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Production of Semi-Biodegradable Sanitary Napkins from Banana Pseudo-stem

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Abstract

Women all around the world use sanitary napkins for menstrual protection. In India only small percentage of women uses sanitary napkins. The main reason for such a low number relates to the affordability of sanitary napkins for people and sanitary napkins available now are non-biodegradable and also cause severe infections which in result affects the women's health. To overcome this challenge, sanitary bio napkins are now made from natural fibres and cotton which are readily available, biodegradable and cost effective. Another perk of using the natural materials was their characteristics like porosity, quick absorption of fluid and its retention capacity of blood for longer time.

The alternative to commercially supplied pads is environmentally friendly plant fibres. Plant fibres are lignocellulosic fibres composed of cellulose, hemicellulose, lignin, pectin, and other polymers. Plant fibres are suitable alternative to commercial sanitary napkin because of its abundance, biodegradability, non-irritant and chemical free, environmental friendliness properties. Emphasis is given to use naturally available absorbents fibres such as banana fibres made from pseudo-stem waste which is usually dumped in open lands leading to soil pollution, also they are they are biodegradable and widely available in nature having low carbon footprint which not only makes it ecofriendly but also reduces the cost of sanitary pad. In present study use of banana fibre and cotton as absorbent core, cotton non-woven fabric spun-lace (both hydrophilic and hydrophobic), PE (polyethylene sheet) as a barrier which prevent leakage of blood and porous sheet as top layer which absorbs blood readily to develop our semi-biodegradable sanitary napkin. Extraction of banana fibre from banana pseudo-stem and alkaline treatment, grinding, drying, pulverization of banana fibre was done respectively to obtain banana fibre pulp from it and further use it as the absorbent core of napkin. The tests were performed for understanding that sanitary napkins developed are up to standard levels of commercially supplied pads. The tests performed were absorbency capacity, leakage test, strike rate and pH test. Hence, the developed napkin is semi-biodegradable.

KEYWORDS: Sanitary napkins, Semi-biodegradable, Banana fibre, Banana Pseudo-stem.

INTRODUCTION

In low-and middle-income countries women struggle to maintain good menstrual hygiene. Many research shows the challenges of menstrual hygiene management in our country. However, studies conducted also highlight consistent challenges in woman's menstrual experience. These struggles are in

part due lack of affordable sanitary necessities. Poor menstrual hygiene can show severe effects on urinary and reproductive organs leading to infertility and other reproductive organ issues. Moreover, in India 40% of girls are absent from school when menstruating. If sanitary pads could be made affordable in terms of cost and product quality, then it will be possible to increase the attendance rate of girls while their menstruation period. As reported females staying longer in schools result in reduced maternal death, improved population health, increased awareness about HIV and HPV.

Usually, the traditional ways of managing menstrual bleeding in our country is the use of clothes, paper, cotton, wool pieces and even leaves which have less absorption capacity and may even cause various infections to the skin due to the attack of various microbial species. Therefore, it is important to use superior absorbents and cost effective menstrual hygiene products.

Sanitary napkin is an absorbent material worn by women during menstruation time. Proper menstrual hygiene practices need to be followed during the menstruation period to improve the health status of women [1]. The essential requirements of sanitary napkins are to absorb and retain blood without leakage, comfort wetting behaviour, breathability, sterilization stability and anti-microbial properties without skin irritants and allergic tendencies [2].

The menstruation is a biological cycle occurring in woman's life throughout the reproductive stage, which starts at the age of 12 or 13 which is termed as 'Menarche' and it ends by the age of 45 to 50 which is termed as 'Menopause'. Every woman has different menstrual cycle, and can vary in duration from one woman to next one, it typically lasts 28 days. The average woman experiences around 2000 periods over the course of her 38 years of life, with the average cycle lasting between 3 and 7 days. The follicular phase (proliferative), ovulation phase, and Luteal phase (secretory) are the three stages of menstrual cycle. Each month the endometrium becomes inflamed, and the luminal portion is shed during menstruation. Menstrual fluid contains mucous, vaginal secretions along with blood.

HYGIENE CARE TO BE TAKEN WITH SANITARY PAD

It goes without saying that during periods, one has to maintain cleanliness and hygiene. Not only does it impact the health but maintaining proper hygiene is also important to prevent certain diseases like UTIs or yeast infections. Hence, the primary and most important maintenance requires changing pads frequently during a menstrual cycle. Pad should be changed in the timespan of 4-6 hours. Using sanitary pad longer than that may lead to severe health issues.

BANANA PLANT

Scientific Classification
Kingdom: Plantae
Division: Magnoliophyta
Class: Liliopsida
Order: Zingiberales
Family: Musaceae
Genus: Musa
Species: acuminate

Fig1: Banana Plant
Courtesy: Google Search

The common name for any of the very large, tree-like, herbaceous plants comprising the genus Musa of the flowering plant family Musaceae is Banana. It contains an above-ground pseudo-stem (false stem) with a terminal crown of large leaves, and elongated and clusters of edible fruit. Banana plant is important for ecosystem as well as commercial purposes. Primarily bananas are cultivated for their fruit and to a lesser extent for the production of fibre. It is very popular for the fact that it has unique texture, taste and can be obtained round year. Ecologically, the plants provide food for various animals, including insects. Bananas are native to the tropical region of Southeast Asia.Banana has seven recorded wild species which are *Musa. lolodensis, M. maclayi, M. peekelii, M. jackeyii, M. textilis, M. bukensis, M. fehi* .

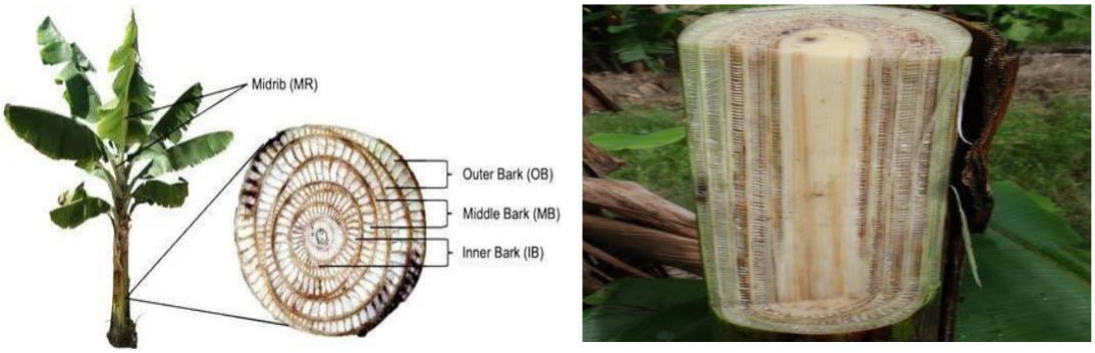


Fig2: Banana Pseudo-stem
Courtesy: Google Search

Banana plant contains a large perennial herb with leaf sheaths that form the trunk which is termed as Pseudo-stem and carry 8-12 leaves that are up to 2.7 m long and 0.6 m wide. It was discovered that the leaf sheath of the banana pseudo-stem is covered in layers. Different species of banana pseudo-stem have different measurements. Banana pseudo-stem consists of 13 layers of the sheath and 11 leaf sheat in the outer layer in the pseudo-stem can be utilized for extracting fibres. A soft central core is present in the pseudo-stem and is tightly covered up by 25 leaf sheaths.

Fibres of high quality are produced due to the chemical composition of banana pseudo-stem and therefore it was selected for the production of sanitary napkin. Different sheath layers contain different percentages of cellulose, lignocellulose and hemicellulose. 60% of the pseudo-stem contain cellulose and lignin content is 20%. Lower lignin content is present in banana pseudo-stem than wood and straw and higher ash and extractive content than wood fibre. Fibres produced from the extracted banana pseudo-stem is attracting the interest of researchers due to its export potential as a source of fibre. According to the variety, soil conditions, climatic, irrigation banana pseudo-stem are of different qualities.

Further, after each harvest farmers either burn banana pseudo-stem which causes air pollution or have to have to pay additional labor to remove them from their farms [3]. The banana plant's stem is a biodegradable agro waste that is reusable, re-plantable and monocarpic. Banana contains natural qualities such as UV protection, moisture absorption, antimicrobial and antioxidant [4]. These properties of banana fibre make banana fibre pads sustainable hygiene product [5]. The amount of CO2 emitted from one commercial sanitary pad is approximately 0.41 kg CO2 while the amount of CO2 liberated from banana fibre pads isestimated to be less than 0.04 kg of CO2 [5][6]. pH is one of the important parameters for sanitary pads. The pH of the sanitary napkins produced is in the range of 7-7.9, which is optimum, and within this range, microbial growth is not observed, making banana fibre pads safe to use [5][7]. Banana fibres are an excellent alternative to synthetic fibres used in sanitary napkins. Banana fibres used in sanitary pads is completely safe, offers antimicrobial protection, retentiveness and comfort. Organic cotton is one the generally used crude material in pads due to its tissue friendly and prevalent fluid maintenance properties. Cotton material keeps away moisture and is comfortable for skin and keeps skin dry.[3]

Sanitary napkin developed by us contains following layers:

1. Top sheet: perforated sheet
2. Non-woven cotton spun-lace hydrophilic layer
3. Absorbent core: Banana fibre pulp+ absorbent cotton
4. Non-woven cotton spun-lace hydrophobic layer
5. Back layer: PE (polyethylene sheet)

Steps involved in production developed sanitary napkins:

Extraction of banana fibre pulp which was done manually and using various shredding machines. Obtained banana fibre then undergoes various treatments which include alkaline treatment with NaOH to lose its tensile strength, then the obtain fibre was grinded using mixer and sheets were prepared out of it. The sheets were sundried and cut into pieces for pulverization (the process in which grinding of large particles take place to make it soft and tiny) which in turn given banana fibre pulp. The obtained banana fibre pulp was combined with absorbent cotton and used as absorbent core of the sanitary napkins. The remaining layers were assembled together with help of hot melt glue which is a construction gum. The developed sanitary napkin is therefore, semi-biodegradable and also helps in managing waste produced from dumping and burning of banana pseudo-stem.

2. Materials and methodology

2.1 Materials

a. Banana fiber pulp
b. Absorbent cotton
c. Perforated sheet
d. Polyethylene sheet
e. Non-woven sheets
f. Hot melt glue

Sanitary napkins contain multi-layer structure and each layer have some specific function. Its designed is based on conventional four layered design with a transferable top layer.

a) Top sheet: it is designed to transfer fluid quickly from the top sheet to the secondary layers. The material used is a perforated sheet which is breathable and allow the fluid to move to the next layer easily.
b) Non-woven layer (hydrophilic): this is the second layer of sanitary pad which is made up of cotton spun-lace which is a hydrophilic absorbent fibre that allows the fluid to pass through it as it is liquid loving and helps to make absorption faster.
c) Absorbent core: this layer is made up of extracted banana fiber pulp combined with absorbent cotton. This layer is interposed between top sheet and barrier layer and its main function is to absorb and retain the fluid. It has comfort, is thin, soft and pliable. 6 grams of this combined fibre was used in each sanitary napkin.
d) Non-woven layer (hydrophobic): this is the second last layer of sanitary pad which is made up of cotton spun-lace which is a hydrophobic fiber that prevents the leakage of the fluid.
e) Back layer: it is the last layer of sanitary pad which is made up of PE (polyethylene) sheet which acts as a barrier layer and prevents the leakage of fluid.

Fig4: Banana fibre

Fig: i. Banana fibre pulp

Fig: ii Absorbent cotton

Fig iii: Perforated sheet

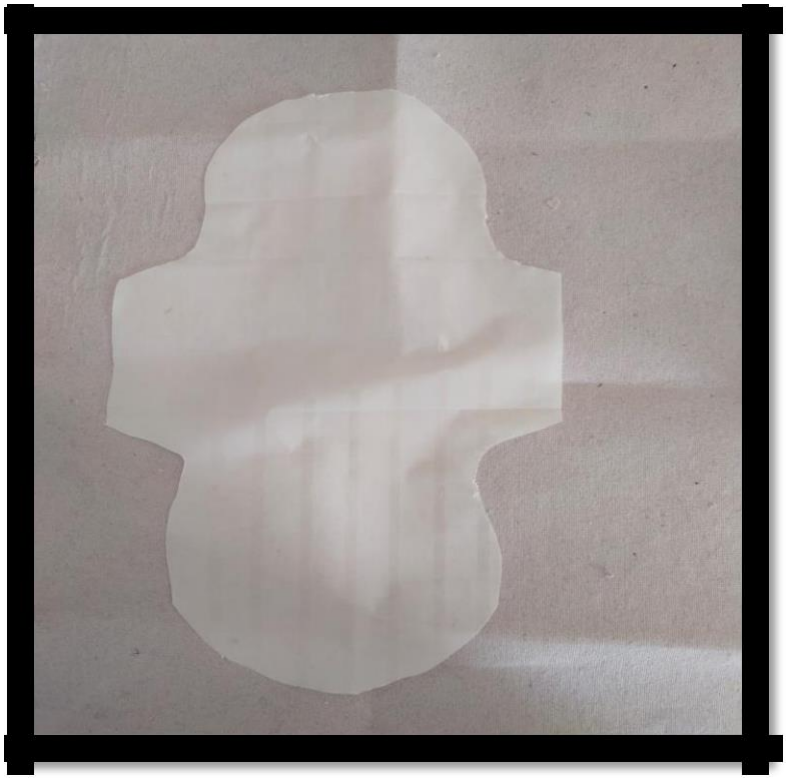


Fig iv: PE (polyethylene) sheet

Fig v: Non-woven hydrophilic sheet

Fig vi: Hot melt glue

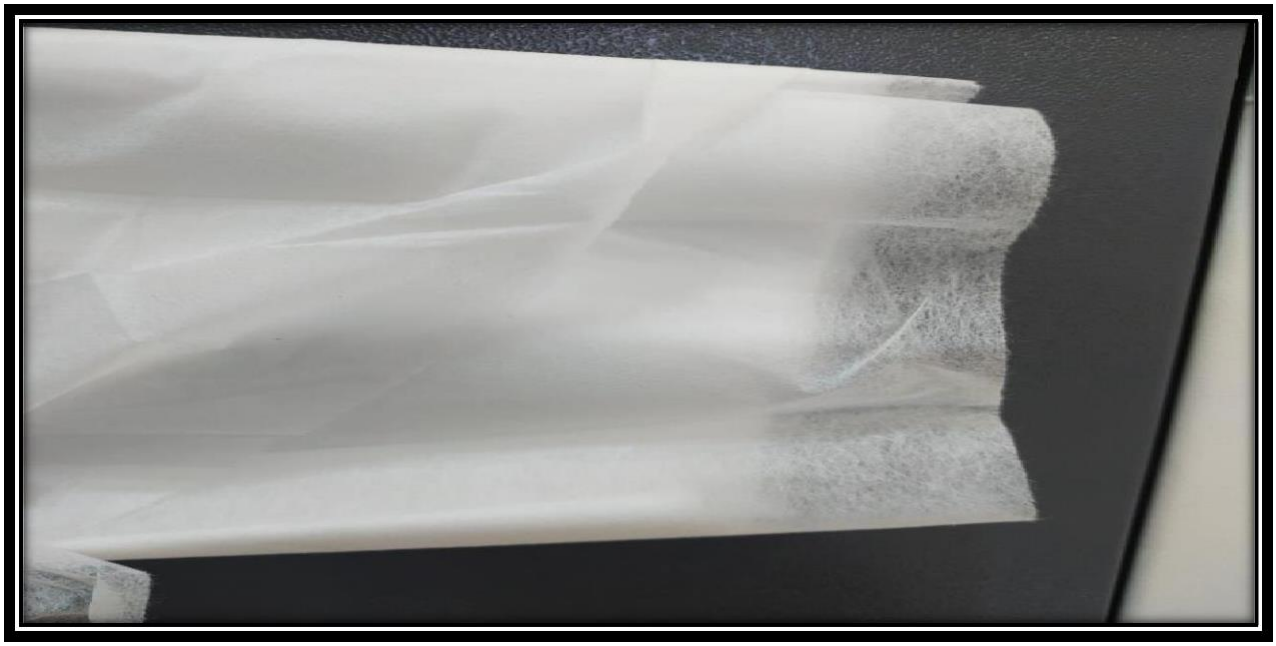


Fig vii: Non-woven hydrophobic layer

3.2. Methodology

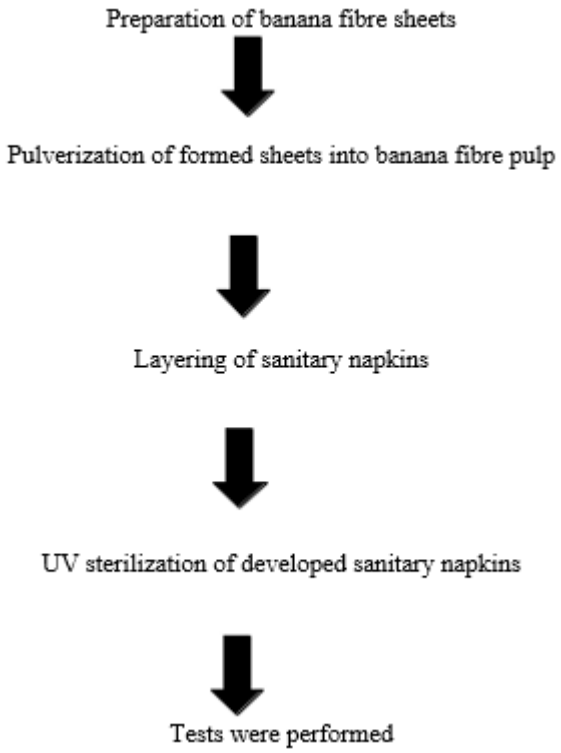


Fig 5: Flow chart of methodology

3.2.1 Preparation of banana fiber sheets

Extraction of banana fiber from the pseudo-stem of the plant was done manually. After extraction, the fibers were cut into tiny pieces and then it was taken in beaker or vessel and was allowed to boil with 150ml of distilled water. 5 grams of sodium hydroxide (NaOH) was added to it. This mixture was allowed to boil for an hour. The mixture was then cooled for about 1 and half hour. Using a paper mould the mixture was then shaped into thin sheets and were allowed to sundry for 12 to 15 hours.

3.2.2 Pulverization of formed sheets into banana fiber pulp

It is the process of applying an external force to a solid material of a certain size to destroy it and reduce it into pieces that are smaller than the original size. The sheets formed were cut into small pieces and then transferred to a pulverizing machine which in turn converts the sheet into fluffy cotton like material which is termed as banana fibre pulp. This banana fibre pulp will now be used as an absorbent material in the sanitary napkin.

3.2.3 Layering of Sanitary napkin

Sanitary pad comprises of multilayered structure in which each layer has unique capacity to perform [8] The banana fibre sheet is combined with absorbent cotton which is then covered by non-woven layers (hydrophilic layer above the absorbent core and hydrophobic layer below absorbent core. The whole setup then has perforated present as a top layer or top sheet which comes in direct contact to skin and PE (polyethylene) sheet as back layer or barrier sheet. All the layers adhere to each other with help of hot melt glue which acts as constructing gum.

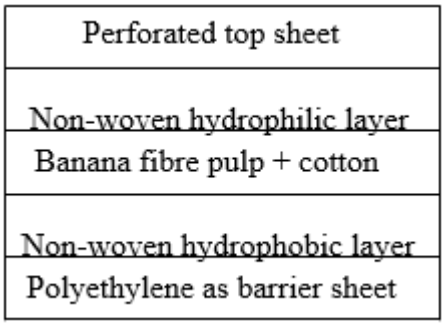


Fig6: Sanitary Napkin Layout

3.2.4 UV Sterilization

The developed sanitary pads were now exposed to UV (Ultraviolet Rays) to sterilize it properly so that all microbes already present on the surface of sanitary pad while its development gets destroyed and we get microbe free sanitary napkins

3.2.1 preparation of banana fibre sheets

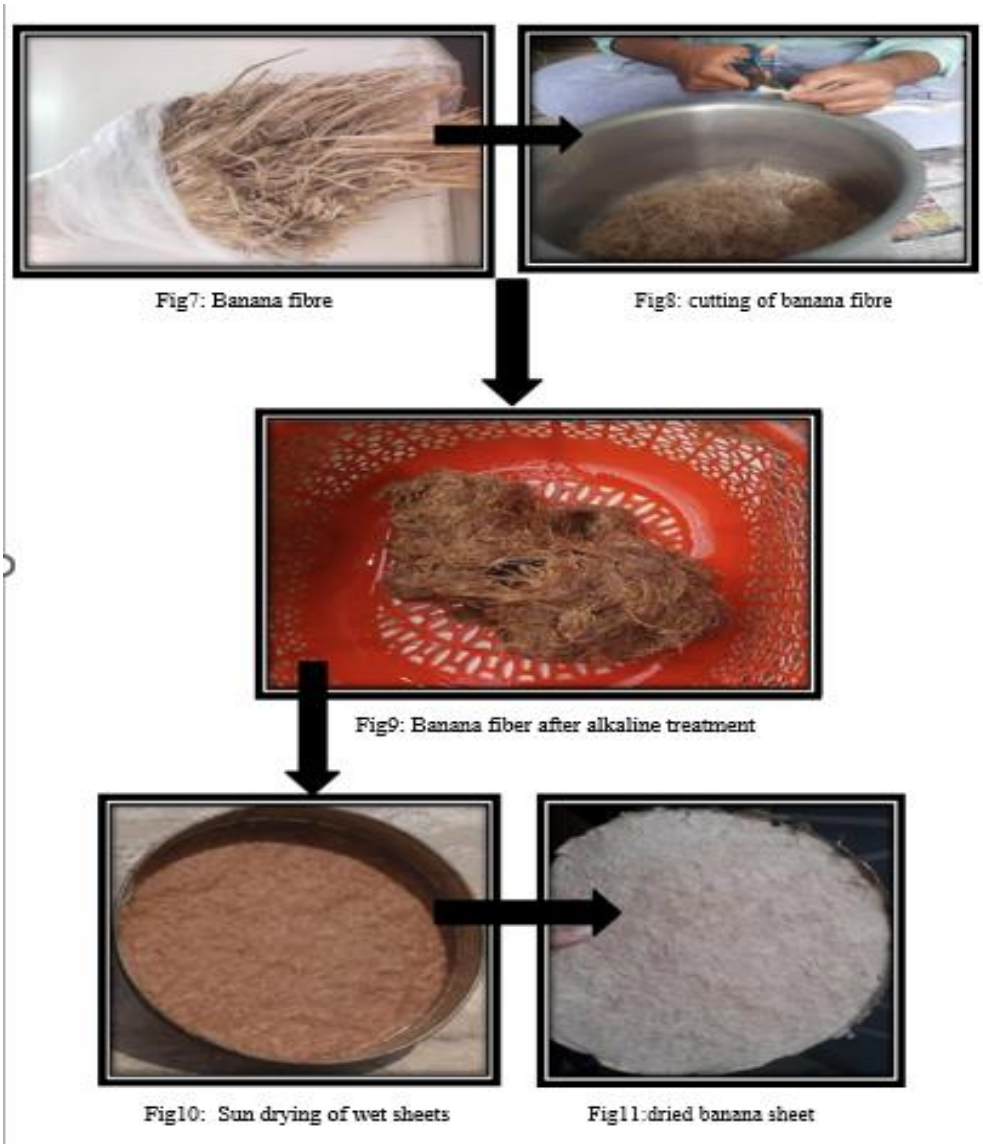


Fig7: Banana fibre

Fig8: cutting of banana fibre

Fig9: Banana fiber after alkaline treatment

Fig10: Sun drying of wet sheets

Fig11:dried banana sheet

3.2.2 Pulverization of formed sheets into banana fibre pulp

Fig12: Banana sheet teared in small pieces

Fig13: Pulverization

Fig14: Banana fiber pulp

3.2.3 Layering of sanitary napkins

Fig15: Perforated sheet (top layer)

Fig16: Absorbent core + non-woven sheet (Middle layer)

Fig17: PE sheet (back layer)

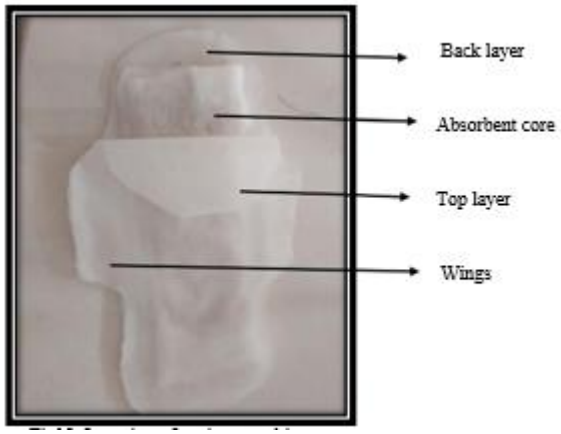


Fig18: Layering of sanitary napkin

Composition and of dimensions of sanitary napkins:

Composition

Top layer	Cotton spun lace non- woven hydrophilic layer(270nm)
Absorbent core	Banana fibre and absorbent cotton (220nm)
Barrier sheet	Non – woven hydrophobic layer (220nm)
Back layer	PE sheet (270nm)
Dimension	
Length	270mm
Width	80mm
Thickness	10mm

Fig19: composition and dimensions

3.2.4 UV Sterilization

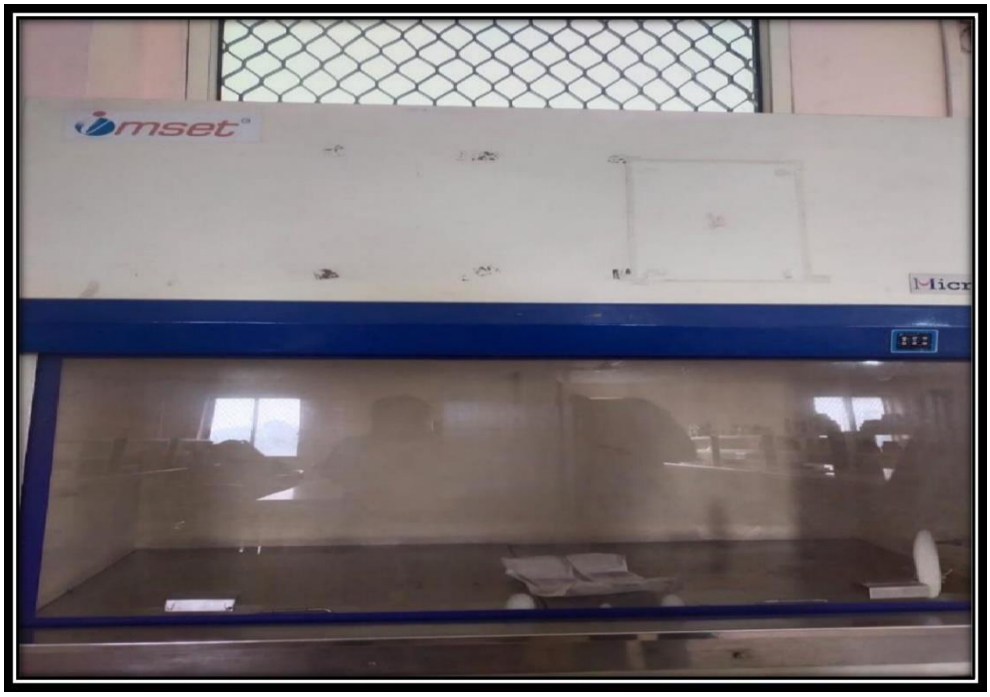


Fig20: UV Sterilization

4. Test methods

4.1. Absorbency capacity

The absorbency capacity is evaluated in accordance with EAS 96:2008-Annex C standard. The sample is first weighed in dry state, and then the fluid is added until saturation is attained. When the pad reached the saturation, a 3.4 kg weight is placed over it, and the excess liquid is wiped off using filter paper and then the pad is weighed. The following formula is used to determine the absorption capacity:

Absorption capacity = (W-X) gm

where,

X is the dry weight of the pad expressed in grams.

W is the final weight of the pad after saturation underweight expressed in grams.

4.2. Leakage proof test

According to EAS 96:2008-Annex B, the test is conducted to analyze the efficiency of the barrier layer. A barrier sheet of 6.5 cm by 6.5 cm specimen size is cut, folded into a cone shape, and placed in a funnel. The test fluid is poured in it. After 24 hours, the fluid filled tunnel was retained and checked for leaks.

4.3 Strike through

One drop of test solution is dropped on test specimen (125mm x 125mm). The time taken by the test fluid to travel from the top layer to the interior layers of the sanitary napkins measured. The duration of time travel is measured in seconds.

4.4 pH of top sheet

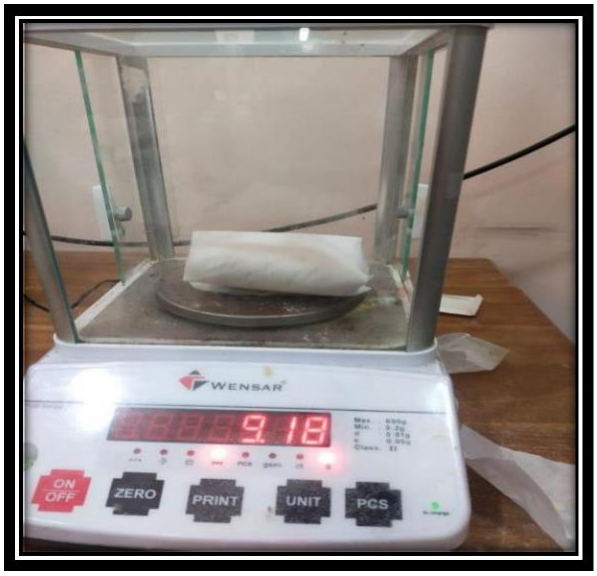
A pH meter is an instrument used to measure hydrogen ion activity in solutions; in other word this instrument measures the alkalinity or acidity of a solution. The degree of hydrogen ion activity is ultimately expressed as the pH level, which generally ranges from 1 to 14.

The pH meter is calibrated with pH 4 and 7 buffer solutions.

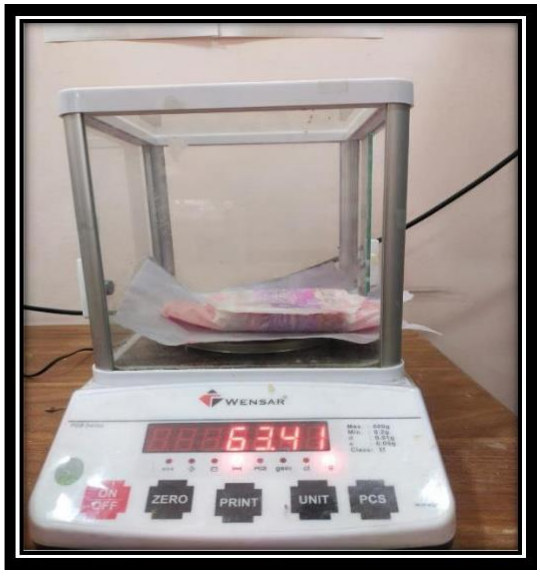
4] RESULT

1.1 Absorbency capacity

Napkin size	Before weight	After weight	Liquid absorbency
Regular	9.18grams	63.41grams	25ml



a) Before weight



b) After weight

Fig24: Fluid absorbency test

5.1.Leakage proof test

Barrier sheet length	Barrier sheet width	Water	Time (hours)
6.5 cm	6.5 cm	20ml	24

Before 24 hours

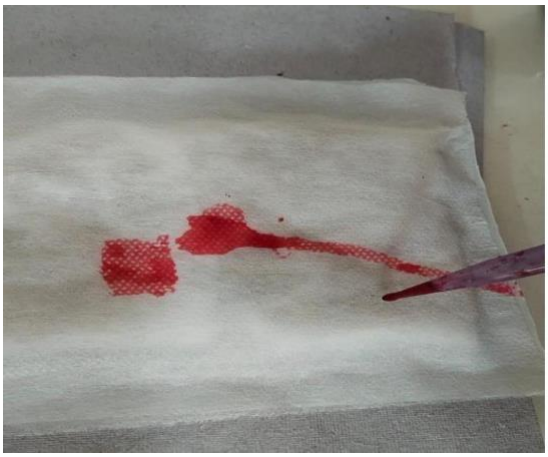
After 24 hours

Fig 25: Leakage proof test

Leakage resistance of the material chosen for sanitary pad's barrier layer has been tested to see how well it can prevent leaks. Only few drops of test fluid were observed after 24hours. The test result demonstrates good liquid resistance of the barrier sheet.

5.3. Strike through

The top sheet of the pad determines whether a test will pass or fail. Below figure depicts the strike through of sample. Additionally, it is suggested that the strike through rate is unaffected by finishes. The fluid is quickly drawn in 14 seconds and transferred to the core structure.



a)Pour fluid

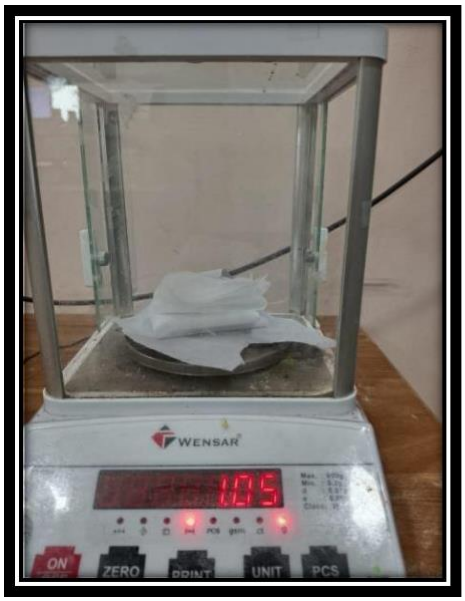
b) Strike through

Fig 26: Strike through test

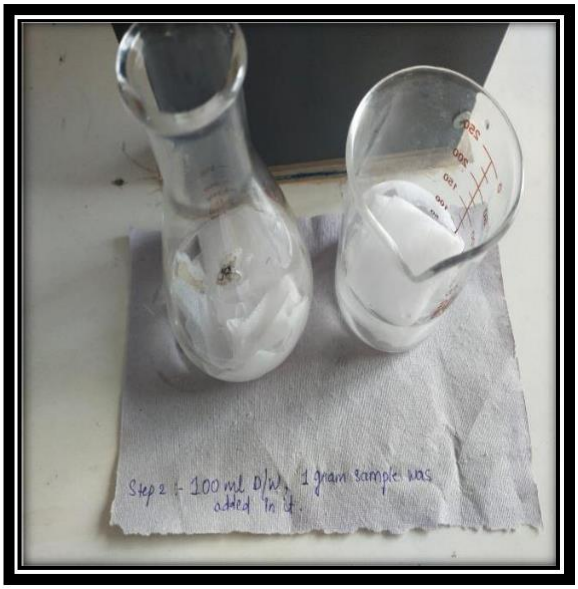
5.4. pH test

pH 4.0 calibration solution into small beaker and insert the electrode. Once the meter is calibrated with the 4.0 solution, it will flash 7.0. Rinse the probe with distilled water, dry it and insert it into a beaker of 7.0 calibration solution. Once it stops flashing, it is calibrated and ready for use.

Add 1 gram of test sample on 100ml distilled water insert the electrode. Wait until the readings become steady. The value of the tested sample is 7.44 pH the pH of the top sheet of the developed sanitary napkin is found to be 7.44 which is slightly acidic.



a) Weight



b) dip in solution

c) pH value

5.5. Final product

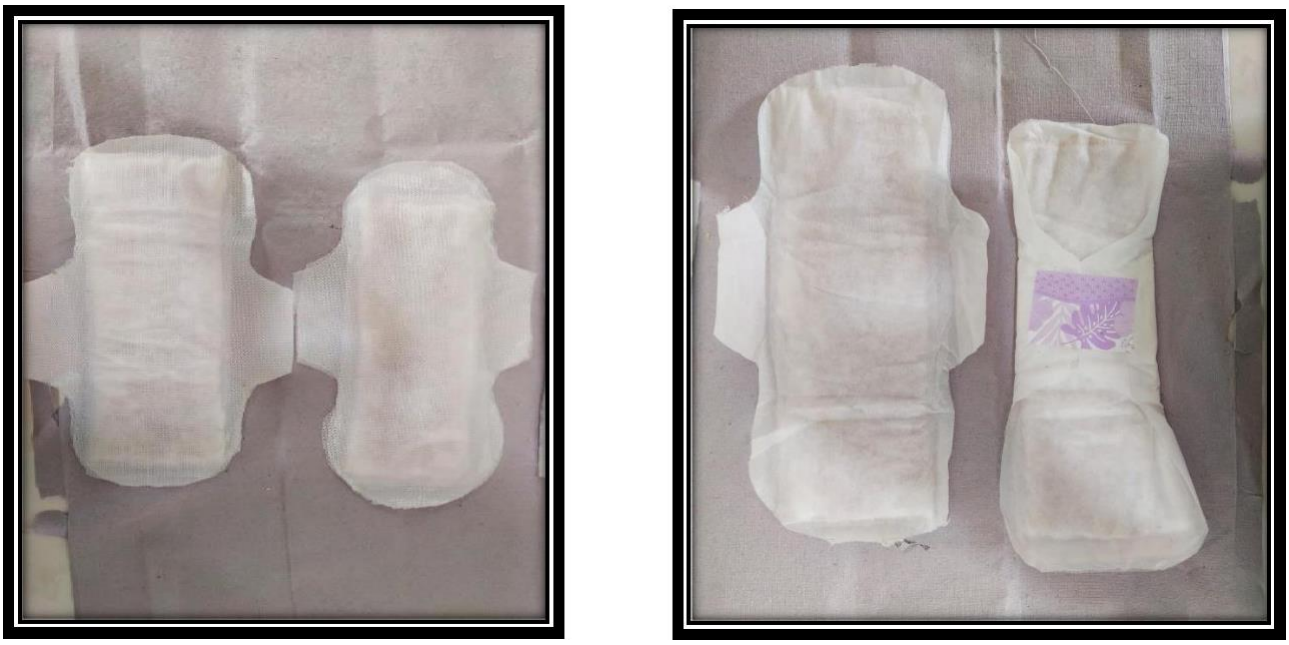


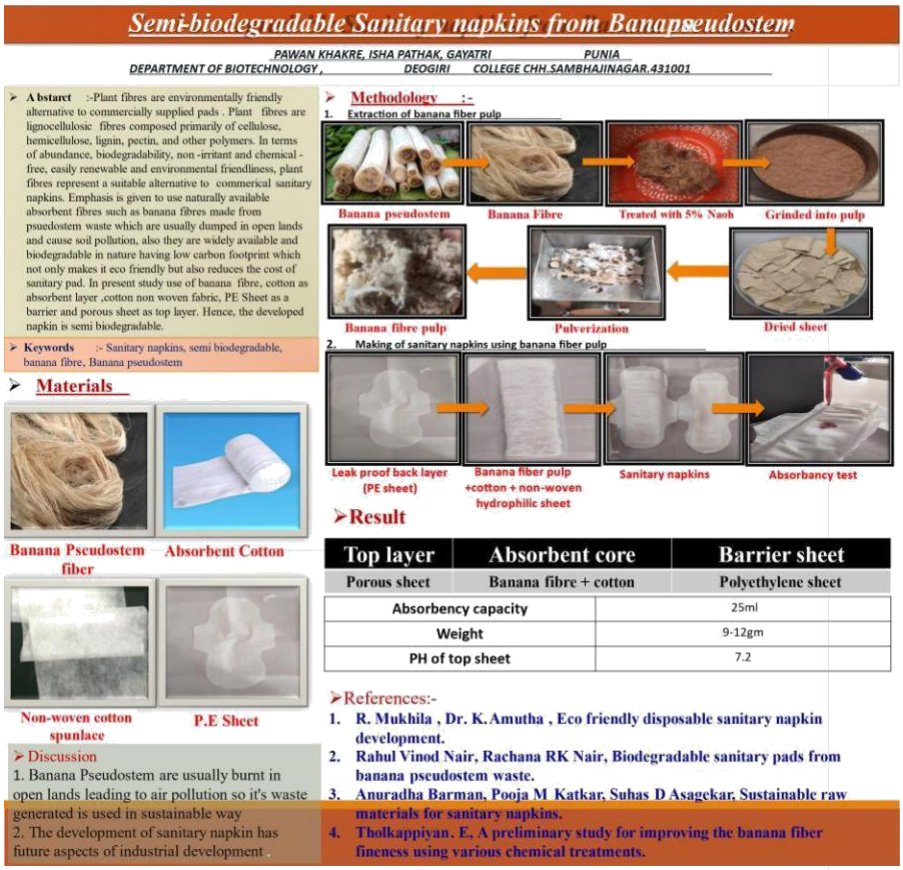
Fig27: Sanitary Napkins from banana fibre

Conclusion

The developed sanitary napkins from banana pseudo-stem went under many tests which includes absorbency of fluid which is 25ml, leak proof test of barrier layer which shows that the used barrier layer is of good quality, strike through rate was calculated which was 14 seconds and the test performed was pH test in which the obtained pH was 7.44 of the top layers.

In conclusion, the development of semi-biodegradable sanitary napkins from banana pseudo-stem is a promising innovation in the race of sustainable menstrual products. While the napkins developed offers partial bio-degradability, further experiments and researches in materials will lead to full bio-degradability. These napkins will be a step towards reducing the environmental issues. With all the required efforts and technology, the future of menstrual products could be both sustainable and environment friendly.

Achievement



Presented poster

Frist winner in poster presentation at national conference "exploring new horizons in forensic chemical and biological sciences" Conducted by Government Institute of Forensic Science.

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