids, surface dryness for comfort, odour free fragrance finish and compactness of napkin for wearers comfort whereas least importance is given for environment and human health. Serious health risks for the wearer have been reported due to the harmful chemicals and fragrance used in commercial sanitary napkins [6]. Another issue is the cost of the sanitary napkin which is far from the economical level of average and below average community in the country. Most of the population is unaware of proper disposability of sanitary napkin after usage. Reports claim that these sanitary napkins once thrown in the environment takes around 100 years for decomposition [7], [8].

The amount of sanitary napkins used over a period of years causes landfills that even exceed a metropolitan land area and causes passive problems to people handling the waste. The current study focuses on developing natural fibre sanitary napkins in terms of absorbency, comfort properties and herbal protection. Kenaf is one such resource which has higher absorbency, economical, soft feel and has anti microbial properties which help the menstruating women relieve from pain and infection [9]. This fibre in combination with cotton results in fine tuned properties suitable for the production of sanitary napkin. In addition to the extensive benefits gained from these fibres being used as absorbent core, the top layer of the sanitary napkin is further finished with neem and turmeric for additional antibacterial protection. On an overview, **the** project work aims **on** producing sanitary napkin with the help of natural raw materials which results in user friendly and cost effective product which enables in production of napkins which are biodegradable after usage so that the product can be used by women of all areas during their menstrual cycle without any hassles.

2. Materials and Methods

2.1 Fibre and Chemicals

Kenaf fibres were sourced from Go green Products, Chennai, Tamil Nadu, India. Cotton fibres were sourced from PSG College of Technology, Coimbatore, Tamil Nadu, India. Biodegradable LDPE (Low density polyethylene) were sourced from Herbilica herbal napkins, Vilankurichi, Coimbatore. Sodium chloride, sodium carbonate, glycerol, methanol, citric acid and carboxymethyl cellulose were procured from Himedia and were used for the study without further modifications.

2.2 Development of Sanitary Napkin

Combination of Kenaf fibre and cotton fibre were used to manufacture the sanitary napkin and is shown in the following figure 1. The order of layering of cotton and kenaf for the manufacturing of sanitary napkin is shown in figure 2.

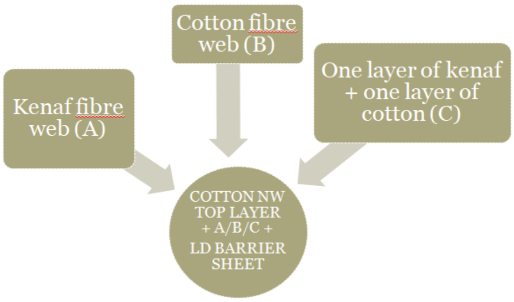

Figure 1 Combination of sanitary napkin using cotton and kenaf

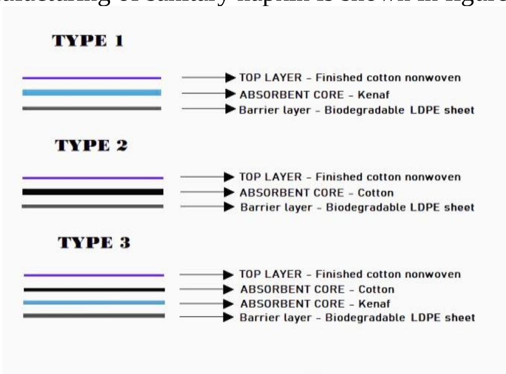

Figure 2 Layering of sanitary napkin using cotton and kenaf

2.2.1 Preparation of Core layer

The absorbent core is the middle layer of the napkin as shown in figure 2. The kenaf fibers were cut down to around two inches and were fed into the shirly trash analyser for cleaning. After cleaning, the fibres were fed into the miniature carding machine for web formation. The cotton fibre were cleaned and made into web using the same machines. The formed kenaf and cotton web were cut down into standard size using the mould shown in Figure 3a. The mould were placed above the web in the cutting machine and by compression, the web were cut down into required size and shape as shown in figure 3b.

Figure 3a Sanitary napking cutting mould

Figure 3b Mould cut sanitary napkin webs

2.2.2 Preparation of Antibacterial Top layer

The cotton non-woven top layer was given an anti-microbial coating to reduce the skin problems using the neem, turmeric extract. The neem leaves and turmeric roots were dried and powdered. The powders were mixed with methanol (100% solvent) at a ratio of 1:10 and were kept in the orbital shaker for 2hrs for evenness. This extracts were further kept for 24 hrs for effective absorption of the actives.

Application of herbal extracts on top layer was done by pad- dry-cure method. 10 % neem and turmeric extract were mixed together with 5gpl citric acid. Citric acid acts a cross linking agent between the extracts and the top layer. The top layers were impregnated with the herbal extract for 30 minutes at room temperature after which the material was dried and cured.

2.2.3 Preparation of sanitary napkin

The absorbent core was sandwiched between the antibacterial treated top layer and the biodegradable LDPE barrier layer. These layers were sealed using the thermal sealing machine at 175 °C. The prepared sanitary napkin is shown in figure 4.

Figure 4 Prepared sanitary napkins using cotton and kenaf fibres

2.3 Testing of Sanitary Napkin

2.3.1 Preparation of artificial blood

The artificial blood used for testing of sanitary napkin was prepared using 1.0 % (W/V) NaCl, 0.4 % (W/V) Na_2CO_3, 10 % (W/V) glycerol, 0.5 % (W/V) carboxymethyl cellulose and 88.14 % (W/V) de-ionized water [10].

2.3.2 Free swell absorptive capacity

The test is to determine the total absorptive capacity of dressing in presence of excess test liquid and in absence of applied load. A sample of 2 inch length is punched out from the sample. The weight of the sample was noted and the coloured blood was taken in a syringe to wet the whole sample. Then it was allowed to absorb freely for 30min in an oven [11]. The sample was taken out and vertically drained to remove the excess blood only on the surface of the sample and absorption capacity was noted from the change in shape of the sample by observing the shape of the sample.

2.3.3 Absorbency percentage

The absorbency % is the total amount of blood the sanitary napkin can absorb till the point of leakage. Dry weight of the napkin was recorded and laid on a flat level glass plate, so that the underside of the napkin was visible. On the centre of sanitary napkin, the blood was added drop by drop slowly using a syringe [10]. The liquid was dropped till the sanitary napkin has absorbed the maximum amount of liquid and has started to leak and this will be the end point of sanitary napkin. The absorbency% was calculated using equation 1 shown below

$$\text{Absorbency } \% = \frac{\text{FW} - \text{IW}}{\text{IW}} * 100 \qquad (1)$$

Where, IW is the Initial weight of the whole napkin and FW is the Final weight of napkin.

2.3.4 Retention percentage

The retention percentage is the ability of the sanitary napkin to hold the absorbed blood on application of 1 kg weight. After the leak point the final weight of the sample was measured and a blotting paper of known initial weight was placed one on the top and one at the bottom of the sample. Over this a standard weight of 1 kg load for 1 min was applied on the portion where the fluid was absorbed. The fluid leaks to the top and bottom layer. At the end of 1 min the napkin and blotting papers from the top and bottom of the pad were removed and the final weight of the napkin and blotting papers were noted [10]. The retention % was calculated using equation 2 where, IW is the Initial weight of the whole sample and FW is the Final weight of the sample

$$\text{Retention } (\%) = \frac{\text{FW} - \text{IW}}{\text{IW}} * 100 \qquad (2)$$

2.3.5 Liquid strike through time

The time taken for the blood to penetrate inside the napkin at dry state is measured as liquid strike through time. The total napkin sample was placed over a glass plate in order to clearly watch the changes that take place in the napkin. Two drops of artificial blood were allowed to fall on the sample by using a syringe[12]. When the blood drop touches the napkin the timer is started and the timer is stopped when the drop disappears from the napkin surface.

2.3.6 Wet back strike through time

The test measures the time taken by blood to penetrate inside the napkin when it is completely wet. Colourless synthetic blood was prepared and 10ml of the blood was dropped over the napkin using a syringe to make it wet. Then 2 drops of coloured synthetic blood was allowed to fall on the napkin using a syringe and time taken by the blood drop to disappear on the top layer of napkin was noted down[12].

2.3.7 Leakage proof test

Leakage proof test is the continuation of retention test. The leak factor is the ability of the sanitary napkin to resist leaking of the absorbed blood from the sides and bottom of the sanitary napkin [10]. The leak factor was calculated using the following equation 3 where, IBB is the initial weight of the bottom blotting paper and FBB is the final weight of the bottom blotting paper

$$Leak\ Factor = \frac{\text{FBB} - \text{IBB}}{\text{IBB}} * 100 \qquad (3)$$

2.3.8 Vertical wicking test

The ability of fluid take up by sanitary napkin is determined by Vertical wicking test. The perepared sanitary napkin is clamped vertically and the 2mm edge of the napkin was immersed in test fluid. [3]. At interval of 1,2,5,10,15,20,25 and 30 minutes the rate of fluid (distance per unit time) travelled along the specimen was visually observed and recorded.

2.3.9 Antimicrobial activity test

The herbal finished top layer and kenaf fibre were tested for antimicrobial activity using AATCC 147 parallel streak method. 25 mm x 50 mm samples were taken for testing. Bacteriostasis agar medium was used as growth medium and test specimens (non sterile) were placed above the medium. Inoculums were prepared using E.coli (gram negative) and S. aureus (gram positive) bacteria [13]. Five parallel inoculums streeks of 50 mm length were loaded across the sample. The prepared samples were incubated at 37 ^{o} C for 18 to 24 hours. The samples after incubation were taken out and zone of inhibition were calculated using the following equation 4 where, $\mathbf{W_i}$ is the width of zone of inhibition and W_s is the width of specimen.

$$Zone\ of\ ihnhibition\ (mm) = \frac{W_i - W_s}{2} \quad (4)$$

3. Result and Discussion

The total absorptive capacity of the napkin in presence of excess fluid is calculated as subjectively to assess the change in shape of sample due to absorption of fluids. The tested samples are displayed in figure 5.a. This test stimulates heavy blood flow or long duration of use of sanitary napkins. The results are listed in table 1. The commercial napkin showed minimal shape change whereas 100% cotton had the highest level of swelling. Liquid strike through test measures the time taken by fluid to be absorbed by the napkin which is expected to be minimal as the wearer wants their skin to be less wet as this condition may cause uneasiness and discomfort. The tested samples are shown in figure 5.b. The commercial napkin had a minimal value and 100% kenaf had the highest value. 100% cotton had average value and Cotton - Kenaf had appreciable values due to the combination of both the properties[14].

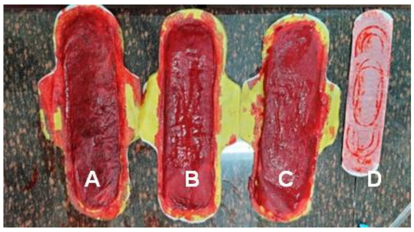

Figure 5.a. Free swell absorption capacity A – Kenaf, B–Kenaf-Cotton, C–Cotton and D- Commercial

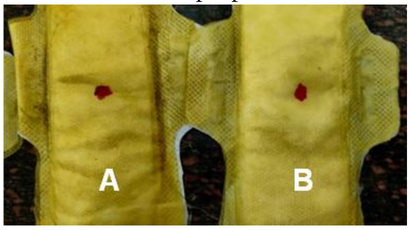

Figure 5.b. Liquid strike through test A – Kenaf and Cotton, B –Cotton

Table 1 lists the derived values of liquid strike through of developed sanitary pads. Wet back strike through test indicates the absorption of blood after the wearer had used the napkin for a certain period of time. Absorbent core with 100% kenaf had a higher value due to the shortened saturation of the fibre structure [14]. 100% cotton showed considerable results due to the inherent fibre structure. The combination of both kenaf and cotton had comparatively better results due to the arrangements of the kenaf layers below the cotton web as shown in table 1.

Table 1 Test results of developed sanitary napkins

Napkin type	Free swell absorption capacity (Change in shape)	Liquid strike through time (sec)	Wet back strike through time (sec)	Absorbency (%)	Retention (%)	Leak factor (%)	Wicking distance(mm) after 30 min
Commercial	No	3	4	353.85	98.31	0.55	65
Kenaf	No	9	11	330.85	94.81	5.0	30
Cotton	Yes	6	8	355.85	91.64	10.56	35
Cotton - Kenaf	Yes	5	5	381.74	97.83	5.56	35

One of the most crucial and indicative test on the performance of the absorbent core is the absorbency test which is depicted in figure 6.a. The absorbency percentage is highest for the combination of cotton-kenaf fibres which is 38% higher than the commercial napkin as shown in table

1. This may be due to the structural layer of cotton wherein the initial absorption is higher and the ability of kenaf to hold back 12 times of fluids to its own weight [15]. The percentage value of 100% cotton is also similar to that of the commercial one, which may be due to the ability of cotton fibre to absorb more amount of blood fluid.

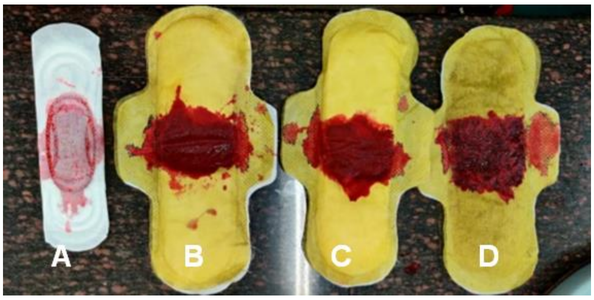

Figure 6.a. Absorbency test of samples A - Commercial, B – Kenaf and Cotton, C – Cotton and D - Kenaf

Fig 6.b. Sample tested for retention

The 100% kenaf fibre had the least value of absorption which may be due to the fact that the kenaf fibre had loose structure. Another reason is that the kenaf fibre consists of non cellulosic contents as the fibre is not treated.

Retention percentage validates whether the sanitary napkin is sufficient and satisfactory for use during physical activities which involve application of pressure like sitting. To improve retention many brands include wings in their sanitary pads. The tested samples are depicted in figure 6.b. Commercial pads had highest retention rates due to the presence of sap whereas 100% cotton had lower retention. This may be due to the low ability of the napkin to hold blood fluids within the fibres. Table 1 lists the retention values for the tested varieties. 100% kenaf had good results in comparison to cotton as it can hold larger amount of blood fluids within the fibrous structure.

Leak factor determines the wearer comfort and is also interconnected with swelling as swelling results in leakage. Most consumers expect no leakage of napkins and this may be achieved by regularly changing the napkin although the basic properties of the absorbent core affect the values and the values of those are listed in composition table 1. 100% cotton shows high leakage which may be noted from figure 6.a due to fact that it has minimal retention property. 100% kenaf had intermediate results and combination of both cotton-kenaf had good appreciable results as it has properties of both in equal proportions. Inferring from the values given in the table 1, it can be understood that there is no greater significant difference in wickability between the produced samples although the nature of the samples are different. The highest wickability is seen in commercial napkins. Both 100% kenaf and cotton-kenaf show same results which may be due to the fact that the absorbent core is formed as a layered structure rather than a blended one. The top layer treated with 10% concentration of neem and turmeric and kenaf fibre were tested for antimicrobial activity by AATCC 147 standards and tested samples are shown in figure 7.a and 7.b [16]. The extensive property to prevent and combat microbial growth in any medium is one of the key feature of utilizing neem and turmeric.

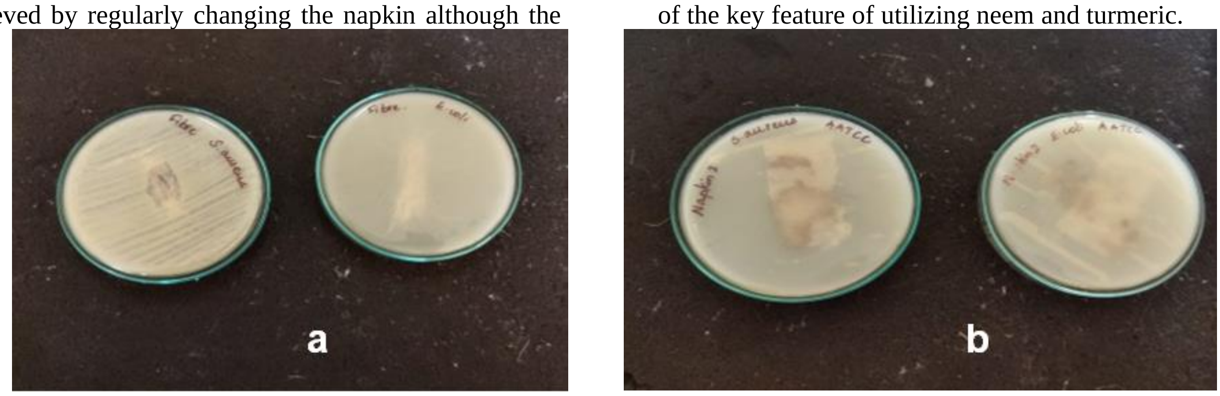

Figure 7 a. Fibre tested against gram positive and negative and b. Top layer tested against gram positive and gram negative

The treated non-woven top layer had potent antimicrobial activity against gram positive organism, the inhibition region was found to be 27.5 mm and for Gram negative organism it shows 5 mm. The tested Kenaf fibre was reported for an inhibition zone of 9.5 mm with Gram positive organism and no inhibition zone was observed with Gram negative organism. This is due to the fact that kenaf fibre has inbuilt antimicrobial and antibacterial properties.

Conclusion

Kenaf fibre proved to be a good alternative for synthetic sanitary napkins and can be effectively used in manufacturing of biodegradable sanitary napkins. Kenaf fibres in combination with cotton fibres provided added advantage in sanitary napkin properties. Cotton possesses inherent properties such as good absorbency which can be beneficial to the absorbent core in combination with kenaf fibres which results in higher efficacy of the produced sanitary napkin. The herbal antimicrobial finish using turmeric and neem on top layer of sanitary napkin further enhances the antimicrobial protection to the user. The Sanitary napkins produced in combination with cotton and kenaf showed better performance among the developed napkins. The developed cotton-kenaf sanitary napkin can be an effective alternative for synthetic napkins available in the market and the developed napkins further contributes to the environment due to is biodegradability.

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