



# The potential of tofu pulp waste as an alternative transport medium for vaginal swabs and wound samples

Richo Saputra<sup>1</sup>, Safira Rakhma Khoirunnisa<sup>1</sup>, Siti Azzahra<sup>1</sup>, Syalwa Putri Anugrah<sup>1</sup>,  
Dinda Risa Puspitasari<sup>1</sup>, Venny Patricia<sup>1,\*</sup>

<sup>1</sup> Department of Medical Laboratory Technology, Poltekkes Kemenkes Banten, Serang, Banten 42121, Indonesia.

\*Correspondence: venny.patricia@poltekkesbanten.ac.id

Received Date: January 3, 2026

Revised Date: January 15, 2026

Accepted Date: January 27, 2026

## ABSTRACT

**Background:** Transport media are essential for preserving specimen integrity and maintaining microorganism viability during delays between collection and laboratory testing. Conventional transport media are often expensive, powder-based, and have limited shelf life after preparation, creating barriers in resource-limited settings. Tofu pulp waste, a nutrient-rich by-product containing fiber, protein, and minerals, may support bacterial survival while also reducing food waste. **Methods:** This laboratory-based experimental study assessed tofu pulp waste as an alternative transport medium for vaginal swabs collected at Mandala Rangkasbitung Community Health Center and infected wound swabs collected at Dr. Adjidarmo Rangkasbitung Regional General Hospital. The study was conducted at the Integrated Microbiology Laboratory of the Banten Ministry of Health Polytechnic, using purposive sampling. Specimens were transported in tofu pulp waste medium (intervention) or standard Amies medium (control) and then subjected to microscopy, bacterial culture, and Gram staining. Effectiveness was evaluated by comparing bacterial viability and recovery between media. **Findings:** The tofu pulp waste medium maintained microorganism viability in both specimen types. Culture and microscopy identified Gram-negative bacteria in wound swabs, including *Citrobacter freundii* and *Proteus mirabilis*, and showed normal vaginal flora and clue cells in vaginal swabs. Overall recovery patterns were comparable to those obtained using Amies medium. **Conclusion:** Tofu pulp waste has strong potential as a low-cost, environmentally friendly alternative transport medium that preserves bacterial stability until laboratory analysis. **Novelty/Originality of this article:** This article provides a new contribution to the field of clinical microbiology by demonstrating that tofu residue, a nutrient-rich byproduct of the food industry, can serve as an effective and stable bacterial transport medium.

**KEYWORDS:** tofu pulp waste; alternative transport medium; microbial viability.

## 1. Introduction

Cervical cancer remains a major global health concern and continues to be a leading cause of morbidity and mortality among women, particularly in low- and middle-income countries, including Indonesia. The disease is characterized by the malignant transformation of cervical epithelial cells at the junction between the uterus and the vagina. In Indonesia, cervical cancer is prioritized as one of the four major diseases targeted by the national screening program, which primarily utilizes Visual Inspection with Acetic Acid (VIA) and Pap smear examinations to detect early precancerous lesions. According to the 2020 Indonesian Health Profile, more than 50,000 women were diagnosed through VIA

### Cite This Article:

Saputra, R., Khoirunnisa, S. R., Azzahra, S., Anugrah, S. P., Puspitasari, D. R., Patricia, V. (2026). The potential of tofu pulp waste as an alternative transport medium for vaginal swabs and wound samples. *Asian Journal of Toxicology, Environmental, and Occupational Health*, 3(2), 129-149. <https://doi.org/10.61511/ajteoh.v3i2.2026.3615>

**Copyright:** © 2026 by the authors. This article is distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).



screening, with thousands of additional suspected cases reported across the country. In Banten Province alone, screening programs have identified hundreds of positive and suspected cases, highlighting the ongoing burden of cervical pathology in the region. However, the effectiveness of screening and subsequent clinical interventions is often complicated by the presence of reproductive tract infections and vaginal dysbiosis, which may obscure symptoms or exacerbate tissue damage.

In many developing and resource-limited settings, diagnostic limitations are particularly evident in the management of reproductive tract infections and wound-related complications. Bacterial vaginosis (BV) and other sexually transmitted infections (STIs) pose substantial health risks for adolescents and women of reproductive age. BV is characterized by a significant shift in the vaginal microbiota, in which protective *Lactobacillus* species are replaced by a diverse community of anaerobic bacteria, including *Gardnerella vaginalis*. Recent epidemiological studies report high BV prevalence rates in clinical populations, often exceeding 30–40% in certain regions, indicating a persistent global burden of the condition (Aklilu et al., 2024; Morrill et al., 2020). Without accurate diagnosis and appropriate treatment, BV can lead to serious complications such as pelvic inflammatory disease, chronic pelvic pain, infertility, and adverse pregnancy outcomes (Rafat et al., 2025; Shimeles et al., 2025). The complexity of the vaginal microbiota and the sensitivity of these organisms to environmental conditions further complicate accurate diagnosis, particularly during specimen transport (Abbe & Mitchell, 2023; Fredricks et al., 2005).

In addition to BV, other reproductive tract infections and shifts in vaginal flora are clinically relevant because they can increase susceptibility to STIs and may complicate screening interpretation in primary care settings. Laboratory-based diagnostic standards for STI-related syndromes emphasize the importance of correct specimen collection and transport to avoid loss of organism viability before culture-based confirmation (Unemo et al., n.d.). Moreover, clinical studies in different populations have repeatedly shown that BV prevalence can remain high in reproductive-age women, underlining the importance of reliable microscopy and transport workflows in routine services (Atia, 2021).

Similarly, surgical site infections (SSIs) and chronic wound infections represent a major source of morbidity worldwide. These infections are particularly problematic in healthcare systems with limited resources, where infection control practices and laboratory support may be inconsistent. Chronic wounds, such as diabetic foot ulcers, are typically polymicrobial environments in which pathogens like *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and various Gram-negative bacteria establish persistent infections (Khalid et al., 2024; Phan et al., 2023). These organisms possess virulence factors that enable adhesion to host tissues and the formation of biofilms, which are structured microbial communities embedded in a protective extracellular matrix. Biofilm formation significantly increases resistance to host immune responses and systemic antimicrobial therapy, making accurate microbiological identification and susceptibility testing essential for effective treatment (Puca et al., 2021; Woriku et al., 2023). Wound infection pathogenesis is not only driven by single pathogens but also by complex wound microbiota that may impair healing through persistent inflammation and biofilm-associated tolerance. Reviews on wound microbiota highlight that microbial community structure, tissue oxygenation, and moisture strongly influence which organisms dominate and how difficult they are to eradicate (Uberoi et al., 2024). Epidemiological studies of surgical wound infections further emphasize that local hospital ecology and perioperative factors shape the spectrum of isolates, reinforcing the need for standardized transport conditions to minimize pre-analytical bias (Giacometti et al., 2000). Delays or errors in specimen handling and transport can lead to decreased pathogen viability or overgrowth of commensal flora, resulting in misleading laboratory findings and the inappropriate use of broad-spectrum antibiotics.

The global burden of bacterial infections and antimicrobial resistance further emphasizes the importance of reliable microbiological diagnostics. A comprehensive global analysis estimated that bacterial antimicrobial resistance was associated with millions of deaths worldwide, highlighting the urgent need for accurate pathogen detection and

targeted therapy (Murray et al., 2022). In parallel, global surveillance literature consistently links delayed culture confirmation and empirical antibiotic exposure with increased selection pressure for resistance, especially in wound and pus infections managed in hospitals. Recent wound-infection datasets also describe diverse aerobic isolates with variable susceptibility profiles, underscoring the practical importance of keeping samples viable from collection to laboratory processing (Onsando Samson, 2025). In many low- and middle-income countries, limited laboratory infrastructure and restricted access to standardized diagnostic materials contribute to delays in pathogen identification and promote empirical antibiotic use (Afolayan et al., 2021). These challenges underscore the critical role of proper specimen transport systems in ensuring accurate laboratory results and supporting antimicrobial stewardship programs.

The accuracy of laboratory diagnosis in both reproductive and wound infections depends heavily on the availability of transport media capable of maintaining microbial viability between the point of collection and the clinical laboratory. Commonly used gold-standard media, such as Amies, Cary-Blair, and Stuart media, are specifically formulated to preserve specimen integrity for several hours without promoting excessive microbial growth. Despite their effectiveness, these media present significant logistical and financial challenges in the Indonesian context. Most commercial transport media are imported, imposing a considerable financial burden on national health systems and community health centers. In Indonesia, the cost of a single transport medium tube may range from IDR 15,000 to IDR 25,000, which can be prohibitive for routine use in underfunded or rural healthcare facilities. This reliance on imported diagnostic supplies contributes to healthcare inequities and hinders progress toward Universal Health Coverage and the Sustainable Development Goals related to equitable health access.

From an operational standpoint, transport media quality determines whether downstream identification and susceptibility testing can be performed reliably, particularly for clinical swabs collected in peripheral sites. Evidence from studies developing low-cost transport formulations in low-resource contexts supports that locally sourced, well-buffered media can be feasible when sterility and stability are ensured (Boiko et al., 2021; Rahmani et al., 2025).

In addition to economic constraints, pre-analytical factors such as specimen handling and transport conditions play a crucial role in determining diagnostic accuracy. Many clinically significant microorganisms, particularly anaerobic and fastidious species, are highly sensitive to oxygen exposure, temperature fluctuations, and nutrient depletion during transit. Inadequate transport conditions may lead to bacterial death, metabolic alterations, or the overgrowth of contaminating flora, ultimately compromising culture results. These challenges are particularly relevant in polymicrobial infections, where accurate preservation of microbial diversity is necessary for correct diagnosis and treatment decisions.

In response to these challenges, there has been increasing interest in developing low-cost, sustainable alternatives to conventional transport media. Recent studies have explored locally produced or simplified transport media for diagnostic applications in resource-limited settings, demonstrating the feasibility of such approaches (Rahmani et al., 2025). The global shift toward sustainable healthcare systems has also encouraged the exploration of environmentally friendly materials derived from agricultural or food-processing by-products. These materials are often abundant, inexpensive, and biodegradable, making them attractive candidates for use in microbiological applications (Montesinos et al., 2024).

One such by-product is tofu pulp waste, commonly known as okara. Okara is produced in large quantities during tofu and soy milk processing and is frequently discarded despite its high nutritional value. It contains substantial amounts of protein, dietary fiber, and essential nutrients that can potentially support microbial survival (Shinde et al., 2025). The fibrous structure of okara, composed of cellulose, hemicellulose, and lignin, can serve as a physical scaffold for microbial attachment, resembling the solid-state environment found in biological tissues. This property aligns with the principles of solid-state fermentation, in

which solid substrates provide both nutritional support and structural stability for microbial maintenance.

In addition to its structural and nutritional properties, okara also contains bioactive compounds such as isoflavones, including genistein and daidzein, which possess antioxidant activity. These compounds have been reported to protect cellular structures from oxidative stress, potentially preserving bacterial viability during storage and transport (Kim, 2024; Privatti et al., 2024). Such protective mechanisms may function similarly to the activated charcoal used in conventional transport media to neutralize metabolic by-products and maintain a favorable microenvironment for microorganisms.

The utilization of okara as a transport medium offers several potential advantages. It provides a low-cost and locally available diagnostic material, reduces environmental pollution caused by food-processing waste, and supports the development of sustainable medical innovations. Moreover, the use of locally sourced materials may strengthen laboratory resilience and reduce dependence on imported diagnostic supplies, particularly in decentralized healthcare systems.

In Indonesia, the operational reality of specimen transport often differs substantially from the ideal conditions assumed in clinical microbiology guidelines. Primary health centers and district hospitals may face delays caused by limited courier schedules, high patient volume, and constrained laboratory capacity, particularly when specimens must be referred to centralized facilities. Such pre-analytical delays are clinically consequential because a swab specimen is not a static entity; the microbial community may shift during transport due to oxygen exposure, temperature variation, and progressive nutrient depletion. These factors can selectively reduce the viability of fastidious organisms while allowing more resilient flora to persist, thereby altering the apparent microbial composition at the time of culture. In syndromes such as bacterial vaginosis and polymicrobial wound infection, where mixed communities are expected, preservation of the original microbial balance becomes critical for accurate interpretation.

Moreover, the broader context of diagnostic equity and supply resilience has become increasingly relevant. Import dependence for routine consumables—transport media, sterile swabs, and culture accessories—can amplify service disruptions and cost volatility. In resource-limited settings, this may translate into fewer specimens being processed microbiologically, delayed antimicrobial susceptibility testing, and a greater reliance on empirical antibiotic therapy. Because antimicrobial stewardship depends on timely and reliable microbiological evidence, innovations that strengthen the pre-analytical chain can have downstream benefits for therapeutic decision-making and resistance control. Accordingly, developing an alternative transport medium from locally available material is not merely a cost-saving strategy; it represents a systems-level intervention that may improve diagnostic continuity, reduce waste, and support sustainable laboratory practice in decentralized healthcare systems.

Therefore, the development of a tofu pulp waste-based transport medium represents a novel and practical approach to addressing both diagnostic and environmental challenges in resource-limited settings. This study aims to evaluate the effectiveness of a tofu pulp waste-based transport medium in maintaining the viability of microorganisms from vaginal and wound swab specimens, compared with the standard Amies transport medium. Through this investigation, the study seeks to provide a scientifically grounded, cost-effective, and sustainable alternative to conventional transport media for use in clinical microbiology.

## 2. Methods

This laboratory-based experimental study employed purposive sampling to compare bacterial viability and recovery from clinical swabs transported in a tofu pulp waste medium versus standard Amies medium, followed by culture on selective and differential agar. The study was conducted at Mandala Rangkasbitung Community Health Center and Dr. Adjidarmo Regional General Hospital, Rangkasbitung, Indonesia, with laboratory

processing from January to May 2025. The sample comprised patients undergoing routine clinical swab testing, including vaginal swabs from female patients and wound swabs from postoperative patients with suspected infection. Equipment included standard microbiological instruments and a biosafety cabinet. At the same time, materials comprised Amies medium, tofu pulp waste, Blood Agar Plate (BAP), MacConkey Agar (MCA), sterile swabs, distilled water, and biochemical media for identification. The composition of the ingredients in tofu pulp waste is as follows: Tofu pulp waste (1.5 g), NaCl (0.45 g), Sodium Hydrogen Phosphate (0.17 g), Potassium Dihydrogen Phosphate (0.03 g), Potassium Chloride (0.03 g), Sodium Thioglycolate (0.15 g), Calcium Chloride (0.015 g), Magnesium Chloride (0.015 g), Seaweed Agar Powder (0.6 g), Distilled Water 150 ml.

### *2.1 Study design and setting*

This laboratory-based experimental study employed a comparative design to evaluate bacterial viability and recovery from clinical swab specimens transported using a tofu pulp waste medium and the standard Amies transport medium. The primary objective was to assess whether a sustainable, locally derived transport medium could maintain microbial viability at a level comparable to the conventional gold-standard medium. The study was conducted at the Integrated Microbiology Laboratory of the Banten Ministry of Health Polytechnic (Poltekkes Kemenkes Banten), Indonesia.

Clinical specimens were collected between January and May 2025 at two healthcare facilities in Rangkasbitung: the Mandala Rangkasbitung Community Health Center and Dr. Adjidarmo Regional General Hospital. These facilities were selected because they routinely manage reproductive health and postoperative wound cases, providing an appropriate clinical setting for specimen collection. All laboratory procedures were performed under standardized biosafety protocols using a Class II biosafety cabinet. Equipment used in the study was routinely calibrated to ensure accuracy and reproducibility of results. Sterilization procedures followed internationally accepted microbiological standards to minimize the risk of contamination.

### *2.2 Materials and equipment*

The primary equipment used in this study included a digital autoclave for steam sterilization, a forced-air laboratory oven for dehydration processes, an analytical balance for precise measurement of medium components, a magnetic stirrer for homogenization, and a binocular light microscope for microbial observation. All laboratory work involving clinical specimens was conducted inside a Class II biosafety cabinet to maintain aseptic conditions. The materials used included commercial Amies transport medium, tofu pulp waste (okara), Blood Agar Plates (BAP), MacConkey Agar (MCA), sterile dacron swabs, distilled water, and biochemical test media for bacterial identification. Additional reagents included Gram staining solutions and IMViC biochemical reagents.

### *2.3 Preparation of the tofu pulp waste and composition of the tofu pulp waste transport medium*

Fresh tofu pulp waste was obtained from a local tofu producer to ensure availability and relevance to local production conditions. The material was subjected to three consecutive washes using sterile distilled water to remove soluble sugars, residual proteins, and other compounds that could promote rapid bacterial growth during transport. After washing, the tofu pulp waste was spread in a thin, uniform layer on sterile trays and dehydrated in a forced-air oven at 60°C for 48 hours.

This temperature and duration were selected to reduce the moisture content to below 10%, thereby inhibiting the growth of contaminating microorganisms. The dried substrate was subsequently ground into a fine powder using a laboratory blender. The powder was then sieved through an 80-mesh screen to obtain a uniform particle size. This step ensured

homogeneous distribution of the substrate within the transport medium and improved rehydration during medium preparation.

Table 1. Composition of the tofu pulp waste transport medium

Component	Amount
Tofu pulp waste (okara)	1.5 g
Sodium chloride (NaCl)	0.45 g
Sodium hydrogen phosphate	0.17 g
Potassium dihydrogen phosphate	0.03 g
Potassium chloride (KCl)	0.03 g
Sodium thioglycolate	0.15 g
Calcium chloride	0.015 g
Magnesium chloride	0.015 g
Seaweed agar powder	0.6 g
Distilled water	150 mL

The tofu pulp waste transport medium was formulated to provide a semi-solid and protective microenvironment capable of maintaining microbial viability during specimen transport. The composition of the medium was as follows on Table 1. Sodium thioglycolate was incorporated as a reducing agent to decrease the redox potential of the medium and support the survival of anaerobic and fastidious organisms. The inclusion of agar provided a semi-solid matrix that prevented desiccation of the swab while limiting excessive microbial growth during transport.

## 2.4 Preparation for transport media

### 2.4.1 Sterilization procedures and preparation of amies medium

All reusable glassware, including beakers, Erlenmeyer flasks, and screw-cap tubes, was sterilized at 121°C for 15 minutes using a digital autoclave. This sterilization protocol is widely accepted for eliminating vegetative cells and bacterial endospores. Work surfaces and instruments were disinfected prior to use to maintain aseptic laboratory conditions.

The Amies transport medium was prepared according to standard laboratory procedures. All components were dissolved in distilled water and heated until completely homogenized. The medium was then dispensed into sterile screw-cap tubes and sterilized by autoclaving at 121°C for 15 minutes. After sterilization, the tubes were cooled and stored at room temperature until use.

### 2.4.2 Preparation of tofu pulp waste medium

The tofu pulp waste transport medium was prepared by dissolving 50 g of tofu powder, 2 g of bacteriological agar, and 1 g of sodium chloride in 100 mL of distilled water. The mixture was homogenized using a magnetic stirrer and heated until the agar completely dissolved, forming a uniform semi-solid solution. The pH of the medium was measured using a calibrated digital pH meter and adjusted to a neutral range of  $7.2 \pm 0.2$ .

This pH range was selected to maintain compatibility with both vaginal and wound-associated microorganisms. The prepared medium was dispensed into 5 mL screw-cap tubes and sterilized by autoclaving at 121°C for 15 minutes. After sterilization, the media were cooled and stored at 4°C if not used immediately.

## 2.5 Clinical specimen collection

Specimens were collected using a purposive sampling approach from two clinical cohorts: vaginal swabs and wound swabs. To strengthen comparability between the intervention and control, specimens were handled as paired observations. For each eligible patient, two swabs were collected from the same anatomical site in immediate succession

using the same technique and operator, and each swab was placed into a different transport medium (tofu pulp waste medium vs. Amies). This paired approach minimized inter-individual variability and ensured that observed differences in recovery were primarily attributable to the transport medium rather than sampling heterogeneity.

After inoculation into transport tubes, specimens were maintained at controlled room temperature (25–27°C) and processed within the routine operational timeframe of the participating facilities. Transport duration reflected real-world referral practice, and all tubes were kept upright and tightly capped to reduce desiccation and environmental exposure. Upon arrival at the laboratory, each specimen was logged, inspected for leakage or visible contamination, and processed immediately for culture and microscopy. This workflow was designed to replicate practical conditions in primary and secondary care settings while maintaining standardized handling steps across all specimens.

### 2.5.1 Vaginal and wound swab cohort

Vaginal swabs were obtained from women aged 15–45 years undergoing VIA screening at the community health center. A sterile dacron swab was inserted approximately 2 inches into the vaginal canal and rotated against the posterior fornix for 10–15 seconds to ensure adequate sample collection. Then, wound swabs were collected from postoperative patients with suspected infections between 1 and 7 days after surgery. The Levine technique was used, in which the swab was pressed and rotated over approximately 1 cm<sup>2</sup> of clean wound bed tissue after cleansing the wound margins with 70% alcohol. This method was selected because it provides a more accurate representation of deep-tissue microorganisms compared with superficial swabbing.

Each specimen was immediately placed into either the tofu pulp waste transport medium (intervention) or the Amies transport medium (control). The specimens were maintained at room temperature (25–27°C) during transport to the laboratory. The specimen collection and basic laboratory diagnostic workflow were aligned with commonly referenced laboratory guidance for STI-related specimen handling, including the need to minimize delays and prevent desiccation during transport (Unemo et al., n.d.). For wound sampling, standardized swab techniques are recommended to improve representativeness of deeper microbial burden compared with superficial sampling (Bessa et al., 2015).

### 2.6 Laboratory analysis

Quality assurance procedures were implemented throughout medium preparation and laboratory processing to reduce contamination and measurement bias. Each batch of prepared transport medium underwent sterility verification by incubating randomly selected tubes without inoculation and monitoring for turbidity or microbial growth on subculture. Culture media (BAP, MCA, and MSA) were also checked for sterility and expected performance using routine laboratory control organisms when available.

Such QA steps are consistent with recommendations in laboratory-oriented reviews emphasizing that pre-analytical handling and culture workflow standardization reduce misclassification in polymicrobial wound infections (Wolf et al., 2021). Microscopy and Gram-stain interpretation followed standardized criteria. Slides were read under consistent illumination and magnification settings, and morphological reporting used predefined categories (cocci, bacilli, coccobacilli; Gram-positive vs. Gram-negative). For biochemical identification, IMViC reactions and confirmatory tests (catalase/coagulase for Gram-positive isolates) were performed according to manufacturer instructions and laboratory SOPs, with appropriate positive and negative controls when feasible. All results were recorded using standardized worksheets to ensure traceability and reduce transcription errors.

### 2.6.1 Microscopic examination

Wet mounts of vaginal swabs were examined under a light microscope at 400× magnification to detect the presence of clue cells. The observation of epithelial cells covered with coccobacilli was considered indicative of bacterial vaginosis. Gram staining was performed using the standard four-step method: crystal violet staining, iodine mordant application, alcohol–acetone decolorization, and safranin counterstaining. Bacteria were classified as Gram-positive or Gram-negative based on their staining characteristics.

### 2.6.2 Culture and biochemical identification

Specimens were inoculated onto Blood Agar Plates (BAP) and MacConkey Agar (MCA) using standard streaking techniques. The plates were incubated aerobically at 37°C for 18–24 hours. For vaginal specimens, an additional set of plates was incubated in a 5–10% CO<sub>2</sub> atmosphere to support microaerophilic organisms. Species-level identification was conducted using IMViC biochemical tests, including Indole, Methyl Red, Voges–Proskauer, and Citrate utilization tests. Catalase and coagulase tests were also performed for Gram-positive isolates to differentiate *Staphylococcus aureus* from other staphylococci.

### 2.6.3 Laboratory analysis and interpretation

Microbial recovery was quantified using the Colony Forming Unit (CFU/mL) method. Comparative statistical analysis was performed to evaluate differences in bacterial viability between the tofu pulp waste transport medium and the Amies control medium. A p-value of <0.05 was considered statistically significant. Consistency in colony morphology, Gram-stain characteristics, and biochemical profiles across the specimen pairs was used as an additional indicator of the effectiveness of the tofu pulp waste transport medium.

## 3. Results and Discussion

### 3.1 Vaginal swab samples

#### 3.1.1 Microscopic examination of vaginal swabs

The examination was conducted to detect microorganisms causing infection and to assess the presence of normal flora using Gram staining and microscopic examination of vaginal swab samples from IVA Test patients at the Mandala Rangkasbitung Community Health Center. As shown in Table 1, microscopic Gram staining of vaginal swab samples revealed a predominance of Gram-positive bacilli (53.33%), consistent with normal vaginal flora, primarily *Lactobacillus* spp., indicating a generally balanced vaginal microbiota. Gram-positive cocci and fungal elements were each observed in 20.00% of samples, suggesting mixed colonization patterns within the vaginal ecosystem, while clue cells were detected in 6.67% of samples, indicating bacterial vaginosis in a subset of patients.

Table 1. Microscopic prevalence of vaginal swabs

Description	N (%)
Gram + bacilli	8 (53.33%)
Gram-positive cocci	3 (20.00%)
Clue cell	1 (6.67%)
Fungi	3 (20.00%)

*Lactobacillus* spp. are the dominant bacteria in healthy vaginal microbiota, accounting for approximately 70% of the normal flora. These organisms produce lactic acid, hydrogen peroxide, and bacteriocins, which help maintain a low vaginal pH and inhibit the growth of

pathogenic bacteria. The presence of these protective mechanisms is essential in preventing the colonization of opportunistic and pathogenic microorganisms.

The detection of clue cells in 6.67% of samples indicates bacterial vaginosis (BV) in a subset of patients. BV is characterized by a shift from a *Lactobacillus*-dominated microbiota to a diverse anaerobic community. This imbalance can increase susceptibility to sexually transmitted infections, adverse pregnancy outcomes, and pelvic inflammatory disease. The identification of clue cells therefore represents a critical diagnostic indicator of vaginal dysbiosis.

These findings demonstrate that microscopic examination effectively differentiates normal vaginal flora from BV-associated alterations. The staining method used also enables clear identification of clue cells and bacterial morphotypes, making it a practical diagnostic tool even in settings with limited laboratory expertise (Martínez-Figueroa et al., 2022). Similar observations have been reported in studies of vaginal microbiota, which highlight the importance of maintaining microbial balance and early detection of dysbiosis in reproductive health management (Aklilu et al., 2024; Rafat et al., 2025).

### 3.1.2 Macroscopic observations on the medium

Samples transported in both Amies and tofu pulp waste media were subcultured onto chocolate agar and Sabouraud Dextrose Agar (SDA) using the spread-plate method to obtain uniform colony distribution. Chocolate agar plates were incubated for 24 hours in a sealed jar to support the growth of fastidious organisms, while SDA plates were incubated at 37°C for 24 hours to promote fungal recovery. Following incubation, colonies were evaluated macroscopically for growth, colony size, shape, surface texture, elevation, and pigmentation. Overall, both transport media yielded comparable growth patterns, indicating that the tofu pulp waste medium preserved specimen viability similarly to the standard Amies medium.

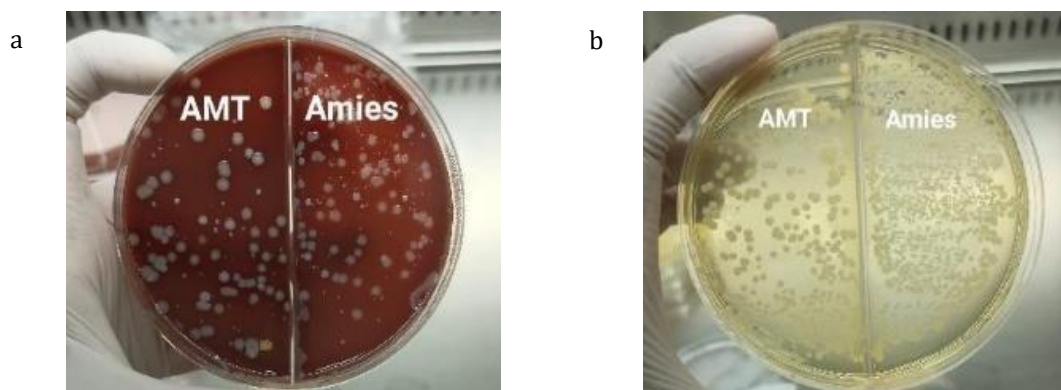


Fig. 1. (a) Chocolate Agar Medium (b) SDA Medium Macroscopic observation of vaginal swab samples using Amies transport medium and tofu pulp waste

Following incubation, colonies were evaluated macroscopically for growth characteristics, including size, shape, surface texture, elevation, and pigmentation. As shown in Figure 1, specimens transported in both Amies and tofu pulp waste media produced comparable colony morphologies on chocolate agar and SDA. On chocolate agar, colonies were round, small to medium in size, and white to cream in color. On SDA, colonies appeared round and convex, with smooth surfaces and white to yellowish pigmentation. The similarity in colony morphology across both transport media indicates that the tofu pulp waste medium maintained microbial viability without causing morphological distortion.

As shown in Table 2, both transport media produced identical culture outcomes. On chocolate agar, 13 of 15 samples (86.67%) exhibited bacterial growth, while 2 samples (13.33%) showed no growth in both groups. On SDA, growth was observed in 3 samples (20%) and absent in 12 samples (80%) for both the Amies and tofu pulp waste media. These identical growth proportions indicate that the alternative medium preserved specimen viability comparably to the standard transport medium.

Table 2. Culture outcomes on chocolate agar and sda by transport medium

No	Transport medium	Chocolate Agar		SDA (Sabaroud Dextrose Agar)	
		Growth n (%)	No growth n (%)	Growth n (%)	No growth n (%)
1.	Amies	13 (86.67%)	13 (86.67%)	3 (20%)	3 (20%)
2.	Tofu pulp waste	13 (86.67%)	13 (86.67%)	3 (20%)	3 (20%)

These identical growth proportions indicate that the tofu pulp waste transport medium performed comparably to the Amies medium in preserving specimen viability. This equivalence suggests that the organic components of tofu pulp waste provided a stable microenvironment that prevented desiccation and excessive bacterial multiplication during transport. The ability of a transport medium to maintain viability without promoting overgrowth is a key requirement for accurate microbiological diagnosis. Previous studies have emphasized that inappropriate transport conditions may lead to either false-negative results due to bacterial death or false-positive results due to overgrowth of commensal organisms. The comparable results observed in this study therefore support the functional suitability of tofu pulp waste as an alternative transport substrate.

### 3.1.3 Microscopic gram-stain prevalence on chocolate agar

As shown in Table 3, microscopic Gram-stain analysis of colonies grown on chocolate agar revealed a predominance of Gram-positive cocci, detected in 10 out of 15 samples (66.7%). Gram-negative cocci, Gram-positive bacilli, and Gram-negative bacilli were each observed in one sample (6.7%), while no growth was detected in two samples (13.3%). This distribution reflects the presence of commensal and opportunistic organisms commonly found in vaginal environments.

Table 3. Microscopic Gram staining prevalence on Brown Agar medium

No	Description	Number	Percentage (%)
1.	Gram-Positive Cocci	10	66.7%
2.	Gram-negative cocci	1	6.7%
3.	Gram-Positive Bacteria	1	6.7%
4.	Gram-negative bacilli	1	6.7%
5.	No Growth	2	13.3%

Similar culture-based approaches remain relevant because they allow practical morphology-based screening before confirmatory methods, especially in settings where molecular diagnostics are limited (Morrill et al., 2020). Microscopic Gram-stain analysis revealed the predominance of Gram-positive cocci, which are commonly associated with commensal and opportunistic organisms in the vaginal microbiota. As shown in Figure 2, colonies from specimens transported in both Amies and tofu pulp waste media exhibited comparable morphology and staining characteristics. This similarity indicates that the tofu pulp waste medium preserved bacterial structural integrity during transport.

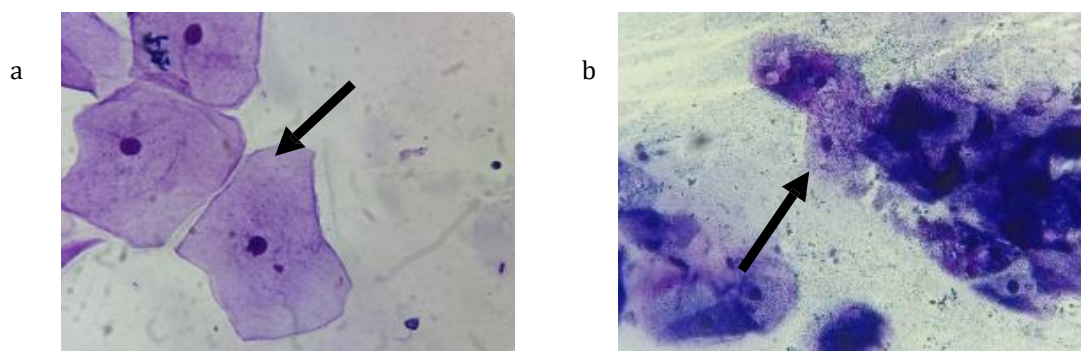
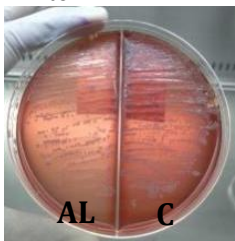
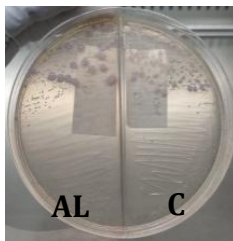
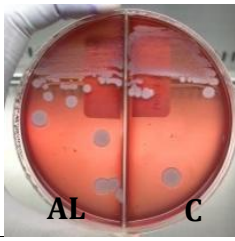
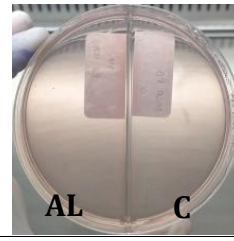
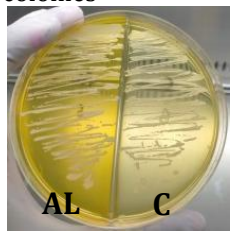


Fig. 2. (a) Gram-positive cocci from Amies (b) Gram-positive cocci from MTAT Microscopic observation of growth media

### 3.1.4 Clinical swab sample from wound

This study evaluated the effectiveness of a tofu pulp waste-based transport medium in preserving microorganisms from infected wound swabs. Fifteen samples were transported using Amies medium or tofu pulp waste medium and cultured on BAP, MCA, and MSA. Overall, bacterial growth was recovered across all culture media, indicating that both transport media preserved specimen viability for subsequent analysis.

Table 4. Distribution of bacterial growth results on culture media

No	Sample	BAP (Blood Agar Plate)	MCA (MacConkey Agar)	MSA (Mannitol Salt Agar)	Interpretation
1.	Sample 1	BAP P1 AL & C: Round, clustered, wet colonies; yellowish-white	MCA P1 AL & C: Round, flat, pink colonies	-	Gram-negative, lactose-fermenting bacteria
					
2.	Sample 2	BAP P8 AL & C: Round, clustered, flat colonies; grayish-white	MCA P8 AL & C: • No growth	MSA P8 AL & C: Round, white colonies	Gram-positive, salt-tolerant bacteria
					

As shown in Table 4, bacterial growth was recovered on multiple culture media from specimens transported in both the alternative and control media. Most samples exhibited characteristic colony growth on BAP, while some produced pink, lactose-fermenting colonies on MCA, indicating Gram-negative enteric bacteria. In other samples, growth on MSA appeared as round white colonies, consistent with salt-tolerant Gram-positive organisms. The comparable colony characteristics and distribution across the two transport media indicate that the tofu pulp waste medium effectively maintained microbial viability during transport.

### 3.1.5 Microscopic prevalence from culture media and bacterial type

Microscopic identification yielded identical results between the alternative and control transport media. As shown in Table 5, the distribution of bacterial types was the same in both groups, with Gram-negative coccobacilli predominating (53.3%), followed by Gram-negative bacilli (33.3%) and Gram-positive cocci (13.3%). These findings indicate that the tofu pulp waste medium preserved the microbial profile without altering bacterial morphology or relative prevalence during transport.

Table 5. Microscopic prevalence from the culture medium

No	Sample	Microscopic	N (%)
1.	Alternative	Gram - bacilli	5 (33.3%)
		Gram - cocobacilli	8 (53.3%)
		Gram + coccus	2 (13.3%)

2. Control	Gram - bacilli	5 (33.3%)
	Gram - cocobacilli	8 (53.3%)
	Gram + coccus	2 (13.3%)

Figure 3 demonstrates the predominance of Gram-negative bacteria among the isolates, particularly *Proteus* spp. and *Escherichia coli*. This pattern is consistent with reports describing wound environments as favorable niches for such organisms due to moisture, tissue damage, and impaired host defenses. Comparative wound studies also describe Gram-negative dominance in chronic and postoperative wound settings, reflecting environmental selection in moist, damaged tissue and prior antibiotic exposure (Lio & Wang, 2012).

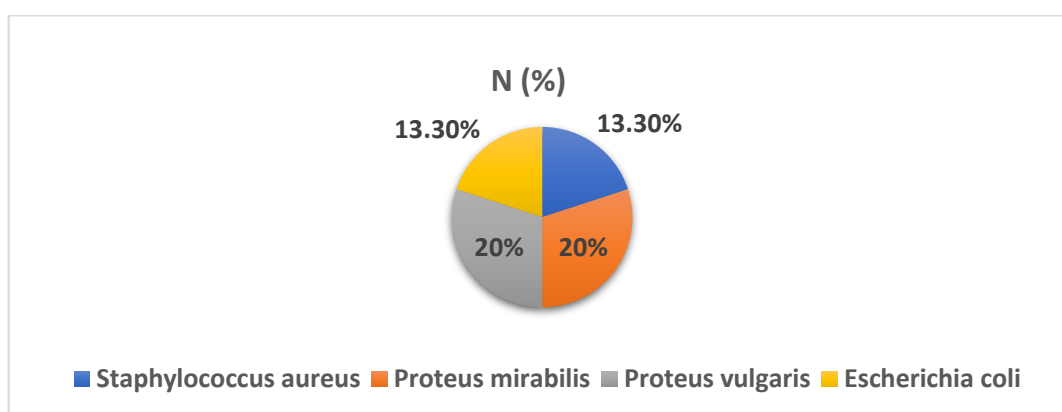


Fig. 3 Pie chart of bacterial type prevalence in control and alternative media

This reinforces the importance of transport conditions that do not selectively suppress Gram-negative viability before culture. In the bacterial identification test, five distinct bacterial species were identified, with the dominant bacterium being the Gram-negative *Citrobacter freundii*. The finding of *Proteus mirabilis* bacteria in post-operative wound samples (20%) is consistent with clinical studies in Indonesia that report this species as the predominant pathogen in pus specimens from surgical patients.

Table 6. Prevalence of bacterial types

Sample	Type of Bacteria	N (%)
Alternative & Control	<i>Staphylococcus aureus</i>	2 (13.3%)
	<i>Proteus mirabilis</i>	3 (20%)
	<i>Proteus vulgaris</i>	3 (20%)
	<i>Escherichia coli</i>	2 (13.3%)
	<i>Citrobacter freundii</i>	5 (33.3%)

*Proteus mirabilis* possesses strong virulence traits, notably swarming motility, enabling rapid dissemination across open wound surfaces. Its successful recovery after transport indicates that the tofu pulp waste medium provides sufficient nutrient support to maintain bacterial viability, thereby reducing the risk of false-negative SSI cultures, including in antibiotic-resistant infections (Suhartono et al., 2022). Enterobacterales isolates from wound infections are frequently discussed in broader surgical infection microbiology literature, where hospital-specific ecology and patient factors determine the dominant species distribution (Giacometti et al., 2000).

### 3.2 Bacterial growth distribution

Culture results demonstrated a predominance of Gram-negative organisms in wound swabs, consistent with studies reporting that such pathogens commonly dominate postoperative infections (Khalid et al., 2024; Worku et al., 2023). Gram-negative bacteria possess adaptive mechanisms that enable them to thrive in moist, nutrient-rich wound

environments and to resist host immune responses. These organisms are frequently associated with healthcare-associated infections and antimicrobial resistance.

The global burden of antimicrobial resistance highlights the importance of accurate microbiological diagnosis, as delays or inaccuracies in pathogen identification may lead to inappropriate antibiotic use and worsening resistance trends (Murray et al., 2022). The comparable recovery of bacteria from both transport media indicates that the tofu pulp waste medium maintained microbial viability during transport. Similar findings have been reported in studies evaluating alternative transport systems for low-resource settings, where locally sourced materials were shown to preserve pathogen viability effectively (Rahmani et al., 2025).

### 3.3 Microscopic prevalence

Microscopic examination showed a predominance of Gram-negative coccobacilli, followed by Gram-negative bacilli and Gram-positive cocci. Biochemical identification confirmed the presence of five bacterial species, with *Citrobacter freundii* as the most common isolate. The successful recovery of these organisms in both transport media suggests that the tofu pulp waste medium effectively preserved bacterial viability and diversity. This performance may be attributed to the biochemical composition of tofu pulp waste, which contains proteins, fiber, and isoflavones that can provide a protective microenvironment for microorganisms.

Soy-derived substrates have been reported to contain antioxidant compounds capable of stabilizing biological molecules and protecting cells from oxidative damage (Kim, 2024; Privatti et al., 2024). These properties may contribute to the preservation of bacterial viability during transport. In addition to microbiological performance, tofu pulp waste-based media offer significant economic and environmental advantages. The use of agro-industrial waste as a culture or transport substrate aligns with sustainable healthcare initiatives and reduces dependency on imported laboratory consumables. Sustainability analyses have emphasized the importance of reducing the environmental footprint of medical products, including diagnostic materials (Montesinos et al., 2024).

### 3.4 Comparative performance of the alternative transport medium

The comparable microbial recovery observed between the tofu pulp waste medium and the standard Amies medium indicates that the alternative formulation was capable of maintaining bacterial viability during the transport phase. In both vaginal and wound specimens, the proportion of bacterial growth, colony morphology, and microscopic characteristics remained consistent across the two media. This suggests that the tofu pulp waste-based medium provided a stable physicochemical environment that prevented both excessive microbial proliferation and premature cell death.

Transport media are designed to preserve the viability of microorganisms without promoting active multiplication. This balance is essential to ensure that the microbial profile at the time of culture accurately reflects the original clinical condition. If a transport medium contains excessive nutrients, it may lead to the overgrowth of fast-growing commensals, masking the presence of clinically significant pathogens. Conversely, if the medium lacks protective components, fastidious organisms may lose viability during transport, resulting in false-negative cultures. The identical growth outcomes observed in this study suggest that the tofu pulp waste medium achieved this critical balance.

The buffering salts and osmotic stabilizers incorporated into the formulation likely contributed to maintaining cellular integrity during the transport period. Electrolytes such as sodium chloride, potassium chloride, and phosphate buffers are commonly used in transport media to prevent osmotic shock and stabilize pH conditions. The addition of sodium thioglycolate also played a crucial role by reducing the oxidation-reduction potential, thereby protecting anaerobic and microaerophilic organisms from oxidative

stress. This is particularly relevant for vaginal pathogens, many of which are highly sensitive to oxygen exposure during transport.

The semi-solid matrix provided by seaweed-derived agar also contributed to the performance of the medium. Semi-solid transport media prevent the desiccation of swab specimens and limit the diffusion of nutrients, thereby minimizing metabolic activity during storage. This structural feature likely helped maintain bacterial viability without encouraging excessive proliferation. The physical consistency of the medium may also have provided a protective scaffold that mimics the natural microenvironment of biological tissues.

In addition to the physicochemical properties, the organic composition of tofu pulp waste may have contributed to the observed results. Okara contains significant amounts of protein, fiber, and bioactive compounds, including isoflavones. These compounds have been reported to possess antioxidant properties that may protect cellular membranes from oxidative damage. The presence of such protective compounds may help maintain bacterial cell integrity during transport, particularly under suboptimal environmental conditions.

Previous research on soy-based substrates has demonstrated their potential as low-cost alternatives in microbiological applications. Soy proteins have been widely used in culture media due to their high nitrogen content and compatibility with bacterial metabolism. The presence of plant-derived proteins in tofu pulp waste may therefore provide a mild protective environment without promoting excessive microbial growth. This characteristic aligns with the primary function of transport media, which is to maintain viability rather than support active proliferation.

In addition, soy-derived substrates and their processing characteristics have been discussed in food-science literature, supporting the plausibility that okara-based matrices can provide a stabilizing environment without necessarily promoting excessive overgrowth during short transport windows (Azizi et al., 2021). The comparable performance observed in this study is also consistent with previous investigations into alternative transport systems. Studies evaluating locally produced viral transport media have demonstrated that low-cost formulations can achieve performance levels similar to commercial products when appropriate buffering and stabilizing agents are used. These findings support the concept that locally sourced materials can be integrated into diagnostic workflows without compromising microbiological accuracy.

### *3.5 Clinical and public health implications*

The development of an effective alternative transport medium has important implications for clinical practice, particularly in resource-limited settings. In many developing countries, the availability of standard transport media is limited by cost, supply chain constraints, and dependency on imported medical products. These limitations can delay diagnostic processes and reduce the reliability of microbiological results.

In primary healthcare facilities, especially those located in rural or remote areas, specimens often require extended transport times before reaching a laboratory. Under such conditions, inadequate transport media can lead to reduced pathogen viability or overgrowth of commensal organisms. This can result in inaccurate diagnoses, inappropriate antibiotic prescriptions, and increased antimicrobial resistance.

The comparable performance of the tofu pulp waste medium suggests that it may serve as a viable alternative in such settings. By utilizing locally available agro-industrial by-products, healthcare facilities may reduce their dependence on imported consumables. This approach aligns with the principles of sustainable healthcare, which emphasize the use of environmentally friendly and locally sourced materials in medical applications. The environmental benefits of this approach are also significant. Tofu production generates large amounts of okara as a by-product, much of which is discarded as waste. The utilization of this material as a microbiological transport medium represents a form of waste valorization, converting an environmental burden into a valuable healthcare resource.

Sustainability studies have highlighted the importance of reducing waste and improving resource efficiency across the medical device lifecycle.

From an economic perspective, the use of tofu pulp waste may substantially reduce the cost of microbiological transport media. Commercial transport media often contain expensive components such as peptone, charcoal, and proprietary stabilizers. Replacing these components with plant-derived materials may lower production costs while maintaining functional performance. This cost reduction could enable broader access to microbiological diagnostics, particularly in underfunded healthcare systems. The findings of this study therefore support the integration of sustainable, locally produced materials into routine diagnostic workflows. Such innovations may help address both economic and environmental challenges while improving access to essential healthcare services.

### *3.6 Study Limitations and Future Directions*

Despite the promising results, this study has several limitations that should be considered. First, the sample size was relatively small, consisting of only fifteen paired specimens. While the results demonstrated consistent trends, larger-scale studies are necessary to confirm the reliability and reproducibility of the findings across diverse clinical settings. Second, the study focused primarily on aerobic and facultative anaerobic bacteria recovered from vaginal and wound swabs. Future research should evaluate the performance of the tofu pulp waste medium in preserving strictly anaerobic organisms, fastidious pathogens, and clinically significant fungi. Molecular methods could also be employed to assess whether the transport medium preserves nucleic acid integrity for downstream diagnostic applications.

Third, the transport time evaluated in this study was limited to the typical duration between sample collection and laboratory processing within the local healthcare system. Additional studies are needed to assess the stability of the medium over extended transport periods and under varying environmental conditions, such as higher temperatures or fluctuating humidity levels. Future research may also explore the optimization of the tofu pulp waste formulation. Variations in drying methods, particle size, buffering systems, or reducing agents may further improve the performance and stability of the medium. Standardization of the preparation process will be essential to ensure consistent quality across different production batches. Finally, cost-effectiveness analyses and field-based implementation studies will be important to evaluate the practical feasibility of large-scale adoption. Such studies could assess not only microbiological performance but also economic savings, supply chain improvements, and environmental benefits.

### *3.7 Practical feasibility and cost considerations*

Beyond analytical performance, the feasibility of routine implementation depends on affordability, local availability of inputs, and ease of preparation. In many Indonesian primary-care settings, the recurring purchase of imported transport media can limit the number of specimens that can be processed for culture, particularly when diagnostic services must be prioritized for urgent cases. The tofu pulp waste approach leverages a widely available by-product of local food processing, potentially reducing exposure to supply-chain disruptions and price fluctuations.

From a workflow perspective, the preparation steps used in this study rely on equipment that is commonly available in microbiology laboratories, including ovens, autoclaves, balances, and basic mixing/heating tools. While the drying and sieving steps require additional time, these can be organized as batch processes, enabling multiple weeks of supply to be prepared in a single production cycle. Importantly, the alternative medium demonstrated comparable recovery outcomes to the reference medium under the study's operational conditions, suggesting that cost reduction can be achieved without compromising diagnostic utility. A formal cost-effectiveness analysis was not performed in this study; however, the observed equivalence in recovery implies that the main

implementation question becomes whether local preparation can be standardized to ensure consistent quality. If standardized, the tofu pulp waste medium could be particularly valuable for facilities that must transport specimens from peripheral sites to district laboratories, where preserving viability during routine delays is essential for accurate culture interpretation and targeted antimicrobial therapy.

### 3.8 Implementation pathway and standardization

For broader adoption, standardization is critical. Okara composition may vary by soybean variety, processing method, and water content, which can influence nutrient levels and potentially affect microbial survival dynamics. Therefore, future implementation should define minimum preparation specifications, including washing cycles, drying temperature/time targets, moisture thresholds, and particle size ranges. Batch records and sterility checks should be incorporated into routine practice to ensure reproducibility and regulatory acceptability.

The need for standardization is also supported by literature noting that variation in raw material composition can affect downstream microbiological performance, making batch control and reproducibility essential for wider adoption (Złoch et al., 2023). In addition, performance verification should be expanded to include longer transport times and a wider range of clinically important organisms, including fastidious anaerobes and fungi, as well as mixed communities typical of chronic wounds. Where molecular testing is available, evaluation of nucleic acid stability would further broaden utility, particularly for settings that rely on downstream PCR confirmation. Finally, implementation studies should assess user acceptability, storage stability under tropical conditions, and integration into routine specimen referral systems.

Future work should also consider compatibility with anaerobic or fastidious organisms and potential molecular downstream testing, as emphasized in broader public-health microbiology discussions on diagnostic workflow strengthening (Hendriksen et al., 2019). Taken together, these steps position the tofu pulp waste medium as a pragmatic innovation that aligns with sustainable laboratory practice. By converting a locally abundant by-product into a diagnostic resource, the approach supports both cost containment and environmental responsibility, while maintaining the core microbiological requirement of preserving viability during the pre-analytical phase.

## 4. Conclusions

This study demonstrated that a tofu pulp waste-based transport medium is capable of preserving the viability and morphological characteristics of microorganisms from both vaginal and wound swab specimens. Comparable growth patterns, microscopic features, and bacterial distributions were observed between specimens transported in the alternative medium and those transported in the standard Amies medium. These findings indicate that the tofu pulp waste formulation provided a stable microenvironment that maintained microbial integrity during the transport phase without promoting excessive bacterial proliferation.

The predominance of clinically relevant Gram-negative organisms, including *Proteus species*, *Escherichia coli*, and *Citrobacter freundii*, was consistently observed in both media, further supporting the functional equivalence of the alternative formulation. The presence of buffering salts, reducing agents, and semi-solid agar, combined with the nutritional and antioxidant properties of tofu pulp waste, likely contributed to the preservation of microbial viability.

In addition to its microbiological performance, the tofu pulp waste medium offers potential economic and environmental advantages by utilizing locally available agro-industrial by-products. This approach may reduce dependency on imported laboratory consumables and improve access to microbiological diagnostics in resource-limited

settings. Further studies with larger sample sizes and extended transport conditions are recommended to confirm its broader clinical applicability.

### Acknowledgement

The authors thank the Institute for Advanced Social Science and Sustainable Future for publication support; the Department of Chemistry, Universitas Negeri Surabaya (LKTIN UNESA 2025) for providing an academic platform; Poltekkes Kemenkes Banten for institutional support and research facilities; and Puskesmas Mandala Rangkasbitung and RSUD dr. Adjidarmo Rangkasbitung for permission and assistance with sample collection. The authors also appreciate all technical and administrative contributors.

### Author Contribution

R.S., S.R.K., and S.A., contributed to the study conception and design, data analysis, and manuscript preparation. D.R.P., and S.P.A., contributed to sample collection. V.P., supervised the research and critically reviewed the manuscript. All authors have read and approved the final manuscript.

### Funding

This study was funded by the Beginner Research Grant of Poltekkes Kemenkes Banten.

### Ethical Statement

The study was approved by the Ethics Committee of Universitas Prima Indonesia (protocols: 118/KEPK/UNPRI/III/2025 for wound samples; 012/KEPK/UNPRI/IV/2025 for vaginal samples).

### Conflicts of Interest

The authors declare no conflict of interest.

### Open Access

©2026. The author(s). This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution, and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit: <http://creativecommons.org/licenses/by/4.0/>.

### References

- Abbe, C., & Mitchell, C. M. (2023). Bacterial vaginosis: a review of approaches to treatment and prevention. *Frontiers in Reproductive Health*, 5, 1–13. [Frontiers Media S.A. https://doi.org/10.3389/frph.2023.1100029](https://doi.org/10.3389/frph.2023.1100029)
- Afolayan, A. O., Bernal, J. F., Gayeta, J. M., Masim, M. L., Shamanna, V., Abrudan, M., Abudahab, K., Argimón, S., Carlos, C. C., Sia, S., Ravikumar, K. L., Okeke, I. N., Donado-Godoy, P., Aanensen, D. M., Underwood, A., Harste, H., Kekre, M., Muddyman, D., Taylor, B., ... Vegvari, C. (2021). Overcoming Data Bottlenecks in Genomic Pathogen Surveillance. *Clinical Infectious Diseases*, 73, S267–S274. <https://doi.org/10.1093/cid/ciab785>
- Aklilu, A., Woldemariam, M., Manilal, A., Koira, G., Alahmadi, R. M., Raman, G., Idhayadhulla, A., & Yihune, M. (2024). Aerobic vaginitis, bacterial vaginosis, and vaginal candidiasis among women of reproductive age in Arba Minch, southern Ethiopia. *Scientific Reports*, 14(1), 9813. <https://doi.org/10.1038/s41598-024-58654-y>

- Atia, A. (2021). Prevalence of Bacterial Vaginosis and their Antibiotic Susceptibility among Women Attending Different Private Clinics in Tripoli, Libya. *Libyan Journal of Medical Sciences*, 5(2), 79–82. [https://doi.org/10.4103/ljms.ljms\\_9\\_21](https://doi.org/10.4103/ljms.ljms_9_21)
- Azizi, N. F., Kumar, M. R., Yeap, S. K., Abdullah, J. O., Khalid, M., Omar, A. R., Osman, M. A., Mortadza, S. A. S., & Alitheen, N. B. (2021). Kefir and its biological activities. *Foods*, 10(6), 1–26. <https://doi.org/10.3390/foods10061210>
- Bessa, L. J., Fazii, P., Di Giulio, M., & Cellini, L. (2015). Bacterial isolates from infected wounds and their antibiotic susceptibility pattern: Some remarks about wound infection. *International Wound Journal*, 12(1), 47–52. <https://doi.org/10.1111/iwj.12049>
- Boiko, I., Krynytska, I., Kohut, I., Bezkorovaina, H., & Stepanenko, V. (2021). Diagnostics of gonococcal infection in ukraine: Current challenges in resource-constrained settings. *Eurasian Journal of Medicine*, 53(3), 180–184. <https://doi.org/10.5152/eurasianjmed.2021.20043>
- Fredricks, D. N., Fiedler, T. L., & Mrazek, J. M. (2005). Molecular Identification of Bacteria Associated with Bacterial Vaginosis. *The New England Journal of Medicine*, 18. <https://www.nejm.org/doi/full/10.1056/NEJMoa043802>
- Giacometti, A., Cirioni, O., Schimizzi, A. M., Prete, M. S. Del, Barchiesi, F., D'errico, M. M., Petrelli, E., & Scalise, A. G. (2000). Epidemiology and Microbiology of Surgical Wound Infections. *Journal of Clinical Microbiology*, 38(2). <https://journals.asm.org/journal/jcm>
- Hendriksen, R. S., Bortolaia, V., Tate, H., Tyson, G. H., Aarestrup, F. M., & McDermott, P. F. (2019). Using Genomics to Track Global Antimicrobial Resistance. *Frontiers in Public Health*, 7, 1–17. <https://doi.org/10.3389/fpubh.2019.00242>
- Khalid, F., Poulouse, C., Farah, D. F. M., Mahmood, A., Elsheikh, A., & Khojah, O. T. (2024). Prevalence and Antimicrobial Susceptibility Patterns of Wound and Pus Bacterial Pathogens at a Tertiary Care Hospital in Central Riyadh, Saudi Arabia. *Microbiology Research*, 15(4), 2015–2034. <https://doi.org/10.3390/microbiolres15040135>
- Kim, S. W. (2024). Opportunities and Challenges of Soy Proteins with Different Processing Applications. *Antioxidants*. <https://doi.org/10.3390/antiox13050569>
- Lio, J., & Wang, T. (2012). Solid-state fermentation of soybean and corn processing coproducts for potential feed improvement. *Journal of Agricultural and Food Chemistry*, 60(31), 7702–7709. <https://doi.org/10.1021/jf301674u>
- Martínez-Figueroa, C., Estrada-Moreno, A. K., Vences-Velázquez, A., & Cortés-Sarabia, K. (2022). One-Step Staining Method for the Identification of Clue Cells and Bacterial Morphotypes Associated with Bacterial Vaginosis. *Microbiology Spectrum*, 10(3). <https://doi.org/10.1128/spectrum.01927-21>
- Montesinos, L., Checa Rifá, P., Rifá Fabregat, M., Maldonado-Romo, J., Capacci, S., Maccaro, A., & Piaggio, D. (2024). Sustainability across the Medical Device Lifecycle: A Scoping Review. *Sustainability*, 16(4). <https://doi.org/10.3390/su16041433>
- Morrill, S., Gilbert, N. M., & Lewis, A. L. (2020). Gardnerella vaginalis as a Cause of Bacterial Vaginosis: Appraisal of the Evidence From in vivo Models. *Frontiers in Cellular and Infection Microbiology*, 10, 1–19. <https://doi.org/10.3389/fcimb.2020.00168>
- Murray, C. J. L., Ikuta, K. S., Sharara, F., Swetschinski, L., Robles Aguilar, G., Gray, A., Han, C., Bisignano, C., Rao, P., Wool, E., Johnson, S. C., Browne, A. J., Chipeta, M. G., Fell, F., Hackett, S., Haines-Woodhouse, G., Kashef Hamadani, B. H., Kumaran, E. A. P., McManigal, B., ... Naghavi, M. (2022). Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet*, 399(10325), 629–655. [https://doi.org/10.1016/S0140-6736\(21\)02724-0](https://doi.org/10.1016/S0140-6736(21)02724-0)
- Onsando Samson, M. W. N. A. N. M. and M. G. (2025). Diversity and antibiotic susceptibility profiles of bacterial isolates from wound infections in patients at the surgical unit of Kisii teaching and referral hospital, Kenya. *PLOS ONE*, 20(6), 1–18. <https://doi.org/10.1371/journal.pone.0326048>
- Phan, S., Phung, O. J., & Lenhard, J. R. (2023). Relative Abundance and Detection of Pseudomonas aeruginosa from Chronic Wound Infections Globally. *Microorganisms*, 11(5), 1210. <https://doi.org/10.3390/microorganisms11051210>

- Privatti, R. T., Capellini, M. C., Aracava, K. K., Pugine, S. M. P., de Melo, M. P., & da Costa Rodrigues, C. E. (2024). Saline as solvent and ethanol-based purification process for the extraction of proteins and isoflavones from wet okara. *Food Chemistry*, 443. <https://doi.org/10.1016/j.foodchem.2024.138605>
- Puca, V., Marulli, R. Z., Grande, R., Vitale, I., Niro, A., Molinaro, G., Prezioso, S., Muraro, R., & Giovanni, P. Di. (2021). Microbial Species Isolated from Infected Wounds and Antimicrobial Resistance Analysis: Data Emerging from a Three-Years Retrospective Study. *Antibiotics*, 10(10), 1162. <https://doi.org/10.3390/ANTIBIOTICS10101162>
- Rafat, D., Agrawal, A., Singh, S., Khalid, S., Khan, A. U., & Nawab, T. (2025). Impact of Glycemic Variability on Vaginal Flora Alterations and Concomitant Antimicrobial Resistance During Pregnancy: Implications for Fetomaternal Outcomes. *The Journal of Obstetrics and Gynecology of India*, 75(S1), 494–503. <https://doi.org/10.1007/s13224-024-02095-0>
- Rahmani, S., Meitha, K., Septiani, P., Priharto, N., Kamarisima, K., Ningrum, R. A., Angelina, M., Agustiyanti, D. F., Wisnuwardhani, P. H., Nugroho, H. A., & Tan, M. I. (2025). Development of an inactivated viral transport medium for diagnostic testing in low-resource countries. *Narra Journal*, 5(3). <https://doi.org/10.52225/narra.v5i3.2068>
- Shimeles, G., Gedefie, A., Motbainor, H., & Genet, C. (2025). Vaginal colonization, vertical transmission rate, antimicrobial susceptibility profile, and associated factors of potential neonatal pathogens among pregnant women at public health facilities of Northeast Ethiopia. *Frontiers in Public Health*, 13. <https://doi.org/10.3389/fpubh.2025.1475357>
- Shinde, R. S., Patil, A. D., Kamble, H. A., Patil, P. D., & Gatade, A. A. (2025). Unlocking the potential of soymilk industry waste (Okara): A comprehensive review on valorization and food applications. *Journal of Food Legumes*, 38(2), 187–198. <https://doi.org/10.53550/jfl.v38.i2.259>
- Suhartono, S., Mahdani, W., & Khalizazia, K. (2022). Prevalence and Antibiotic Susceptibility of *Proteus mirabilis* Isolated from Clinical Specimens in the Zainoel Abidin General Hospital, Banda Aceh, Indonesia. *Open Access Macedonian Journal of Medical Sciences*, 10(1), 1532–1537. <https://doi.org/10.3889/oamjms.2022.10695>
- Uberoi, A., McCready-Vangi, A., & Grice, E. A. (2024). The wound microbiota: microbial mechanisms of impaired wound healing and infection. *Nature Reviews Microbiology*, 22(8), 507–521. <https://doi.org/10.1038/s41579-024-01035-z>
- Unemo, M., Ballard, R., Ison, C., Lewis, D., Ndowa, F., & Peeling, R. (n.d.). *Laboratory diagnosis of sexually transmitted infections, including human immunodeficiency virus* Editor-in-Chief. WHO. [www.who.int/reproductivehealth](http://www.who.int/reproductivehealth)
- Wolf, E. A., Rettig, H. C., Lupatsii, M., Schlüter, B., Schäfer, K., Friedrich, D., Graspentner, S., & Rupp, J. (2021). Culturomics approaches expand the diagnostic accuracy for sexually transmitted infections. *International Journal of Molecular Sciences*, 22(19), 1–13. <https://doi.org/10.3390/ijms221910815>
- Worku, S., Abebe, T., Alemu, A., Seyoum, B., Swedberg, G., Abdissa, A., Mihret, A., & Beyene, G. T. (2023). Bacterial profile of surgical site infection and antimicrobial resistance patterns in Ethiopia: a multicentre prospective cross-sectional study. *Annals of Clinical Microbiology and Antimicrobials*, 22(1), 96. <https://doi.org/10.1186/s12941-023-00643-6>
- Złoch, M., Maślak, E., Kupczyk, W., & Pomastowski, P. (2023). Multi-Instrumental Analysis Toward Exploring the Diabetic Foot Infection Microbiota. *Current Microbiology*, 80(8), 1–15. <https://doi.org/10.1007/s00284-023-03384-z>

## Biographies of Authors

**Dinda Risa Puspitasari**, is a graduate of the Medical Laboratory Technology program at Poltekkes Makassar, Indonesia. Her academic focus includes clinical chemistry, microbiology, and laboratory diagnostics, particularly in the development of laboratory techniques and quality control practices.

- Email: [dindarisap@gmail.com](mailto:dindarisap@gmail.com)
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

**Richo Saputra**, is currently a Diploma III student in Medical Laboratory Technology at Poltekkes Kemenkes Banten, Indonesia. His academic training emphasizes microbiology, bacteriology, and laboratory diagnostic techniques.

- Email: [richo.saputra2007@gmail.com](mailto:richo.saputra2007@gmail.com)
- ORCID: 0009-0006-7721-1481
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

**Safira Rakhma Khoirunnisa**, is an undergraduate student in Medical Laboratory Technology at Poltekkes Kemenkes Banten, Indonesia. Her academic focus centers on clinical chemistry, toxicology, and microbiology, with particular interest in laboratory diagnostics and biomedical analysis.

- Email: [khoirunnissa1006@gmail.com](mailto:khoirunnissa1006@gmail.com)
- ORCID: 0009-0000-7870-3409
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

**Siti Azzahra**, is currently an undergraduate student in Medical Laboratory Technology at Poltekkes Kemenkes Banten. Her academic interests include clinical chemistry, hematology, and microbiology, particularly in laboratory diagnostic procedures and basic biomedical analysis.

- Email: [sitiazahra486@gmail.com](mailto:sitiazahra486@gmail.com)
- ORCID: 0009-0005-3121-2799
- Web of Science ResearcherID: N/A
- Scopus Author ID: /A
- Homepage: N/A

**Syalwa Putri Anugrah**, is a graduate of the Medical Laboratory Technology program at Poltekkes Makassar, Indonesia. Her academic interests include clinical chemistry, hematology, and microbiology, with a focus on laboratory diagnostic procedures and biomedical analysis.

- Email: [syalwaputria02@gmail.com](mailto:syalwaputria02@gmail.com)
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

**Venny Patricia**, is affiliated with the Department of Medical Laboratory Technology, Poltekkes Kemenkes Banten, Indonesia. Her research interests include bacteriology, antimicrobial resistance, and laboratory diagnostics.

- Email: [venny.patricia@poltekkesbanten.ac.id](mailto:venny.patricia@poltekkesbanten.ac.id)
- ORCID: 0000-0002-6111-3207
- Web of Science ResearcherID: N/A
- Scopus Author ID: 57210232217
- Homepage: Google Scholar ([ebprShIAAAAJ&hl](https://scholar.google.com/citations?user=ebprShIAAAAJ&hl))