



## FORMULATION AND EVALUATION OF BIODEGRADABLE HERBAL SANITARY NAPKIN

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### ABSTRACT

Women all around the world use sanitary napkins for menstrual protection. Menstrual hygiene and awareness has been the need of the hour for women's physical and mental health. 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 and also cause severe infections there by affecting women's health. Use of synthetic and non-biodegradable napkin results in skin irritation, itches, rashes and complicated diseases like cervical cancer on prolonged usage. To overcome this challenge, sanitary bio napkins are made from natural materials. In the present study, naturally available cheap materials like banana fiber (*Musa balbisiana*), lotus fiber (*Nelumbo nucifera*) and crown flower (*Calotropis gigantean L*) erukkum cotton which are easily available, biodegradable and cost effective were used.

**KEYWORDS:** Biodegradable, Banana fibers, Lotus fibers, Erukkum cotton, Sanitary napkin.

### 1. INTRODUCTION

A study of 'Sanitary protection Every woman's health right' estimated that 335 million menstruating women dispose sanitary napkins. Environment portal Down to earth estimated that 432 million pads are disposed every month. Since these pads are non-biodegradable, the napkins stay in the landfills for about 800 years. On an average, a single woman generates 125kg of disposable sanitary waste during her menstruating years.

Sanitary napkins should provide comfort and safety, and also improve every woman's health and lifestyle. Women place these napkins next to the most delicate and absorbent tissue in our body. Women spend at least 20% of their life with these sanitary napkins. India being a developing country, having 1.34 billion populations, in those 323.6 million peoples is female between the age

group of 15-49. In previous years, papyrus, Moss, grass, Bandages were used during menstrual time and these materials can causes Irritation, Itchiness Skin rashes, allergy and lead to very serious health problems due to the presence of microorganisms.

Nowadays everybody is concerned with creating the eco-friendly environment by reducing the environmental problems and nature pollution. Besides, health and hygiene is also very much important for human beings. The utmost pollutions are from textile industry, dye industry and healthcare industry. Among these, healthcare wastes are the major pollution that will create deliberate complications to the humans. One major problem is the manufacturing and clearance of sanitary napkins. The napkins produced by the companies which are not degradable and unsafe for women's.

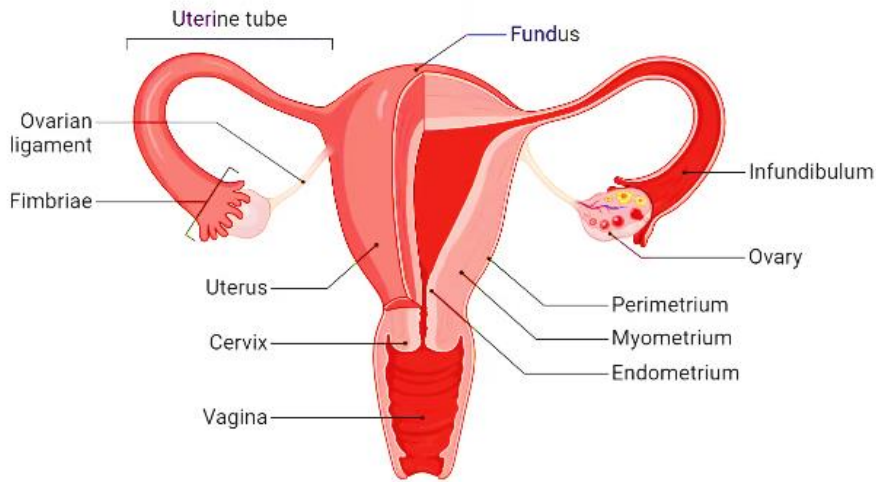


**Fig No: 1 Sanitary Napkin.**

**1.1 Female Reproductive System**

A female's internal reproductive organs are the vagina, uterus, fallopian tubes, and ovaries. The vagina is a

muscular, hollow tube that extends from the vaginal opening to the uterus. Because it has muscular walls, the vagina can expand and contract.

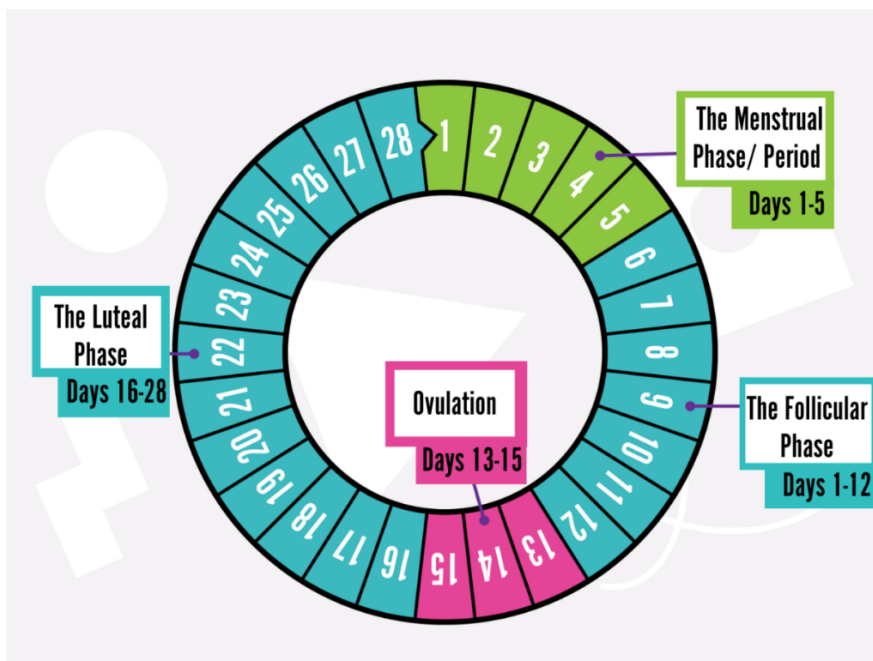


**Fig No: 2 Female reproductive system.**

**1.2 Menstrual cycle**

A menstrual cycle consists of natural changes that occur in a woman's body every month in preparation for pregnancy. Menstruation starts at puberty and ends at

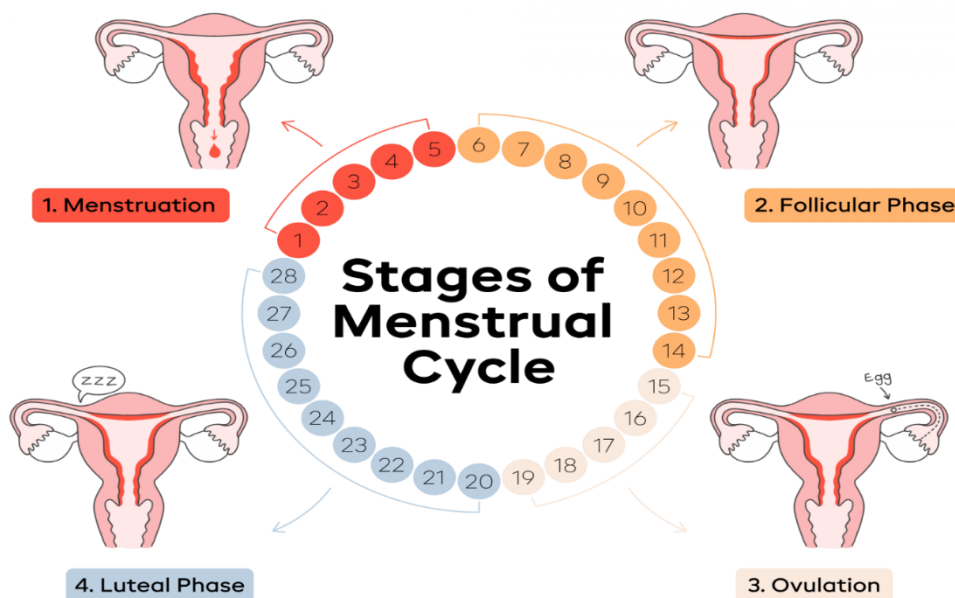
menopause. The cycle lasts an average of 28 days but may vary between 20 and 40 days. The first day of a cycle is the first day of a menstrual period and the last day is that of the following period.



**Fig No: 3 Menstrual cycle.**

**1.2.1: Phases of the menstrual cycle**

There are four phases: menstruation, the follicular phase, ovulation and the luteal phase.



**Fig No: 4 Stages of Menstrual cycle.**

**2. AIM AND OBJECTIVE**

**AIM**

Recently, natural resources are gaining attention in solving the problems faced by the people around the world. This study proved that the replacement of non-degradable material with the biodegradable material for developing products is herbal sanitary napkin. Use of natural material in napkins will be cost effective and it can be biodegradable. Using this technology, we can find

a suitable solution to make the world better for future generation.

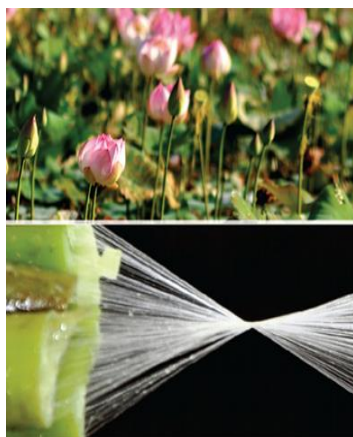
**OBJECTIVE**

Selection of the alternative herbal sanitary napkin, antimicrobial and biodegradable material/ improvement for the commercially available Sanitary Napkin. Designing of the biodegradable Sanitary Napkin.

**3. PLANT PROFILE**



**BANANA TREE**  
(*Musa balbisiana*)



**LOTUS**  
(*Nelumbo nucifera*)



**CROWN FLOWER**  
(*Calotropis gigantean L*)

**Fig No: 5 Plant pictures.**

**3.1 MUSA BALBISIANA**

Banana fiber is a natural bast fiber which has wide range of uses in handicraft product developments such as mat, rope and twines, but only 10% of its pseudo stem is being used for making products and remaining is waste

or used as fertilizer. As it has a property like weatherproof, UV protection (because of lignin content), moisture absorption, anti-oxidant and bio degradable etc., it can be used to make variety of products that help farmers economically and have wide scope to create new

market. Recent studies have indicated banana fiber possesses a lot of advantageous physical and chemical

properties which can be used a very good raw material for the textile and packaging industry.

**Table No: 1 Taxonomical classification of *MUSA BALBISIANA*.**

<b>Kingdom</b>	Plantae – plantes, Planta, Vegetal, plants
<b>Subkingdom</b>	Viridaplantae – green plants
<b>Infrakingdom</b>	Streptophyta – land plants
<b>Division</b>	Tracheophyta – vascular plants, tracheophytes
<b>Subdivision</b>	Spermatophytina–spermatophytes, seed plants, phanérogames
<b>Infradivision</b>	Angiospermae–flowering plants, angiosperms, plantas com flor, angiosperma, plantes a fleurs, angiospermes, plantes a fruits
<b>Class</b>	Magnoliopsida
<b>Superorder</b>	Lilianaes–monocots, monocotyledons, monocotyledones
<b>Order</b>	Zingiberales
<b>Family</b>	Musaceae – banana
<b>Genus</b>	Musa L. – banana
<b>Species</b>	Musa X sapientum var. paradisiaca L. (pro sp.) – banana, plantain, French plantain.

### 3.2 *NELUMBO NUCIFERA*

Natural fibers are being extensively used in recent technological and structural applications due to the need for biodegradable materials. Fiber from the stem of *Nelumbo nucifera* (lotus) and the investigations via physical, structural and thermal properties on the alkali-treated fiber. Lotus fibre is a

unique material that has been used for centuries in different parts of the world. Due to the labour-intensive nature of the process, it is considered a luxury material and is often more expensive than other textiles. However, its sustainable and natural properties make it a promising alternative to synthetic fibres in the fashion industry.

**Table No: 2 Taxonomical classification of *NELUMBO NUCIFERA*.**

<b>Kingdom:</b> Plantae
<b>Phylum:</b> Magnoliophyta
<b>Class:</b> Magnoliopsida
<b>Subclass:</b> Magnoliidae
<b>Order:</b> Nymphaeales
<b>Family:</b> Nelumbonaceae
<b>Genus:</b> Nelumbo
<b>Subject:</b> Nelumbo nucifera Gaertn.

### 3.3 *CALOTROPIS GIGANTEAN L.*

*Calotropis gigantea* fiber is a kind of natural cellulose fiber that regains increasing attention nowadays, thus it is evaluated here aiming to replace cotton or kapok fibers to some extent. New discoveries are found about its morphological structure, indicating that it has sharper, closed tip and coarser, open end, and that it usually has 4-6 grooves along its longitudinal axis, with fully distributed microvillus on its surface. the fiber is obvious lower than cotton fiber and a little higher than kapok fiber. Furthermore, the fiber has good water absorbing and releasing capability, implying it has excellent water transmissivity.

#### Taxonomical classification

- ✚ Binominal name: *Calotropis gigantea* (L.) Dryland.
- ✚ Kingdom: plantae
- ✚ Subkingdom: Tracheobionta
- ✚ Unranked: angiosperms
- ✚ Unranked: Eudicots
- ✚ Unranked: Asteroids
- ✚ Order: Gentianales
- ✚ Family: Apocynaceae

- ✚ Genus: *Calotropis*
- ✚ Species: *C. gigantea*

## 4. MATERIALS AND METHODS

### 4.1 Authentication certificate for

The plant material collected was identified and authenticated by by Dr. KN Sunil kumar Research officer HOD Department of pharmacognosy, Dr. P.Elankani Research officer (Siddha), Sci III-Incharge, SIDDHA CENTRAL RESEARCH INSTITUTE (Central Council for Research in Siddha, Chennai, Ministry of AYUSH, Government of India) Anna Govt. Hospital Campus, Arumbakkam, Chennai – 600106, Certified that the sample submitted by V Ramya, R Reshma, B Rohini, S Sandhiya and S Sandhiya, B.Pharm - Final year, Aadhibhagavan College of Pharmacy, Thiruvannamalai district - 604407 was identified as:

**Form No: PCOG002-ACF**

**Date: 03.08.2023**

#### 4.1.1 *Calotropis gigantea* (L.) Dryand

Authentication certificate for: 579.03082301

Code: C03082301G

Part: Seed hair

#### 4.1.2 *Nelumbo nucifera* Gaertn

Authentication certificate for: 580.03082302

Code: N03082302N

Part: Pedicel

#### 4.1.3 *Musa × paradisiaca* L

Authentication certificate for: 581.03082303

Code: M03082303P

Part: Leaf sheath

## 4.2 MATERIALS AND METHODS

### 4.2.1 Trail formulation of herbal sanitary napkins

Selection of raw materials with the aim of replacing them in different layers of Sanitary Napkins. Our materials have similar characteristics as present in commercially available sanitary napkin with biodegradable characterizes.

### Raw materials used in order to meet our objectives are

- ✚ Cotton netted fabric
- ✚ Super absorbent material (SAM)

- ✚ Natural fibers (husk fibers and cotton fibers)
- ✚ Non woven fabric

### The layers of our Napkin are

- ✚ First layer – Cotton net fabric
- ✚ Second layer- Super absorbent material
- ✚ Third layer- Natural fibres and cotton
- ✚ Fourth layer- Non woven fabric

### 4.2.2 Preparation of crown flower cotton (*Calotropis gigantean* L)

#### Ginning

Cotton picked from the plants contains seeds, so it must be ginned. Ginning is the method of separating cotton seeds from pods. Traditionally, ginning was done by hand. Cotton ginning is the method of extracting the fibre from the seeds. After that, the fibre goes through processes including opening, mixing, cleaning, carding, and combing.



Fig No: 6 Ginning by Hand.

### 4.2.3 Preparation of herbal sanitary napkin using banana fibre

Sanitary napkins contain multilayered structure and each layer should have some specific function. Banana fiber, Erukkum Cotton, muslin cloth and canvas cloth were used as a source of material. Banana fiber is naturally occurring material and completely degradable and poses no side effect to humans and environment. Erukkum Cotton, as top layer is one the generally prompted crude material in napkin due to its non-aggravation, tissue-friendly and prevalent fluid maintenance properties. Cotton material keeps away moisture and keeps skin dry and make skin comfort.

#### Preparation Banana Fiber

The banana fibers are extracted from the stem of the banana tree and was cut into tiny pieces. The small banana fiber pieces were taken in the vessel or beaker and allow it to boil with water for an hour. To this, sodium hydroxide was added. Later, it was filtered using

a filter paper and the mixture was poured onto a mold of a required shape and let too dry under sunlight for a day. The banana sheet is formed after drying.

#### Softening Of Canvas Cloth

Canvas cloth is used as a top layer in the sanitary napkin. It is usually used in making collar of shirts to maintain stiffness. To remove the starch from the cloth we have to soften by scrubbing it with brush so that the pore size will be increased and this also increasing the pore size of the cloth.

#### Layering Of Sanitary Napkin

Sanitary pad comprises of multilayered structure in which each layer have explicit capacity to perform. The Banana fiber sheet is wrapped up with organic cotton which is covered with Muslin cloth. The whole setup is again wrapped up with a Canvas cloth.

#### 4.2.4 Preparation of herbal sanitary napkin using lotus fiber

The fiber was collected from lotus. the fiber was dried at room temperature and checked for moisture content and stored in a properly ventilated room. Sanitary napkins contain multilayered structure and each layer should have some specific function. lotus fiber, Erukkum Cotton, muslin cloth and canvas cloth were used as a source of material.

##### Alkali Treatment

Lotus fiber was treated with sodium hydroxide solution at a concentration of 4 g/L and MLR (material to liquor ratio) of 1:40 at 80–90°C for 30 minutes. As the fibers obtained with alkali treatment were quite coarse and harsh in nature, they were further treated with enzyme to make it softer and finer.

##### Bleaching

As the fibres extracted from corn husk were yellow in colour, they were bleached using 2 g/L hydrogen peroxide for 60 minutes.

##### Packaging of napkin

The cotton was placed on to the thin lotus fibre and then it was covered by the muslin cloth. The softened canvas cloth was used to wrap the entire sheets and then the

corner of the canvas cloth in the napkin was allowed to stick using heat or else stitches can be made in the corner of the napkin.

#### 4.2.5 Preparation of herbal sanitary napkin using silk

The Silk material was collected from hand loom silk shop. Sanitary napkins contain multilayered structure and each layer should have some specific function. Wasted silk materials, Erukkum Cotton, muslin cloth and canvas cloth were used as a source of material.

##### Hydrogel Preparation

Hydrogel was synthesized by using sodium carboxymethyl cellulose, gelatin and starch as with modifications in temperature conditions. Malic acid was used as crosslinking agent. Finally cut the silk material in suitable size and then add hydrogel pasted in a silk surface to dried in room temperature.

##### Packaging of napkin

The erukum cotton was placed on to the thin silk sheet and then it was covered by the muslin cloth. The softened canvas cloth was used to wrap the entire sheets and then the corner of the canvas cloth in the napkin was allowed to stick using heat or else stitches can be made in the corner of the napkin.



Banana Fibre



Lotus Fibre



Silk



Silks with Gelling agent



Crown Flower Cotton (Erukkum cotton)



Cotton with fiber

Fig No: 7 Material used in napkins.



Napkin layer (Trail)



Banana Fibre Napkin Layout



Lotus Fibre Napkin Layout



Silk Sheet Napkin Layout

Fig No: 8 Napkin Layer Layout.



Trail - 1 Normal cotton with fibre.



Trail - 2 Erukkum cotton with fibre.



Trail - 2 Erukkum cotton with and Normal cotton fibre.  
Fig No: 9 Trail Formulation of Napkins.



F1 Banana fibre

+

Crown Flower Cotton  
(Erukkum cotton)



F2 Lotus Fibre

+

Crown Flower Cotton  
(Erukkum cotton)



F3 Silk sheet

+

Crown Flower Cotton  
(Erukkum cotton)

Fig No: 10 Formulation of Erkkum Cotton containing different Fiber napkins.

## 5. EVALUATION PARAMETERS

### 5.1 PHYSICAL PARAMETERS

The manufactured napkins were assessed for following physical parameters:

#### 5.1.1 Physical Properties Of Sanitary Napkin

The comparison of physical characteristics among various sanitary napkin pad samples used in this research. All of the Six samples used in this experiment have a product width of between 150 and 160 mm, followed by trial samples (T-1 to T-3) and newly developed samples (F-1 to F-3). The weight of the commercial samples was regarded as a standard weight during the development of sanitary napkin as the quality of sanitary napkin depends on the size and weight.

#### 5.1.2 pH Of The Sanitary Napkins

The pH of sanitary napkins was tested as per the method given in IS: 1390-1961, using the aqueous extracts of the samples. 2 g of absorbent layer from the test napkins was taken and put into 100 mL of distilled water (pH-7) at room temperature. The sample was shaken in a mechanical shaker for 30 minutes, and the aqueous extract was checked for its pH. Six samples of each type were tested, and the mean of their readings was calculated.

### 5.2 TESTING OF SANITARY NAPKIN

#### 5.2.1 Preparation Of Artificial Blood

The artificial blood used for testing of sanitary napkin was prepared using 2.5 % (W/V) Amaranth, glycerol, 7.5 % (W/V) and 90 % (W/V) de-ionized water.

#### 5.2.2 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. 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.

#### 5.2.3 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. When the blood drop touches the napkin the timer is started and the timer is stopped when the drop disappears from the napkin surface.

#### 5.2.4 Wet Back Strike Through Time

The test measures the time taken by blood to penetrate inside the napkin when it is completely wet. Colour less 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.

#### 5.2.5 Wicking Test

The ability of fluid take up by sanitary napkin is determined by Vertical wicking test. The prepared sanitary napkin is clamped vertically and the 2mm edge of the napkin was immersed in test fluid. 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.

#### 5.2.6 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.

$$R = 100 (M - D) / (D - T)$$

Where,

R = retention %

M = mass of moist with its tare mass in grams

D = mass of dried with its tare mass in grams

T = mass of the tare.

#### 5.2.7 Total Absorptive Capacity By Pad

Absorptive capacity performs a significant feature in sanitary napkins, which are determined by the frequency of use without blood leakage. Absorptive capacity (amount of liquid absorbed) of sanitary napkin may be represented by the ability to absorb liquid or menstrual fluid (Fraizer 2006; Chakwana and Nkiwane 2014). The absorption experiment was performed using artificial blood to assess the absorption capacity of the pad samples. Absorptive capacity of developed pad samples was evaluated herbal sanitary napkins.

## 6. RESULTS AND DISCUSSION

### RESULTS

#### 6.1 Physical parameters

Table No: 3 Physical Parameters.

S.NO	SAMPLE NO	PRODUCT LENGTH (mm)	PRODUCT WIDTH (mm)	PRODUCT THICKNESS (mm)	PRODUCT WEIGHT (gm)	PRODUCT pH
1	T1	275	160	5.30	7.37	6.58
2	T2	275	150	5.40	7.50	6.53
3	T3	280	155	6.10	8.10	6.44
4	F1	285	150	5.10	8.97	7.15
5	F2	290	150	5.10	8.63	7.18
6	F3	280	150	5.25	9.10	7.30

#### 6.2 Testing of sanitary napkin

Table No: 4 Testing Of Sanitary Napkin.

S.NO	SAMPLE NO	RETENTION %	TOTAL ABSORPTIVE CAPACITY	LEAK THROUGH AND REMARKS
1	T1	83.31 %	54.76	No leak through
2	T2	86.75 %	58.21	No leak through
3	T3	84.01 %	53.97	No leak through
4	F1	98.81 %	67.31	No leak through
5	F2	97.43 %	64.20	No leak through
6	F3	91.78 %	60.02	No leak through

Table No: 5 Testing Of Sanitary Napkin.

S.NO	SAMPLE NO	FREE SWELL ABSORPTION CAPACITY (Change in shape)	LIQUID STRIKE THROUGH TIME (sec)	WET BACK STRIKE THROUGH TIME (sec)	WICKING DISTANCE (mm) AFTER 30 min
1	T1	NO	4	6	55
2	T2	YES	6	9	50
3	T3	NO	7	8	65
4	F1	NO	4	7	35
5	F2	NO	9	10	45
6	F3	YES	12	10	40

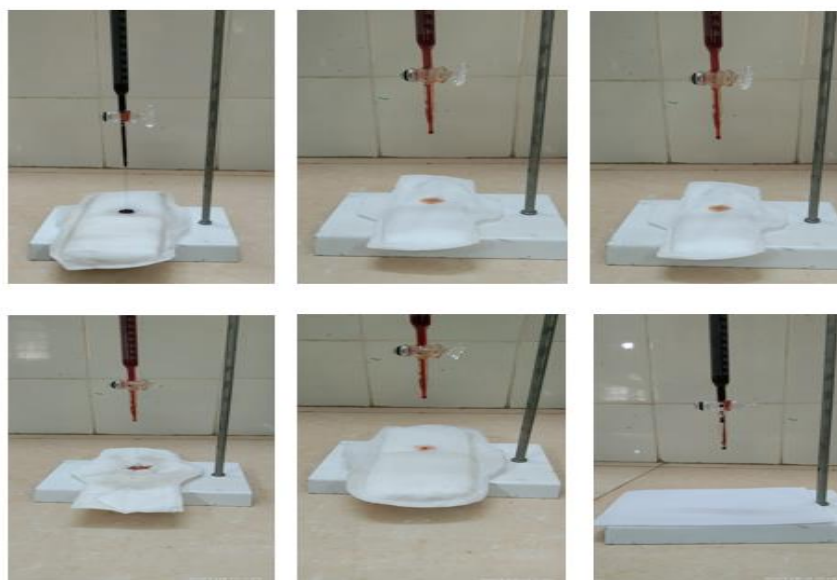


Fig No: 11 Liquid Strike Through Test.



Fig No: 12 Absorbency Test.

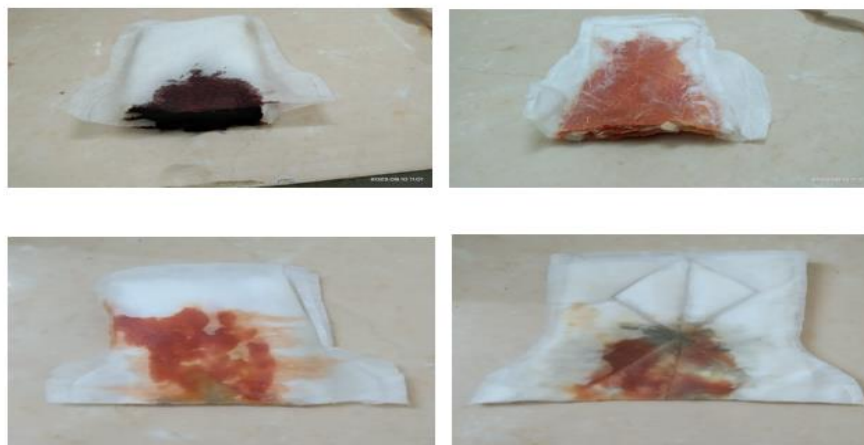


Fig No: 13 Retention Time.



Free Swell Absorption Capacity



Artificial Blood

Fig No: 14 Free Swell Absorption Capacity &amp; Artificial Blood.

## DISCUSSION

Banana and lotus fibre proved to be a good alternative for sanitary napkins and can be effectively used in manufacturing of biodegradable sanitary napkins. fibres in combination with erukkum cotton fibres *CALOTROPIS GIGANTEAN L* 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 fibres which results in higher efficacy of the produced sanitary napkin. The results of the study clearly indicate that Banana, lotus fibres and silk sheet could prove to be

a promising alternative in various hygiene products like sanitary napkins, diapers and absorbent sheets.

Though the absorbency and water retention of banana fibres are very high, This might have resulted due to factors such as the top sheet and erukkum cotton *CALOTROPIS GIGANTEAN L*, used in the construction of sanitary napkins. As consumption of hygiene products is on a continuous rise, alternative sources are required to replace wood pulp due to environmental concerns. As fibre is considered a waste, its utilization as replacement of big leap in conservation of natural resources.

## 7. CONCLUSION

Recently, natural resources are gaining attention in solving the problems faced by the people around the world. The Sanitary napkins produced in combination with cotton and fibre showed better performance among the developed napkins. The developed cotton-fibre 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 its biodegradability. Use of natural material in napkins will be cost effective and it can be affordable by the lower income people. Using this technology, we can find a suitable solution to make the world better for future generation.

## 8. REFERENCES

- Barman A\*, Katkar PM and Asagekar SD. "Natural and Sustainable Raw Materials for Sanitary Napkin", *Textile Sci Eng*, 2017; 7: 3.
- Dhinakaran M, Senthil CS, Sathis TK (2017) "Development and characterization of sanitary napkins with Lyocell/Modal as absorbent core". *International Research Journal of Engineering and Technology*, 4: 1003-1006.
- C.Vigneshwaran, V.Pavithra, V.Gayathri and K.Mythili: Banana fiber: Scope and Value Added Product Development vol.9 issue 2, spring2015
- O. L. Shanmugasundaram, R V M Gowda, "Development and Characterization of Bamboo and Organic Cotton Fibre Blended Baby Diapers" *Indian Journal of Fibre & Textile Research*, Sept. 2010; 35: 201-205.
- Pepper LR, Dumain J (2016) *Textile exchange organic cotton market report*.
- Pohlmann M (2016) Design and materials selection: analysis of similar sanitary pads for daily use. *International Journal of Engineering Research and Application*, 6: 74-79.
- AATCC Test Method 30-1993. Antifungal activity, assessment on textile materials: mildew and rot resistance of textiles. AATCC Technical Manual, American Association of Textile Chemists and Colorists, Research Triangle Park, NC.
- Chanana, Bhawana and Suri, Mona. 2005. Design and development of low cost sanitary napkins using cotton knitwear waste.fiber2fashion.com.
- Indian Standards, Specifications for Sanitary Napkins, (First revision), IS: 5405-1981.
- Indian Standards Institution, New Delhi.
- Joshi, M.; Ali, S. Wazed; Purwar, R. and Rajendran, S. 2009. Eco friendly antimicrobial finishing of textiles using bioactive agents based on natural products. *Indian Journal of Fibre and Textile Research*, 34: 296-304.
- M. M, "Development of Eco-Friendly Sanitary Napkins using *Sansevieria trifasciata* Fibres coated with *Rosa damascena* Extracts," *Int. Res. J. Adv. Sci. Hub*, vol. 3, no. Special Issue ICOST, 2021; 2S: 76–82. doi: 10.47392/irjash.2021.043.
- Das, A., Kothari, V. K., Makhija, S., Avyaya, K. 2008. Development of High-Absorbent Light-Weight Sanitary Napkin. *Journal of Applied Polymer Science*, 107(3): 1466-1470.
- Karakurd Elma, S., Kaynak, I., Nohut, S., Daşdemir, M. 2018. Development of Novel Sanitary Napkin Airlaid Absorbent Core Material with Improved Liquid Acquisition Performance. 7th International Technical Textiles Congress, 10-12 October, Izmir.
- Wijesingha, R.A.N.S., Perera, M.A.I. 2017. Developing Sanitary Napkins Using Corn Husk Fibres. *Proceeding of the 15th Open University Research Sessions OURS*, 2017; 129-132.
- Woeller KE, Hochwalt KE (2015) Safety assessment of sanitary pads with a polymeric foam absorbent core. *Regulatory Toxicology and Pharmacology*, 73: 419-424.
- Teli MD, Mallick A, Srivastava A (2015) Parameters of choice of sanitary napkins-a techno-commercial survey. *Journal of the Textile Association*, 76: 235-235.
- Farage MA (2007) A Behind the scenes look at the safety assessment of feminine hygiene pads, *The New York academy of sciences*.
- Brindha MD, Vinodhini V, Alarmelumangai K, Malathy NS (2012) Physicochemical properties of fibres from banana varieties after scouring. *Indian Journal of Fundamental and Applied Life Sciences*, 2: 217-221.
- Mishra S, Pandey R, Singh MK (2016) Development of sanitary napkin by flax carding waste as absorbent core with herbal and antimicrobial efficiency. *International Journal of Science, Environment and Technology*, 5: 404-411.
- Chanana B. Design and development of low cost sanitary napkins. PhD thesis. Delhi: Lady Irwin College, University of Delhi, 2009.
- Arif D, Niazi MBK, Ul-Haq N, Anwar MN, Hashmi E (2015) Chitosan coated cotton fiber: physical and antimicrobial properties for apparel use. *Fibers Polym*, 16(7): 1519–1526.
- Bardajee GR, Pourjavadi A, Soleyman R, Sheikn N (2008) Irradiation mediated synthesis of a superabsorbent hydrogel network based on polyacrylamide grafted onto salep. *Nucl Instrum Methods Phys Res B*, 266: 3932–3938.