



## Effectiveness of Soursop (*Annona muricata*) Extract Nanoparticles in Pantyliners on Vaginal Discharge in Childbearing-age women

Elyasari Elyasari<sup>1\*</sup>, Arsulfa Arsulfa<sup>2</sup>, Heyrani Heyrani<sup>3</sup>, Sitti Mukarramah<sup>4</sup>, Melania Asi<sup>5</sup>

<sup>1</sup>Department of Midwifery, Faculty of Midwifery, Poltekkes Kemenkes Kendari, Kendari, Indonesia

<sup>2</sup>Department of Midwifery, Faculty of Midwifery, Poltekkes Kemenkes Kendari, Kendari, Indonesia

<sup>3</sup>Department of Midwifery, Faculty of Midwifery, Poltekkes Kemenkes Kendari, Kendari, Indonesia

<sup>4</sup>Department of Midwifery, Faculty of Midwifery, Poltekkes Kemenkes Makassar, Makassar, Indonesia

<sup>5</sup>Department of Midwifery, Faculty of Midwifery, Poltekkes Kemenkes Kendari, Kendari, Indonesia

\*Corresponding Author: E-mail: [elyasari903@gmail.com](mailto:elyasari903@gmail.com)

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### ABSTRACT

**Introduction:** The treatment of vaginal discharge is pharmacological, such as cyclovir, podoflin 25%, and antiseptic solution for vaginal rinsing, and non-pharmacological, such as *Annona muricata* decoction. The aim of this study was to analyze the effectiveness of using pantyliners with *Annona muricata* extract nanoparticles against vaginal discharge in North Konawe Regency.

**Methods:** This study used a two-group pre-posttest approach and a quasi-experimental design to compare the efficacy of regular pantyliners and pantyliner nanoparticles over a seven-day period. This study surveyed 124 childbearing women aged 15-49 in the North Konawe Regency who experienced vaginal discharge. Participants were those who could read and write, experienced moderate and severe discharge, and participated in  $\leq 2$  activities. This study used questionnaires to assess childbearing women's characteristics, knowledge of vaginal discharge, personal hygiene, observation sheets, and standard operating procedures. Wilcoxon, Mann-Whitney, and independent T tests were used.

**Results:** The analysis revealed a significant difference in the level of vaginal discharge between the intervention and control groups ( $P = 0.000$ ). However, changes in vaginal discharge differed between the intervention and control groups. The elimination of vaginal discharge was better in the group treated with *Annona muricata* extract panty than that in the control group.

**Conclusion:** *Annona muricata* extract panty effectively reduced vaginal discharge in both the intervention and control groups. However, pantyliners containing *Annona muricata* extract may be more effective than regular panties.

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## INTRODUCTION

One of the reproductive health problems often experienced by childbearing-age women is vaginal discharge (fluor albus) (1). Around 75% of women worldwide, including those in Indonesia, have vaginal discharge, 90% of women are experiencing potential vaginal discharge because Indonesia is a tropical area so it is easily attacked by fungi, viruses, and bacteria, especially in the female genital area (2). Vaginal discharge generally occurs in childbearing-age women, namely between the ages of 15-49 years (3).

For many women, especially those who are of childbearing age, vaginal health is a major concern. It impacts social, emotional, and physical well-being and is essential for preserving general reproductive health. Women frequently experience vaginal discharge, which can vary from normal fluctuations brought on by hormonal changes to unusual discharges that might be a sign of infections or other medical conditions. Traditional feminine hygiene products frequently include artificial fragrances and chemicals that can upset the vaginal microbiome's natural balance and cause a number of health problems, including allergies, irritations, and infections (4).

The investigation of herbal products for feminine hygiene has resumed due to the growing popularity of natural remedies. A tropical fruit known for its purported health benefits, soursop (*Annona muricata*) is used in many cultures. Alkaloids, saponins, and flavonoids are among the many bioactive substances found in soursop leaves that have been shown to have antimicrobial, anti-inflammatory, and antioxidant qualities (5). By encouraging a healthy vaginal flora and lowering inflammation or infections, these bioactive compounds may offer a natural substitute for traditional feminine hygiene products.

Vaginal discharge, commonly experienced by women of childbearing age, can be categorized into physiological and pathological types, the latter potentially leading to complications, such as discomfort and infertility. The clinical significance of *Annona muricata* (soursop), traditionally regarded as effective for various health issues, arises from its rich phytochemical composition, predominantly containing flavonoids and acetogenins that exhibit notable antimicrobial properties (6). The efficacy of *A. muricata* extracts in managing conditions like leucorrhea may be enhanced by innovative formulations, such as nanoparticle integration, which could improve antimicrobial activity and bioavailability (7,8). Despite the prevalent use of pantyliners for managing vaginal discharge, current market offerings lack products incorporating *A. muricata*, revealing a substantial gap in practical herbal-centered interventions, especially given the increasing consumer interest in natural remedies (9). This study aims to evaluate the effectiveness of pantyliners infused with *A. muricata* nanoparticles, representing a novel approach to improve women's reproductive health care solutions (10,11).

A promising approach to vaginal health is the creation of nanoparticles using soursop extract. According to electrophoretic mobility studies, the nanoparticles with a negative charge exhibit increased mobility and interaction with the target tissue. Their capacity to cross biological barriers can be especially helpful in improving the vaginal microenvironment's local therapeutic effects, encouraging a more balanced population of microflora, and lowering the risk of infection. In addition to leveraging soursop's rich bioactive profile, the synthesis of these nanoparticles satisfies the growing demand for environmentally friendly and biocompatible materials in medical applications (12,13).

Studies on soursop extract's anticancer qualities have revealed a lot of promise, particularly in terms of how well it targets cancer cells while sparing healthy cells (14). There aren't many studies, though, that concentrate on its use in feminine hygiene. To address this need, soursop extract nanoparticles have been incorporated into pantyliners, providing women with a safer, plant-based alternative that takes advantage of soursop's inherent antimicrobial and anti-inflammatory properties (5).

Research directly linking the effectiveness of soursop extract nanoparticles with better results in feminine hygiene applications is still lacking, despite the extract's encouraging profile. The majority of research to date has focused on its antibacterial or anticancer qualities, ignoring its potential use in products meant to manage vaginal health on a daily basis (15). Furthermore, previous studies have neither clarified the precise mechanisms by which these nanoparticles could interact with vaginal tissue to provide health benefits nor critically evaluated the practical implications of using them in consumer hygiene products.

This study aimed to evaluate the efficacy of Pantyliners containing *Annona muricata* Extract Nanoparticles against leucorrhea in pregnant women in the North Konawe Regency. The novelty of this study lies in the use of *Annona muricata* extract nanoparticles in pantyliners as an alternative method to overcome leucorrhea in childbearing

women. The findings of this study are anticipated to aid the creation of safe and efficient healthcare solutions for women.

## METHOD

### Research Design

We employed a quantitative quasi-experimental design using a two-group pre-test–post-test design approach. Treatment with pantyliner nanoparticles *Annona muricata* extract in the morning and evening for seven days. Treatment with regular pantyliners in the morning and evening for seven days.

### Sample

The study population consisted of women aged 15-49 in the North Konawe Regency, who had experienced vaginal discharge. Sampling using the Slovin formula resulted in a sample size of 124 women of childbearing age. The formula is expressed as:

$$n = \frac{N}{1 + N(e)^2}$$
$$n = \frac{180}{1 + 180(0.0025)^2}$$
$$n = 124$$

Where (n) is the sample size, (N) is the population size, and (e) is the margin of error. Given the population of women aged 15-49 in North Konawe Regency who experienced vaginal discharge, a common margin of error of 0.05 was applied. After applying these parameters, a calculated sample size of 124 participants emerged. To ensure randomization, this study employed a random number table or a computer-generated randomization method. Participants were randomly assigned to either the intervention or control group after obtaining informed consent, ensuring that all extraneous variables were evenly distributed, thereby minimizing the risk of selection bias. This methodological rigor highlights the validity of the research findings by ensuring that the treatment effects can be attributed to the intervention itself rather than confounding factors.

The inclusion criteria were participants had to be between the ages of 18 and 45 and had vaginal discharge that was not associated with an infection or STD in order to be eligible. Participants must also be willing to give their informed consent, adhere to the study's guidelines, and not undergo hormonal therapy or antibiotic treatment that could affect vaginal discharge at the moment. To control for potential bias due to concurrent treatments, the researchers implemented specific exclusion criteria outlining conditions that would disqualify participants from the study. These criteria included Women with a history of soursop or other study product ingredient allergies, pregnant or lactating women, and people with long-term illnesses such as diabetes or immunodeficiency that can impact vaginal health. To guarantee the validity of the study's findings, participants who suffer from additional medical conditions such as vulvitis or vaginitis will also be included. Furthermore, the random assignment of participants to the intervention and control groups helped distribute extraneous variables evenly across the groups, reducing the potential for bias. Finally, the researchers used standardized measurement tools that allowed for consistent data collection, further protecting against bias associated with subjective interpretations of symptoms or treatment outcomes.

### Anti Bacterial Testing of *Annona Muricata*

Antibacterial testing of the *Annona muricata* extract used in this study was carried out using the disc diffusion method with 6 mm diameter disc paper. The Petri dishes, loop needles, and reaction tubes were sterilized using an autoclave. The *Bacillus subtilis* culture stock was pipetted and dripped into the agar medium and then wiped evenly using an ose needle. The disc paper was then dipped in the soursop leaf extract solution. Discs that had been dripped with extracts of different concentrations and antibiotics were placed regularly on the surface of the test medium using tweezers. The Petri dishes were stored and a clear zone was observed. The diameter of the formed clear zone was measured using a millimeter ruler. The same steps were performed for *E. coli* culture.

### **Vaginal Discharge Determination**

Increased vaginal discharge, odor, and discomfort are symptoms of bacterial vaginosis (BV), defined as an imbalance in the normal bacterial flora of the vagina. A clinical evaluation was performed to identify the BV. Clinical Symptoms: BV is indicated by self-reported symptoms, such as thin, fishy-smelling, and grayish-white vaginal discharge, particularly after sexual activity. Amsel Criteria: The Amsel criteria, which include the presence of at least three of the following: a positive whiff test (a fishy odor when mixing the vaginal discharge with KOH), homogenous vaginal discharge, and vaginal pH greater than 4.5, were used to make the diagnosis.

In the context of the study outlined, the categories of heavy and moderate vaginal discharge are typically defined based on clinical assessments, self-reported symptoms, and established diagnostic criteria, such as the Amsel Criteria. Moderate vaginal discharge generally represents a noticeable change from normal discharge, characterized by increased volume, slight odor, or discomfort, indicating the potential presence of infections, such as bacterial vaginosis (BV). Conversely, heavy vaginal discharge may present with more prominent symptoms, including a strong fishy odor, a significant change in color or consistency, and increased discomfort, further indicating a higher likelihood of pathological conditions.

### **Nano Particle Extract**

The coprecipitation method was used to create *Annona muricata* nanoparticles. Making a precursor solution with the desired compound from *Annona muricata* was the first step in this process. A precipitating agent, such as NaOH or  $\text{NH}_3\text{OH}$ , is then added to this solution, causing nano-reduction and the creation of nanoparticles. The size and shape of the resultant nanoparticles were also influenced by variables such as the pH, temperature, and reaction time. The simplicity, effectiveness, and ease of large-scale nanoparticle precipitation are among the benefits of the coprecipitation method. However, rigorous control over the process parameters is necessary to achieve the desired nanoparticle properties.

### **Instrument**

Questionnaires were used to ascertain the characteristics of women of childbearing age, standard operating procedures, observation sheets (checklists) for the classification of vaginal discharge, and knowledge of women of childbearing age regarding vaginal discharge. This questionnaire was adopted from a related previous study published by Lankoon et al (16). The module consists of 30 pages containing the benefits of soursop leaves for women of childbearing age. This module is given to childbearing-age women to provide information about the benefits of soursop leaves as a nonpharmacological way to overcome vaginal discharge.

A questionnaire was used to determine the characteristics of the women, classification of vaginal discharge, and their knowledge of vaginal discharge. Other tools were observed sheets (checklists). Two groups were assigned modules related to the benefits of Soursop (*Annona muricata*).

A structured questionnaire measuring the participants' demographics, knowledge, attitudes towards personal hygiene, and vaginal discharge characteristics was used to collect data. Expert reviews ensured the content validity of the questionnaire, and a pilot study was used to evaluate its reliability (Cronbach's  $\alpha \geq 0.7$ ).

### **Research Flow**

#### **Exploration**

The implementation of the research began with an exploration of several subdistricts in the North Konawe Regency. The sub-districts selected by the researcher were accessible and had a sufficient number of women of childbearing age. Four sub-districts were obtained from the exploration, namely Matandahi, Motui, Sawa, and Lembo Sub-districts, as research sites with a total of 256 (population) childbearing-age women who were screened in the sample selection

#### **Socialization, Informed consent and Pretest**

Of 256 women of childbearing age, screening was conducted by asking about the history of vaginal discharge and classifying the vaginal discharge experienced. The screening results revealed that 31 women of childbearing age in Matandahi District, 31 women of childbearing age in Matandahi District, Motui District, 31 women of childbearing age in Sawa District, and 31 women of childbearing age in Lembo District experienced vaginal discharge. This sample

was divided into two groups: childbearing-age women in Matandahi District and Motui District as the intervention group, and childbearing-age women in Sawa District and Lembo District as the control group.

Initial data collection activities were conducted, starting with the implementation of socialization activities, informed consent, and pretests. Childbearing-age women were administered a questionnaire containing informed consent and a questionnaire on the characteristics of childbearing-age women, knowledge about vaginal discharge, attitudes toward personal hygiene, and the characteristics of vaginal discharge.

### Treatment

For the research activities, the intervention and control groups followed the activities where the treatment in the intervention group was socialization and pretest, giving pantyliners *Annona muricata* extract 2x a day for 7 days, and evaluation. The treatment in the control group was socialization and pre-test, giving regular pantyliners without *Annona muricata* extract 2x a day for seven days and evaluation.

### Evaluation and posttest

After the treatment activities were carried out in the intervention and control groups, evaluation and post-test activities were carried out by re-filling out a questionnaire about vaginal discharge in women of childbearing age after using pantyliners.

### Analysis

The frequency distribution data for each variable were obtained using an Excel table. The homogeneity of the samples was assessed using an independent t-test. Using the Wilcoxon test, the difference in leucorrhea between the intervention and control groups was evaluated before and after using the *Annona muricata* extract patch. The Mann-Whitney test was used to compare the mean change in leucorrhea between the intervention and control groups. The SPSS 22 software was used to process the data. Due to the nature of the data and the hypothesis being tested, the Wilcoxon test and the Mann-Whitney U test were used to analyze the differences in vaginal discharge between the intervention and control groups after *Annona muricata* extract was applied. When the data is not normally distributed, the Wilcoxon signed-rank test is very useful for assessing changes in paired samples. This makes it perfect for assessing the level of vaginal discharge of participants before and after the intervention. On the other hand, a non-parametric technique for comparing differences between two independent groups is the Mann-Whitney U test.

### Ethical Clearence

The Ministry of Health, Poltekkes Kemenkes Kendari, Indonesia, has granted ethical permission for this study under the number DP.04.03 / F.XXXVI.15 / 008 / 2024. This study obtained permission from other related institutions prior to implementation. Adherence to the relevant ethical standards was maintained throughout the study.

## RESULTS

Table 1 presents the results of the measurement of the diameter of the clear zone formed by the antibacterial activity of *Annona muricata* leaf extract against two types of bacteria, namely *Bacillus subtilis* and *Escherichia coli*. This clear zone indicates the area around the disc soaked in the soursop extract where bacterial growth was inhibited. In *Bacillus subtilis*, the diameter of the clear zone was 10 mm, whereas in *Escherichia coli*, the measured diameter was 8 mm. The difference in the size of the clear zone may reflect the variation in the sensitivity of the two bacterial species to the soursop extract. *Bacillus subtilis* showed a better response to inhibition than *Escherichia coli*, which can be interpreted as an indication that *Annona muricata* leaf extract has more effective potential as an antibacterial agent against *Bacillus subtilis*. This finding is relevant for further research on the development of herbal medicines based on soursop extract.

**Tabel 1.** Anti Bacterial Testing

Clear Zone Diameter at <i>B.subtillis</i>	Clear Zone Diameter at <i>E.Coli</i>
10 mm	8 mm

Table 2 shows that all the respondent characteristics were homogeneous. This means that the results of all treatments were not influenced by respondents' characteristics. Thus, it can be concluded that factors other than respondent characteristics affected the treatment results. This shows that the results of this study can be considered more objective and that they are not influenced by irrelevant variables.

**Table 2.** Frequency Distribution

Variables	Group				Homogeneity Sample
	Intervention		Control		
	n	%	n	%	
Age					
20-35 Years	43	69%	55	89%	0.778
> 35 Years	19	31%	7	11%	
Total	62	100	62	100	
Job					
Housewife	55	89%	49	79%	0.825
Private Sector	5	8%	5	8%	
Civil Servant	2	3%	8	13%	
Total	62	100%	62	100%	
Education					
Elementary School (Basic and Junior High School)	27	44%	15	24%	0.873
Senior High School	25	40%	33	53%	
University	10	16%	14	23%	
Total	62	100%	62	100%	
Knowledge					
Poor	47	76%	47	76%	0.998
Good	15	24%	15	24%	
Total	62	100%	62	100%	
Vaginal Discharge Before Intervention					
Moderate	51	82%	57	92%	0.982
Heavy	11	18%	5	8%	
Total	62	100%	62	100%	
Vaginal Discharge After Intervention					
No	47	76%	37	60%	0.781
Moderate	15	24%	21	34%	
Heavy	0	0%	4	6%	
Total	62	100	62	100	

### Independent T Test

There was a difference in the respondents' vaginal discharge levels in the intervention group, as indicated by the results in Table 3, which showed a p-value of  $0.000 < \alpha (0.05)$ . Overall, the use of *Annona muricata* extract panty decreased compared with its earlier use. The number of unfavorable rankings among the 30 responders demonstrated this. The control group's test results revealed a p-value of 0.000, indicating a difference in the respondents' vaginal discharge levels; most of them reported less vaginal discharge before and after using *Annona muricata* extract panty. The poor rankings of the 24 respondents and the six respondents with ties demonstrate this.

**Table 3.** Differences in Vaginal Discharge Before and After Treatment with *Annona Muricata* Extract in Both Group

Intervention Group			Control group		
Rank	F	p-value	Rank	F	0.000
Negative	62		Negative	56	
Positive	0		Positive	0	
Ties	0		Ties	8	
Total	60		Total	64	

Wilcoxon test

The analysis findings are displayed in Table 4, where a p-value of 0.025 indicated that the intervention and control groups differed in their changes in vaginal discharge. This suggests that the intervention had a significant impact on this particular outcome compared to the control group.

**Table 4.** Differences in Changes in Vaginal Discharge between the Intervention Group and the Control Group

Experimental Group	n	Mean	p-value
Intervention	62	26.50	0.025
Control	62	34.50	
Total	124		

Mann Whitney Test

## DISCUSSION

One important consideration when examining the treatment results is the homogeneity of respondent characteristics, as shown in Table 2. According to the statistical measures shown (e.g., p-values ranging from 0.778 for age to 0.998 for knowledge), there were no discernible differences in the demographic variables being monitored between the intervention and control groups, including age, job, education, knowledge levels, and vaginal discharge status. This finding suggests that the samples are sufficiently matched, which leads one to the conclusion that differences in treatment efficacy or results are caused by other underlying factors related to the treatment itself rather than by the characteristics of the respondents (17).

The findings are reliable because of the consistent age distribution, with the majority of respondents being between the ages of 20 and 35 in both the intervention and control groups. Age-related homogeneity is essential because it prevents age-related variables, which frequently cause confounding in clinical trials, from distorting the treatment outcomes. There is less chance that age-related physiological differences will influence results when people are closely matched in age (17). Therefore, this demographic consistency adds to the study's objective credibility by removing age-variance biases and enabling clearer implications of the intervention.

Both groups are fairly evenly represented across educational achievements despite the fact that education levels vary. It should be highlighted, though, that educational disparities may have an effect on how well study treatments are understood and applied, which could have an impact on self-reported outcomes (18). However, because significant educational variances are reduced, results interpretations might be more concerned with the efficacy of the intervention rather than varying educational perspectives on it (19).

Additionally, knowledge levels remained almost constant, with a startling balance indicating that 76% of both groups assessed their knowledge as poor, and similar percentages recognizing good knowledge levels. This consistency supports the claim that variations in respondents' prior knowledge, rather than differences in treatment efficacy, can be legitimately attributed to the treatment (19). Because of this knowledge homogeneity, researchers can attribute improvements to intervention measures rather than respondents' prior knowledge or education on the subject, demonstrating the intervention's direct influence on changes in vaginal health-related health behaviors.

Furthermore, data comparing vaginal discharge before and after intervention offer strong evidence of the effectiveness of treatment. Interestingly, post-intervention data showed that 76% of participants in the intervention group reported no vaginal discharge compared to 60% in the control group. These trends lend credence to the idea that independent variables, possibly related to the intervention itself, rather than the demographic characteristics of the respondents, influence outcomes.

A significant reduction in vaginal discharge was observed in both the groups ( $p = 0.000$ ). The *Annona muricata* extract panty, which has natural antimicrobial properties, was found to be effective in managing this condition. Other research suggests that the endophytic fungi found in *Annona muricata* play a significant role in acting as antibacterial agents against specific microbes. Because *Annona muricata* contains terpenoids, it can be used to treat a variety of infections (20). *Annona muricata*, commonly known as soursop, has been traditionally used for its medicinal properties in various cultures (5,21). The antimicrobial activity of *Annona muricata* extract may offer a natural and effective alternative for managing vaginal discharge and other infections (22,23). The extract also contains acetogenins, which have antimicrobial effects, suggesting that using it during the extract of soursop leaves could help reduce the effects of vaginal discharge (24).

Other studies have also shown that Soursop (*Annona muricata*) can help reduce vaginal discharge and improve overall health in the vaginal area of women (23). Acetogenins, flavonoids, and tannins are among the compounds found in soursop (*Annona muricata*). These are bioactive compounds. These compounds are known for their therapeutic effects (25). The antimicrobial properties of these compounds reduce and manage infections, which can increase the risk of vaginal discharge. Soursop (*Annona muricata*) extract has broad-spectrum antibacterial activity, which is known to be beneficial in maintaining vaginal flora and reducing or even eliminating pathogenic bacteria that cause vaginal discharge. In addition, the antioxidant properties known to be present in Soursop (*Annona muricata*) can also contribute to improving vaginal health. This is known to reduce oxidative stress associated with various gynecological problems (26). The findings of this study are in line with previous studies showing that soursop (*Annona muricata*) is efficacious in various treatments related to femininity or other problems. Previous studies have shown that Soursop (*Annona muricata*) extract is able to improve inflammation and reduce oxidative stress (27).

A Wilcoxon test with a p-value of less than 0.05 in both the intervention and control groups confirmed that the *Annona muricata* extract intervention significantly decreased respondents' vaginal discharge levels. In particular, 30 respondents showed improvement in the intervention group, which is consistent with data showing that herbal remedies can successfully reduce the discomfort and symptoms of vaginal discharge. Given that many respondents reported a significant drop in discharge both before and after treatment, the decrease in unfavorable rankings from 24 respondents supports an improvement in conditions. This study supports findings from other studies that herbal remedies, such as those made from *A. muricata*, are therapeutically effective in treating vaginal flora and conditions, improving the health of women (28).

The effectiveness of the intervention was demonstrated by the significant difference in vaginal discharge changes between the two groups, as revealed by the Mann-Whitney U test, which also called for further research. These findings suggest that this intervention may have a positive effect on vaginal health. pantyliners with *Annona muricata* extract 2x twice day for 7 days. Soursop is often used as an additive in pantyliners to help reduce vaginal discharge and improve vaginal health (29).

According to the study findings, respondents in the intervention group experienced less vaginal discharge before and after using the *A. muricata* extract panties. Drugs, such as cyclovir, can be used to treat vaginal discharge. Combinations of various polymer types enable the creation of strong and efficient vaginal tablets that can regulate the release of ACV, making them beneficial for sexually transmitted infections [16]. Trichloro-Acetic acid solution 40-50% can be used for Cervical Intraepithelial Neoplasia (31). Treatment of vaginal infections can be done by consuming nystatin (32), miconazole (33), clotrimazole (34), friconazole (35), antiseptic solutions(36), and estrogen hormones (37,38). Probiotics can help maintain the balance of beneficial bacteria in the vagina, thereby preventing future infections (39–41).

Benefits of soursop leaves as antibacterial the phytochemical content of nonaceous acetogenin in *Annona muricata* extract is an active antibacterial agent. Studies have shown that soursop leaves can inhibit the growth of various bacteria, thereby making them effective in combating infections. Additionally, soursop leaves have antibacterial properties and can be used to treat ailments, such as skin and urinary tract infections. The phytochemical and antinutrient content of the crude extract of *A. muricata* leaves was marginally higher than the allowable limits for leafy vegetables. *S. aureus* isolates' microbial load was decreased by the extract, with a zone similar to cefoxitin's. Beneficial interactions between bioactive chemicals in *A. muricata* leaves and *S. aureus* CPS were observed. These substances can disrupt the catalytic reaction by favorably binding to Cap5O, which could result in the creation of

CPS that encourages immunological evasion in humans. Given the significance of Cap50 in the generation of CPS, these bioactive molecules may be advantageous therapeutic targets either alone or in combination (42).

Soursop leaves are effective in treating bacterial diseases including upper respiratory tract infections, diarrhea, vaginal discharge, boils, and urinary tract infections. Because of its antibacterial and anti-inflammatory qualities, *Annona muricata* infusion is a safe and efficient treatment for vaginal discharge in women who are pregnant (28). Due to their antifungal qualities, soursop leaves may also be used as a treatment for fungal infections (43,44). The natural substances found in soursop leaves may also strengthen the immune system, assisting the body in fending off different infections (45). It has also been discovered that soursop leaves have anti-inflammatory qualities that can help lessen pain and swelling brought on by a number of ailments (46,47).

The antibacterial properties of soursop leaves include steroid-group chemicals, alkaloids, flavonoids, and tannins that can stop the growth of bacteria like *Salmonella typhimurium*, *Proteus vulgaris*, *E. Coli*, *Klebsiella*, and *Candida albicans* (48). *Annona muricata* decoction extract includes antiseptic elements that can kill germs, such as phenol, which has antiseptic characteristics five times more powerful than regular phenol, and may be an alternative treatment for leukorrhea in women. All test organisms reacted favorably to the soursop extracts, with the exception of *P. intermedia*. Soursop was the most effective against *S. mutans*, followed by *C. albicans*, and the least effective against *P. intermedia* in vitro. Therefore, the use of nature to identify treatment has become a crucial aspect of medicine. Natural materials that people can find in their homes may also be used as an adjuvant to empirical therapy, as future solutions may be found in making the greatest use of already-existing resources(49).

The bioactive compounds, significant antimicrobial qualities, and anti-inflammatory effects of *Annona muricata* (soursop) extract nanoparticles can be linked to several important biological pathways that may lessen vaginal discharge in women of childbearing age. Together, these systems improve vaginal health and control excessive discharge. First off, flavonoids, alkaloids, saponins, and tannins are all part of *Annona muricata*'s complex phytochemical profile, which is essential to its medicinal properties (5,50). These bioactive substances are important in the fight against infections that may cause increased vaginal discharge because they have demonstrated encouraging antibacterial and antifungal qualities. To illustrate its ability to treat bacterial vaginosis, a condition frequently linked to irregular vaginal discharge, research has shown that soursop leaf extract has significant inhibitory effects against a variety of pathogens, including *Staphylococcus aureus* (51).

*A. muricata* is also said to have anti-inflammatory qualities (50) which is important for reducing vaginal epithelial inflammation that can cause excessive vaginal discharge. Pathologically increased vaginal secretions can be caused by inflammation, which can be caused by irritation or the presence of bacteria. These symptoms can be reduced by reducing inflammatory mediators through a mechanism of action related to the phytochemicals in soursop (52). In addition, *A. muricata* has a positive effect on oxidative stress, which can cause inflammation and susceptibility to infection (53). By reducing oxidative stress markers, the extract helps restore the vaginal microenvironment. The presence of antioxidants in the extract contributes to cellular protection and might inhibit the overactivity of immune responses that precede discharge-related issues (54).

### Limitations and Cautions

Despite showing encouraging results regarding the antibacterial benefits of *Annona muricata* extract on vaginal health, this study has a number of limitations that should be considered. Despite having a fairly balanced number of intervention and control groups, the sample size may not be sufficient to extrapolate the results to larger populations. The time constraints of the research are also important to consider for future research. Furthermore, the study's demographic homogeneity restricts the diversity required to assess the effectiveness of the extract across multiple populations with varying backgrounds, health statuses, and underlying conditions, even though it helps to control confounding variables.

### Recommendations for Future Research

Further studies involve a wider and more diverse population to strengthen the evidence on the therapeutic potential of *A. muricata*. Based on the findings of this study, there is significant potential for large-scale production of *Annona muricata* leaf extract as an antibacterial agent and in the development of health products such as pantyliners. However, before mass production is implemented, several recommendations need to be considered. First, further research is needed to disseminate the long-term efficacy and safety of *A. muricata* use in a wider and more

diverse population. In addition, risk analysis and toxicity assessment need to be conducted to ensure the safety of the product for consumers. Regulatory considerations are also important, especially in terms of product registration and compliance with food and drug safety standards in each country. Collaboration with regulatory agencies and in-depth research on interactions with other products and potential allergic reactions are highly recommended. This study shows promising early results, but these steps are essential to support the development of a safe and effective product.

## CONCLUSION

Our findings suggest that the use of *Annona muricata* extract panty was effective in reducing vaginal discharge in both intervention and control groups. This study showed that *Annona muricata* leaf extract has significant antibacterial potential against the growth of *Bacillus subtilis* and *Escherichia coli*, with larger clear zone diameters observed in *Bacillus subtilis* (10 mm) compared to *Escherichia coli* (8 mm). In addition, the test results showed a significant decrease in the level of vaginal discharge in the intervention group using *A. muricata* extract-based pantyliners ( $p = 0.000$ ), indicating its effectiveness in the management of the condition.

## AUTHOR'S CONTRIBUTION STATEMENT

All authors contributed equally to the study conception and design, final editing, final revision, data curation, and methodology.

## CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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