Innovating Feminine Hygiene: Formulation and Evaluation of Poly Herbal Sanitary Napkins

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Abstract:

Rising health and environmental concerns about conventional sanitary napkins, due to synthetic materials that may cause infections, are driving interest in eco-friendly alternatives. This demand for safer, sustainable feminine hygiene products is spurring innovative research. This study focuses on the formulation and evaluation of poly herbal sanitary napkins incorporating natural antimicrobial agents, specifically Curcuma longa (turmeric) and Azadirachta indica (neem). These herbal components were selected for their well-documented and antimicrobial anti-inflammatory properties.



The top sheet was developed by needle punching wool fibre over cotton non-woven fabric, and the core layer was sandwiched between cotton and banana fibre. It is recommended to be changed every 3-4 hours to avoid certain bacteria that can fester in blood.

The poly herbal sanitary napkins were developed using biodegradable materials to address environmental concerns associated with conventional sanitary products. Comprehensive testing, including absorbency, Leakage proof, Wicking, Fluid retention test and microbial inhibition assessments, was conducted to evaluate the performance and benefits of these innovative napkins. The antimicrobial activity was assessed using a qualitative agar diffusion method, revealing significant inhibition zones: 30mm and 25mm for Gramnegative and Gram-positive bacteria, respectively, with Azadirachta indica (PHSN1); 22mm and 20mm with Curcuma longa (PHSN2); and 35mm and 30mm with a combination of both herbs (PHSN3).

The results indicate that the poly herbal sanitary napkins provide enhanced protection against microbial infections, superior comfort, and effective menstrual hygiene management. The study concludes that integrating Curcuma longa and Azadirachta indica into sanitary napkins offers a promising alternative to conventional products, promoting women's health while contributing to environmental sustainability.

Keywords: -Feminine hygiene, Poly herbal sanitary napkins, Biodegradable materials, Herbal extracts, Curcuma longa, Azadirachta indica, Eco-friendly sanitary products, Menstrual care innovation

1) Introduction:

1.1) Menstruation

Management of menstrual hygiene is a critical problem for all women and girls as the sanitary pads are expensive. Since menstruation is directly linked to the human reproductive process, it is important for women and girls to manage menstruation appropriately [1]. Girls and women have shyness and less knowledge about reproductive tract infections due to the usage of certain synthetic sanitary napkins. So, there is a need to educate and make women aware about the health hazards and environmental pollution associated with them [2]. Menstruation is a process in which woman discharge blood and other material from the lining of the uterus at an interval of about28 to 35 days from puberty until menopause. Previously, women experienced menstruation approximately 40 times owing to pregnancy and lactation amenorrhea, whereas in developed economies today, women can expect up to 400 menses in their lifetime [3]. Menstrual blood is partly blood and partly tissue from the inside of uterus which flows from uterus through cervix and out of body through vagina. The menstrual cycle is a term to describe the sequence of events that occur in body as it prepares for the possibility of pregnancy each month. Menstrual cycle is the time from the first day of menstrual period until the first day of next menstrual period. Every person's cycle is slightly different, but the process is the same [4,5].

It causes serious problems to the women if not managed properly. This menstrual discharge can be absorbed by some absorbent material. The functional requirement of a feminine hygiene product is to absorb and retain the menstrual fluid so that back tracking of fluid does not happen and at the same time it should be odour free.

1.2) Sanitary Napkin

The increasing awareness of health and environmental impacts of conventional sanitary napkins has led to a growing interest in eco-friendly and health-conscious alternatives. 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 long-term use of the pad which leads to many Urinary Tract Infections and other harmful diseases in women. The increasing demand for safer, more effective feminine hygiene products has driven research towards innovative solutions that prioritize both health benefits and environmental sustainability. A Sanitary Napkin is also known as a Sanitary Pad or Menstrual pad, is an absorbent item worn

A Santary Napkin is also known as a Santary Pad of Menstrual pad, is an absorbent item worn by individuals who menstruate to manage menstrual flow. It is typically made of layers of absorbent material and is worn inside panty to absorb menstrual blood flow from uterus during menstruation. Sanitary napkins come in various sizes, shapes and absorbency levels to accommodate different needs.

It is related to health or the conditions affecting health, especially with reference to cleanliness, precautions against disease, etc. It is unpolluted, antiseptic, germfree & clean [6].

1.2.1) Chemicals use in Sanitary Napkins:

Sanitary napkins used nowadays, during the menstruation periods are not really made up of pure cotton, instead of these they are made with various plastic chemicals like Bisphenol A [BPA] and Bisphenol S [BPS], polymers such as polyethylene (PET), polypropylene, polyethylene glycol (PEG), Polyurethanes, odour neutralizers and laced with artificial colours.

In some cases, natural materials such as mud leaves and dung and animal skins are used to control menstrual flow in natural way.

1.2.2) Classification of Menstrual Products:

Sanitary protection industry can be broadly classified into four main categories: Sanitary pads, Tampons, Period panties and Menstrual cups. Functions of sanitary Napkins are to absorb and retain menstrual fluid and isolate menstrual fluids from the body. [Table:1]

S.No.	Classification	Definition	Illustration		
1)	Pads	Pads are thin strips of fabric that adhere to panty. A few feature flaps or flaps that extend over the edges of panty to shield against leaks and marks. Certain pads are meant for one-time use, while others are washable and can be used again. [Fig:1]	D		
			Figure:1		
2)	Tampons	Tampons are small inserts crafted from cotton that are inserted into the vagina to absorb menstrual flow. Certain tampons feature an applicator that assists in their insertion. They are equipped with a string at the tip, making it simple to remove them. [Fig:2]	Figure:2		
3)	Period panties	Period panties function similarly to standard panties, but they feature additional fabric layers designed to soak up menstrual blood throughout cycle. They come in various styles for days with light, medium or heavy flow. [Fig:3]	<image/>		
4)	Menstrual Cup	Menstrual cups come in the form of small bells or pouches and are constructed from materials like rubber, silicone or flexible plastic. A majority of these cups can be used more than once, while a few are meant for single-use. [Fig:4]	Figure:4		

Table:1-Classification of Menstrual Products

1.2.3) Types of Sanitary Napkins:

Sanitary napkins are indispensable among the daily necessities that women usually keep. There are different types of Sanitary Napkins.

For young girls who have menstruation for the first time, the choice of sanitary napkins requires special attention. Many sanitary napkins on the market have different functions and fabrics. Choosing the type of sanitary napkin that suits skin type is very important. Women who don't know much about them can learn from the following. [Table:2]

S.No	Types	Definition	Illustration
1)	Regular Sanitary pads	Regular pads are made for medium flow days, meaning they are neither too loose nor too dense. They offer an ideal compromise between soak-up and bulkiness, making them ideal for daily use throughout the menstrual cycle. [Fig:5]	
2)	Overnight Sanitary pads	These night time pads are uniquely crafted for night time applications. They are usually longer and absorb more liquid than standard pads. They offer additional coverage and security to avoid any accidents while sleeping. They can offer greater comfort and a sleepless-free experience. [Fig:6]	Figure:6
3)	Ultra-thin sanitary pads	Ultra-thin sanitary pads are crafted to be slim and provide reliable absorbency. They give dependable protection for days with light to moderate flow. [Fig:7]	Figure:7
4)	Maxi pads	Maxi pads are bulkier and possess greater absorbency compared to basic and super-thin pads, offering enhanced protection. They are tailored for women dealing with intense menstrual bleeding and are also typically beneficial at the onset of menstruation when the blood flow is usually stronger than on other days. [Fig:8]	Eigure:8
5)	Panty liners	These panty liners are thin pads specifically made for minimal menstrual blood flow. They are slimmer and not as absorbent as standard sanitary pads. Additionally, they assist in preventing panty stains from the first spotting, a common occurrence for many women either at the start or the finish of their periods. [Fig:9]	Figure:9
6)	Reusable sanitary pads	Reusable sanitary pads serve as a more environmentally friendly option compared to single-use ones, crafted from materials that are both washable and absorbent, allowing for repeated use. They commonly originate from cotton, bamboo, or hemp fibres. Choosing reusable sanitary pads is a wise decision for individuals aiming to reduce their contribution to environmental garbage. [Fig:10]	Figure:10
7)	Bio-degradable Sanitary pads	Bio-degradable sanitary pads serve as a greener option compared to standard plastic ones. They are crafted with substances that are capable of decomposing naturally with time. These products come from organic fibres and contain minimal chemicals and artificial dyes. [Fig:11]	Figure:11

			Figure:12
9) Ma	Maternity pads	Many women who have given birth experience bleeding after childbirth. Therefore, they need to use maternity pads that are specially made to handle this type of bleeding. These maternity pads are longer, thicker and more absorbent than regular sanitary pads. They are also made to be extremely soft and very comfortable for the new mom, and they are 100% free of rashes. [Fig:13]	Figure:13

Table:2- Types of Sanitary Napkins

1.2.4) How To Use Sanitary Pads:

For discretion and for ease of carry, most sanitary pads are wrapped individually. But if you are someone who is using the sanitary pad for the first time, using it might seem like a daunting task. So, follow these steps to use a sanitary pad.

Wash Your Hands:

To maintain a hygiene level, it is advisable to wash hands before and after handling a pad. So, make sure to wash your hands.

Unwrap the Package:

First, take out the pad from the packet and open the package in which it has been wrapped. Then peel off the center backing and stick the pad from the adhesive side onto panty. Then, peel off the paper from the wings and wrap the wings around the edges of panty to make sure pad is placed securely.

Change Regularly:

Make sure that you change pad frequently, at least every 5-6 hours depending on flow.

1.2.5) How to Dispose Sanitary Pads:

Just like using the pad, disposing of sanitary pads is not that difficult. However, there are certain things that you need to keep in mind while doing so.

 \succ Wrap the pad:

When you are about to change, unstick the pad from the panty and wrap it either in tissue paper, newspaper or the wrapper of next pad. Some pads even come with sanitary disposable bags.

Use a dedicated bin:

After wrapping, throw it in a bin or a designated sanitary disposable bin. If you don't have one then you can use the regular dustbin to throw it in. But make sure the bin is secured with a lid to maintain hygiene and contain the odor.

Do not flush:

Never flush sanitary pads down the toilet as it can clog it and cause some serious plumbing issues. Always make sure that dispose of pads while throwing them in a bin, whether you are at home or any other place.

1.2.6) Complications of using Sanitary Napkins:

- Commercially available menstrual pads are made up of dioxins, petrochemicals, artificial fragrances etc. When these chemicals come in contact with sensitive skin tissue, it leads to skin irritation.
- Cellulosic chlorine bleached pulp; rayon which is used to increase absorbency of pad contains dioxin which leads to cervical cancer.
- Deodorants and synthetic material used in sanitary pads blocks dampness and heat which encourages yeast and bacterial growth [7].
- One of the major concerns of disposable pads is its non-biodegradability which increases generation of menstrual waste which ends up in leaking into nature and polluting rivers.
- Also, it causes occupational hazard as the used pads are to be picked up by waste pickers by their bare hand.
- Contaminants leads to various body defects such as hormonal disruption, infertility, cervical cancer, Urinary Tract Infection (UTI), Poly Cystic Ovary Syndrome (PCOS), rashes, allergic conditions, etc.
- Also, there is a possibility for Toxic Shock Syndrome (TSS) caused due to poisonous toxins from the bacteria such as Staphylococcus and Streptococcus that are accumulated in reproductive organs.
- Apart from all these, a dangerous chemical called Dioxin [8]. The effect of dioxin is cumulative and may stay in the body for 20 years after exposure. Hence these dioxins, other fragrances and deodorants can enter into the blood stream and affect locally and the immune system causing various diseases.
- 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.

2) Herbal Sanitary Napkin:

Herbal sanitary napkins are feminine hygiene products infused with natural ingredients such as herbs and plant extracts. These ingredients are believed to offer additional benefits such as soothing irritation, reducing odour providing antibacterial properties or promoting comfort during menstruation. The exact composition of herbal sanitary napkins can vary widely depending upon the brand and intended therapeutic effects.

Herbal sanitary pads or napkins are made from natural plant fibres. The natural pads have a soft top layer that breathes with skin and an absorbent cellulose core that keeps you dry during period.

Since they are free of plastics, chlorine, latex and carcinogenic substances, these herbal sanitary pads or napkins are safe and do not irritate the most delicate vaginal region of the female body. Because they are free of plastics and other chemicals, they are easily biodegradable and contribute to an eco-friendlier and plastic-free society.

It is made up with 100% herbal and chemical-free sanitary napkins. Everything is made of pure cotton and is devoid of plastic [9].

Commercially available sanitary napkins have many complications towards women health as well as to the environment. As a result, natural and inexpensive antimicrobial agent such as Aloe Vera, Neem and Curcumin extract solution is used in this research to maintain consumer hygiene.

2.1) Herbal Sanitary Napkins Provide:

> Hygiene:

Sanitary waste disposal has become an increasing problem in India, thus biodegradable napkins should be made.

> Performance:

Women generally prefer sanitary napkins based on their absorptive capacity.

> Uncontaminated:

Napkins should have less side effects and should not cause wide range of diseases.

Comfort:

Napkins should be comfort and not produce any unpleasant odour as they are used throughout the day during menstruation.

➢ Economic:

Sanitary napkins should be available at an affordable cost that every woman can buy. Based on the above criteria herbal sanitary napkins should be made. This will promote hygienic menstruation around the world and there is avoidance of several diseases caused due to the harmful synthetic sanitary napkins.

2.2) Herbal Resources:

Organic cotton is used as top sheet which is one the commonly advised raw material for sanitary napkin because of its non-irritant, skin friendly and superior liquid retention properties. It is soft and breathable which gives comfort and dryness. Cotton wicks away moisture and keeps skin dry [10]. Organic cotton is cultivated from non-treated Genetically Modified (GMO) seeds and is grown using method and materials having low impact on environment that is without any use of synthetic agricultural chemicals such as fertilizers and pesticides. The cotton should be biodegradable in nature. The ideal moisture management of this cellulosic fibre is responsible for the reduced bacterial growth. Sanitary pads can also be developed from banana (*Musa paradisiaca*) fibre to make affordable, quality, eco-friendly sanitary napkins and available in recent years to girls and women in developing country. Banana is a natural absorbent fibre; the key reason is its natural porosity [11]. Banana fibre is an eco-friendly fibre like jute fibre (Corchorus olitorius). It is biodegradable and has no negative effect on environment.

2.3) Ideal properties of Herbal Sanitary Napkins:

- The major factor for the pad is to absorb the blood flow without any back-flow or leakage.
- ➢ It should produce NO odour.
- ➢ It should be comfortable.
- > It should have NO negative effects on the environment.
- ➢ It should have good antimicrobial activity.
- It shouldn't cause irritation.
- ➢ It should have High level of hygiene.

2.4) Benefits of Herbal sanitary napkins:

- > The usage of herbal sanitary pads or napkins helps restore harmony and balance during menstruation.
- > They lower the risk of acquiring cervical cancer and pelvic inflammatory disease.
- ▶ Using Herbal sanitary pads or napkins can help women reduce their risk of uterus loss.
- > It kills bacteria and removes any odours that may be present.
- ➢ It boosts immunity.
- ➢ It is comfortable and cool.
- ➢ Herbal pads are comfortable, absorbent and help to eliminate chemical exposure that comes with any regular menstrual product.

3) Background and Rationale:

3.1) Menstrual Hygiene Management (MH):

- Hygiene Practices: Proper menstrual hygiene practices are essential to prevent infections and maintain reproductive health. Using appropriate sanitary products helps in managing menstrual flow hygienically and comfortably.
- Impact on Health: Poor menstrual hygiene can lead to reproductive tract infections (RTIs), including bacterial vaginosis and urinary tract infections (UTIs), which may affect fertility and overall health [12].

3.2) Comfort and Confidence:

- > **Psychological Well-being:** Using comfortable and reliable feminine hygiene products enhances women's confidence and self-esteem during menstruation [13].
- Social Participation: Access to quality menstrual products allows women to engage fully in daily activities, including education, work, and social interactions, without discomfort or embarrassment.

3.3) Safety and Quality:

- Health Risks: Some conventional feminine hygiene products may contain chemicals (e.g., dyes, fragrances) that can cause skin irritation or allergic reactions. Choosing products with safe materials reduces these risks.
- **Regulatory Standards:** Ensuring that feminine hygiene products meet regulatory standards for safety and quality is crucial to protect women's health [14].

3.4) Education and Empowerment:

- Access and Awareness: Providing access to affordable and appropriate menstrual products empowers women and girls to manage their menstruation with dignity and without interruption to their daily lives.
- **Education:** Comprehensive menstrual health education promotes informed choices regarding menstrual products, hygiene practices, and reproductive health [15].

4) Aim and Objective:

The aim and objective of this study is to Formulate and Evaluate Polyherbal Sanitary napkin containing natural herbal extracts of *Curcuma longa, Azadirachta indica* and *Aloe barbadensis*.

5)Methods:

- > Procurement of various poly herbal extracts (neem, aloe vera, curcumin).
- > Preparation of banana fibre from Banana pseudo stem.
- ➢ Fabrication of the napkin layers.
- > Development of sanitary napkins by employing poly herbal extracts.
- ➢ Artificial blood preparation.
- \succ Evaluation studies.

5.1) Procurement of Various Poly Herbal Extracts:

Azadirachta indica, Curcuma longa and Aloe barbadensis obtained as gift sample from "Sun Pure extracts Pvt. Ltd", New Delhi.

> Azadirachta indica:

Azadirachta indica, commonly known as neem, margosa, nim tree or Indian lilac, is a tree in the mahogany family Meliaceae. Neem extracts can be used against hundreds of pests and fungal diseases that attack food crops. It is a Natural Medicine, Pesticide and Insecticide [16,17]. Properties:

- Neem has antibacterial, antiviral, anti-parasitic activity.
- Neem leaf has antibacterial properties.
- It is also antifungal.
- Neem leaf is also antioxidant, anti-mutagenic and anti-carcinogenic.
- > Curcuma longa:

Curcuma longa, a member of the ginger family (*Zingiberaceae*), has rhizomes below the ground. *Curcuma longa* has been used for thousands of years as a remedy in the traditional Indian and folk medicine for the cure of a large variety of illnesses, such as inflammation, infectious diseases and gastric, hepatic and blood disorders[16,17].

Properties:

- It has antibacterial activity.
- It is eco-friendly and non-irritant.
- > Aloe barbadensis:

The Aloe vera plant has been known and used for centuries for its health, beauty, medicinal and skin care properties. The name Aloe vera derives from the Arabic word "Alloeh" meaning "shining bitter substance," while "vera" in Latin means "true."

Properties:

- It avoids irritation
- It avoids odour.
- It decreases the amount and length of time of discomfort.

5.2) Preparation of Banana Fibre:

Banana fibre, also known as Musa fibre, is derived from the pseudo stems of banana plants (Musa spp.), primarily from the species *Musa textilis* and *Musa paradisiaca*. Banana fibre is a versatile natural fibre extracted from the stems of banana plants [18]. It has gained attention in recent years due to its eco-friendly properties and various applications in different industries.

Banana Fibre is used in the production of fabrics and clothing. It is popular in various handicrafts such as bags, mats, carpets, and decorative items due to its aesthetic appeal and strength and used in the production of high-quality specialty papers, adding texture and strength to the final product [19]. So Here [Fig:14] shows the procedure for preparation of Banana Fibre.



Figure: 14 Preparation of Banana Fibre

5.3) Development/Fabrication of Napkin Layers:

The development/fabrication of sanitary napkins, or sanitary pads, involves the manufacturing process of creating absorbent products used primarily by women during menstruation. These products play a crucial role in menstrual hygiene management, offering comfort, convenience, and protection. Fig:15 illustrates, steps involved in development/ fabrication of sanitary napkin layers.



Figure: 15 Development/Fabrication of Sanitary Napkin Layers

5.3.1) Formulation of Poly Herbal Sanitary Napkin:

Different combinations of sanitary napkins which were employed in this study are shown in Table:3.

	Formulation Code				
Ingre	dients	PHSN1	PHSN2	PHSN3	
Azadiraci	hta indica	0.8gm	-	1gm	
Curcuma longa		-	0.3gm	0.5gm	
Aloe bar	badensis	0.5gm	0.5gm	0.8gm	
Banana fibre (Thickness)		0.5cm	0.8cm	1.0cm	
Cotton (Thickness)	Bottom layer	0.3cm	0.3cm	0.3cm	
	Top layer	1.0cm	1.0cm	1.2cm	

 Table:3- Formulation table of Poly Herbal Sanitary Napkin

5.3.2) Schematic Representation of Sanitary Napkin:

Fig: 16 Sanitary napkin depicted with different layers.



Figure: 16 Schematic representation of Prepared sanitary napkin

5.4) Artificial Blood Preparation:

- Take a beaker and add 2.5gm of potassium thiocyanate then dissolve in 50ml of distilled water.
- > 2.5gm of ferric chloride is dissolved in 50ml of distilled water in another beaker.
- > Add potassium thiocyanate solution to ferric chloride solution.

5.5) Evaluation Tests:

5.5.1) Absorbent capacity:

The absorbency capacity was measured according to EAS 96:2008-Annex C standard, using artificial blood as test fluid. Initially dry weight of sample was taken and then fluid poured on it until saturation is reached. On reaching saturation 3.4 kg weight was placed over it and blotted with filter paper to remove the excess fluid and pad is weighted [20].

Absorption capacity is calculated by the following formula:

Absorption capacity = (W-X) gms

X=Dry weight of pad expressed in grams

W=Final weight of pad after saturation underweights expressed in grams.

5.5.2) Leakage proof:

The test was carried out according to EAS 96:2008-Annex B standard. It determines the efficiency of barrier layer. A specimen size of 6.5cm X 6.5cm barrier sheet was cut and folded into a cone and place in a funnel. The funnel filled with test fluid was kept for 48hrs, and then checked for any leakage.

5.5.3) Wicking Test:

Tests can be done according to BS3424 Method 21 (1973) which specifies "determination of resistance to wicking." The experiment is meant to the ability to take up fluid. One end of the pad is immersed to about 10mm in the synthetic blood and the fluid absorption along the pad is measured in mm for 1,5,10,15,20 & 30 minutes. Wicking is a desired characteristic of a sanitary pad as it allows fluid to spread along the entire absorbent structure [21,22].

5.5.4) Fluid retention capacity:

The measurement of fluid retention is determined by using the standard ASTM D 461.A

sample of the pad is to be immersed in fluid at room temperature for five minutes to completely wet it out. The fluid logged sanitary napkin is weighted, dried and reweighed. Fluid retention is calculated as a percentage of dry mass.

5.5.5) Anti-microbial test:

Antimicrobial test was carried out using Agar Diffusion test. Test was carried against gram positive (Staphylococcus aureus bacteria) and gram negative (Pseudomonas aeruginosa) bacteria [23,24]. The treated samples were placed on the incubated agar plate with test bacteria for 24hrs at 37° C. After incubation the samples was assessed visually; the area of inhibition was the measure of antimicrobial efficiency.

6) **Results and Discussion:**

6.1) Procurement of Various Poly Herbal Extracts:

Poly herbal samples (*Azadirachta indica, Curcuma longa* and *Aloe barbadensis*) obtained as gift sample from "Sun pure Extracts Private Limited", New Delhi and were illustrated in Fig:17



Figure: 17 Poly Herbal Extracts

6.2) Preparation of Banana Fibre:

Extraction of banana fibre from banana pseudo stem from Day-1to day-25 illustrated in Fig: 18.

- **Day-1:** Soaking of banana Pseudo stem in 5% HCl.
- > Day-20: Decomposition of Pseudo Stem Material leaving Fibre.
- **Day-25:** After squeezing and drying the sample, pure fibre is obtained.



Figure: 18 Banana fibre preparation

6.3) Development/Fabrication of herbal sanitary napkin:

6.3.1) Raw Materials used in the Preparation of Sanitary pad:

Various ingredients and raw materials used for the formulation of poly herbal sanitary napkin are illustrated in Fig: 19.



Figure:19 Raw materials of poly herbal sanitary napkin

6.3.2) Procedure:

The following procedure depicts formulation development and fabrication of a sanitary napkin using poly herbals, Fig:20.



Figure: 20 Sanitary napkin preparation

6.4) Artificial Blood Preparation:

To test absorption capacity, the solution having same density and viscosity as blood is required. So, this artificial blood provides similar properties as blood. It is prepared by following process depicted as Fig:21.



Figure:21 Preparation of Artificial Blood

6.5) Evaluation:

6.5.1) Absorption Capacity:

The absorption capacity test values of various formulated sanitary napkins are shown in Table:5.

From results it is observed that the developed sanitary napkin shows good absorption capacity because both cotton and fibre have good absorption capacity which ultimately increases the product absorbency.

When compared to three formulations PHSN3 shows more absorbency capacity. Absorbency test of optimized formulation PHSN3 was depicted as Fig:22.

Calculation for optimized formulation PHSN3 as follows: -

Initial weight of Sanitary Napkin(X)=3.5gm

Final Weight of Sanitary weight after absorption of artificial blood(W)=7.5gm

Absorption Capacity = (W-X) = 7.5 gm - 3.5 gm = 4 gm



Figure:22 Absorption capacity of sanitary napkin (PHSN3)

6.5.2) Leakage Proof test:

Barrier layer selected for sanitary pad is a Fibre which is tested to determine its ability to prevent leakage. It is observed that there was no sign of leakage with three different formulations i.e. PHSN1, PHSN2 and PHSN3 when the barrier sheet was folded into a cone and place with fluid for 48hrs.The test confirms that the barrier film is liquid proof. Leakage proof of PHSN3 was shown in Fig:23.



Figure:23 Leakage proof test

6.5.3) Wicking Test:

Developed poly herbal sanitary napkins are subjected to test for wick ability performance. The difference in the wick ability can be seen according to time duration. Three samples show different values of wick ability tabulated as Table:4. PHSN3 shows more wick ability than PHSN1 and PHSN2 which is shown in Fig: 24.

S.No.	Time (in	Measurements (in mm)			
	minutes)	PHSN1	PHSN2	PHSN3	
1.	1	28	27	30	
2.	5	45	43	48	
3.	10	54	53	55	
4.	15	62	60	64	
5.	20	73	71	76	
6.	30	87	85	90	

Table:4 Measurement of wick ability



Initial stage t=0 min After 10 min After 30 min Figure: 24 Wickability of sanitary napkin (PHSN3)

6.5.4) Fluid Retention Test:

The small cut sample is immersed in blood and dried. Then dry mass subjected to determination of fluid retention values. Fig:25 depicts dried cut sample of PHSN3. The values of fluid retention of different samples were shown in Table:5.

Calculation for optimized formulation PHSN3 as follows: -Initial weight of Sample (With Artificial blood) W1`=5.5gm Final Weight of Sample (after drying) W2=1.16gm



Figure: 25 Fluid Retention test (PHSN3)

6.5.5) Anti-Microbial Test:

The study's evaluation of the antimicrobial activity of Curcuma longa and Azadirachta indica using the qualitative agar diffusion method highlights the effectiveness of these herbal extracts in combating microbial growth. The findings, as illustrated in Fig:26 & 27, demonstrate the potent antimicrobial properties of both herbs, with notable differences in their efficacy against Gramnegative and Gram-positive organisms.

The treated sample with Azadirachta indica extract (PHSN1) exhibited significant antimicrobial activity, with an inhibition zone of 30mm for Gram-negative bacteria and 25mm for Grampositive bacteria. This indicates a strong ability to inhibit microbial growth, particularly against Gram-negative organisms.

Similarly, the sample treated with Curcuma longa extract (PHSN2) showed an inhibition zone of 22mm for Gram-negative bacteria and 20mm for Gram-positive bacteria. While slightly less potent than Azadirachta indica, Curcuma longa still demonstrates substantial antimicrobial activity.

The combined treatment with both Azadirachta indica and Curcuma longa (PHSN3) resulted in the most pronounced antimicrobial effects, with inhibition zones of 35mm for Gram-negative bacteria and 30mm for Gram-positive bacteria. This suggests a synergistic effect between the two herbs, enhancing their overall antimicrobial efficacy.

In conclusion, the antimicrobial activity of Azadirachta indica and Curcuma longa, individually and in combination, underscores their potential as effective natural agents for use in poly herbal sanitary napkins. The enhanced inhibition zones observed with the combined treatment (PHSN3) suggest that incorporating both herbs into the formulation may offer superior protection against microbial infections. These findings support the continued development and use of poly herbal sanitary napkins to promote feminine hygiene and health.



Figure: 26 Antimicrobial activity of developed poly herbal sanitary napkins (PHSN1, PHSN2, PHSN3)



Figure: 27 Graphical representation of antimicrobial activity of developed poly herbal sanitary napkins (PHSN1, PHSN2, PHSN3)

S.No.		Type of Test					
	Formulation	Absorbance	Leakage	Wicking	Fluid	Anti-microbial	
		Capacity (in	proof	test after	retention	activity (in mm)	
		gm)	test	30min.	(in %)	Gm-	Gm+ve
				(in mm)		ve	
1.	PHSN1	3	No	87	20.51%	30	25
			leakage				
2.	PHSN2	2	No	85	19.01%	22	20
			Leakage				
3.	PHSN3	4	No	90	21.09%	35	30
			leakage				

The following [Table: 5] shows the results of all evaluation tests of three formulations which were performed in this study.

Table: 5 Results of Evaluation Tests of developed poly herbal sanitary napkins (PHSN1, PHSN2, PHSN3)

7) Conclusion:

The development and evaluation of poly herbal sanitary napkins represent a significant advancement in feminine hygiene products. This research demonstrates the feasibility of integrating herbal components into sanitary napkins, offering enhanced benefits compared to conventional products. The formulated poly herbal napkins not only provide effective menstrual hygiene management but also incorporate natural antimicrobial and anti-inflammatory properties, thereby reducing the risk of infections and promoting overall vaginal health.

Developed sanitary napkins shows satisfactory results including performance and comprehensive evaluations in terms of absorbency tests, Leakage proof, microbial inhibition assessments, Wicking and Fluid retention, indicate that the poly herbal sanitary napkins meet and exceed standard performance criteria. The incorporation of herbs such as neem, aloe vera, and turmeric has shown promising results in providing additional comfort and therapeutic benefits to users.

Furthermore, the eco-friendly nature of these napkins, made from biodegradable materials, addresses the growing concern of environmental sustainability associated with disposable menstrual products. By leveraging the therapeutic properties of herbs and focusing on biodegradable components, this innovative approach not only meets the hygiene needs of women but also aligns with global efforts to reduce environmental impact.

In conclusion, the formulation and evaluation of poly herbal sanitary napkins mark a transformative step in the feminine hygiene industry. This innovation holds the potential to improve women's health, enhance user comfort, and contribute to sustainable practices. Future research and development should continue to refine these products and explore the incorporation of additional herbal ingredients to further expand their benefits.

8) Strengths and Limitations:

8.1) Strengths:

- Efficacy: Polyherbal sanitary napkins are often designed to provide enhanced efficacy in managing menstrual flow and related discomforts due to the combination of herbal ingredients known for their therapeutic properties.
- Safety: Herbal ingredients are generally perceived as safer compared to synthetic materials, reducing the risk of allergic reactions and irritation. They are often free from chemicals like dioxins and fragrances that may be present in conventional products, minimizing potential health risks.

User satisfaction: The soothing properties of herbal ingredients can provide a more comfortable experience during menstruation, reducing irritation and promoting a sense of freshness.

> Novelty and Innovation:

a) Introduction of Poly Herbal Components: Utilizes natural, herbal ingredients which may provide additional health benefits compared to traditional sanitary napkins.

b) Eco-friendly Approach: Use of biodegradable materials reduces environmental impact.

> Health Benefits:

a) Antimicrobial Properties: Herbal components may offer natural antimicrobial and antifungal properties, enhancing hygiene and reducing the risk of infections.

b) Hypoallergenic: Natural ingredients are less likely to cause allergic reactions or skin irritations compared to synthetic materials.

> Sustainability:

a) Biodegradable Materials: Focus on using materials that break down naturally, reducing long-term waste.

b) Renewable Resources: Use of herbal components promotes sustainable agriculture and reduces reliance on non-renewable resources.

Consumer Appeal:

a) Natural Ingredients: Growing consumer preference for natural and organic products may drive market acceptance.

b) Enhanced Comfort: Potentially better comfort due to the use of natural fibers and herbs.

Comprehensive Evaluation:

a) Thorough Testing: Extensive laboratory and field testing to evaluate absorbency, comfort, and antimicrobial efficacy.

b) Holistic Approach: Considering not just the physical properties but also the health benefits and environmental impact.

8.2) Limitations:

Variability of Herbal Ingredients:

a) Inconsistent Quality: Variations in herbal component quality due to factors like harvest conditions, processing, and storage.

b) Standardization Issues: Difficulty in standardizing herbal ingredients to ensure consistent product performance.

Cost Implications:

a) Higher Production Costs: Potentially higher costs of sourcing and processing natural materials compared to synthetic alternatives.

b) Market Pricing: Higher costs might translate to higher prices for consumers, potentially limiting market penetration.

Regulatory Challenges:

a) Compliance with Standards: Ensuring compliance with health and safety regulations for both sanitary products and herbal ingredients.

b) Approval Processes: Lengthy approval processes for new materials and formulations.

Limited Research:

a) Lack of Long-term Studies: Limited long-term data on the efficacy and safety of poly herbal sanitary napkins.

b) Comparative Studies: Few comparative studies with conventional sanitary napkins to conclusively demonstrate benefits.

Consumer Acceptance:

a) Cultural Barriers: Potential cultural resistance to adopting new types of sanitary products.

b) Awareness and Education: Need for consumer education about the benefits and use of poly herbal sanitary napkins.

> Scalability:

a) Production Scale: Challenges in scaling up production while maintaining quality and efficacy of the herbal components.

b) Supply Chain Management: Ensuring a reliable supply chain for diverse herbal ingredients.

9) Future Directions:

Further research on herbal sanitary napkins can explore several areas to optimize formulations and expand on existing findings:

- Optimization of Herbal Combinations: Investigate the synergistic effects of different herbal combinations to enhance antimicrobial, anti-inflammatory, and soothing properties.
- Standardization of Herbal Extracts: Develop standardized methods for extracting active compounds from herbs used in sanitary napkins. This ensures consistent potency and efficacy across different batches.
- Clinical Trials with Larger Sample Sizes: Conduct robust clinical trials with larger participant groups to further validate the safety, efficacy, and user satisfaction of herbal sanitary napkins. Studies should include diverse populations to assess variability in responses.
- Long-term Safety Studies: Evaluate the long-term safety profile of herbal sanitary napkins through extended follow-up studies. Assess any potential adverse effects associated with continuous use over months or years.
- Biodegradability and Environmental Impact: Investigate the biodegradability of herbal sanitary napkins and their overall environmental impact compared to conventional products. This includes assessing decomposition rates and potential eco-friendly disposal methods.
- Mechanisms of Action: Explore the mechanisms through which herbal ingredients exert their effects in sanitary napkins. This includes pharmacological studies to understand how herbs interact with skin and mucosal tissues.
- User Acceptance and Preferences: Conduct qualitative research to understand user perceptions, preferences, and experiences with herbal sanitary napkins. This can guide improvements in product design and marketing strategies.

Author Contributions:

All authors made substantial contributions in their own way in all aspects for successful completion of research work. Samyuktha.Metta, Keerthana. Madhavaram, Sirisha. Meesala: Conceptualization, design, Formal analysis; acquisition of data, or analysis and interpretation of data; Writing-review; editing or revising it critically for important intellectual content, Samyuktha.Metta, Keerthana. Madhavaram, Sirisha.Meesala, Swetha Mekala, Siddabhathula Govardhini Swetha, Naveena.R: Funding acquisition; Investigation; Project administration; Visualization, Supervision, Writing-review; editing.

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Authors disclose no conflicting interest with current work.

Ethical Statement

This study does not involve experiments on animals or human subjects.

Data Availability

All data generated and analysed are included in this research article.

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