

Formulation and evaluation of medicated gauze pad from banana pseudostem fiber

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Abstract: An appropriate atmosphere is necessary to promote the dynamic and complex process of wound healing. Because of its ability to speed up the healing process of wounds, banana fibre is utilised as one of the best wound dressing materials. Banana fibre also needs to be lightweight and capable of withstanding wetness. This study used the medication ornidazole and the polymer psyllium husk to manufacture and cover the banana pseudo-stem fibre gauge pad. According to the findings, coated gauge pads have a faster drying time and better water absorption. Coated gauge pad samples with FTIR, SEM, tensile strength, etc. characteristics showed a biphasic releasing pattern with sustained ornidazole release for up to 48 hours. The material for the gauge pad was discovered to be biocompatible with human erythrocytes.

Keywords: Controlled release, Wound healing, Sutures, Biocompatible etc.,

A. Introduction:

Wound healing is an essential biological process that restores skin integrity after injury. It involves a complex and dynamic cascade of cellular and molecular events, including haemostasis, inflammation, proliferation, and tissue remodelling. While the human body is capable of healing minor injuries autonomously, chronic or infected wounds require external intervention to prevent complications such as microbial infection, delayed healing, tissue necrosis, or systemic infection. Conventional wound dressings, including cotton gauze, bandages, and synthetic polymer-based materials, are extensively used worldwide. However, these materials have notable limitations such as low moisture retention, a tendency to adhere to the wound bed (causing pain during removal), and the inability to deliver therapeutic agents in a controlled manner. Moreover, many of these materials are non-biodegradable and derived from petroleum-based polymers, contributing to environmental burden.

Banana pseudo stem fiber, in particular, has high tensile strength, a natural ability to absorb fluids, and biocompatibility, which make it suitable for direct contact with biological tissues. The primary goal of a wound dressing is not just physical protection but also therapeutic support. Hence, integrating medicated components into a natural fiber-based dressing significantly enhances its clinical value. Ornidazole, a nitro imidazole antimicrobial agent, exhibits potent activity against anaerobic bacteria and protozoa. Its inclusion in a topical delivery system can control or prevent wound infections, particularly in deep or necrotic tissue where anaerobes thrive. Topical delivery of antimicrobials offers site-specific action, reduces systemic toxicity, and avoids the first-pass metabolism. To develop a functional medicated gauze pad, suitable excipients are essential. In this study, psyllium husk is employed as a natural gelling agent that helps in forming a film or coating on the gauze. Gum Tragacanth, another natural polymer, acts as a binder and provides consistency to the formulation.

Polyethylene glycol (PEG) is included to enhance flexibility and pliability of the gauze coating. Tween 80, a non-ionic surfactant, ensures proper drug dispersion and helps in emulsifying components. Methyl paraben is used as a preservative to prolong shelf-life, and sodium hydroxide is added for pH adjustment to ensure compatibility with the skin.

Combining these components into a medicated gauze using banana pseudo stem fiber can result in an advanced wound dressing system with the dual benefits of natural fiber sustainability and targeted drug delivery.

B. Material and methods:

1. Material : Banana pseudo stem fiber, ornidazole, psyllium husk, gum tragacanth, polyethylene glycol 4000, methyl paraben etc.,

2. Method : medicated gauze pad (Films) were prepared via solvent casting method. The medicated gauze pad characterized by Physical appearance, thickness, folding endurance, tensile strength. Fourier infra-red spectroscopic (FTIR), and Scanning electron microscopy (SEM) was done. In vitro release of drug done by micro centrifuge tube shaking method.

C. Spectroscopy Study:

1. U.V spectroscopy

1. Standard stock solution: 1.00 mg/ml (1000 $\mu\text{g/ml}$) dissolve 100.0 mg ornidazole in methanol and make up to 100.0 mL.
2. Intermediate stock: 100 $\mu\text{g/ml}$ dilute 1.0 mL of 1000 $\mu\text{g/ml}$ stock to 10.0 ml with solvent.
3. Working calibration standards: 5, 10, 15, 20, 25, 30 $\mu\text{g/ml}$ (prepare in 10 ml volumetric flasks from 100 $\mu\text{g/ml}$ intermediate or by direct dilution from the 1000 $\mu\text{g/ml}$ stock).
4. Wavelength for measurement (λ_{max}): By taking absorbance in the range 200nm-400nm on UV spectrophotometer, we determined the maximum wavelength (λ_{max}).

2. Compatibility studies by FTIR Spectroscopy:

The compatibility study of ornidazole with excipients was studied by FTIR spectroscopy. The method used for study is pressed KBr pellet method and the ratio of sample is should be 1:100, where 1 is a part of drug sample and 100 is a part of KBr. The scanning range was 400-4000 cm^{-1} at ambient temperature. (Perkin Elmer Spectrum-65).

D. Formulation of medicated gauze pad

1. **Polymer Gel Base Preparation:** Warm 50 mL of distilled water to $\sim 60^{\circ}\text{C}$. Dissolve PEG 4000, Tween 80, and methyl paraben under stirring. Gradually disperse psyllium husk and gum Tragacanth into the solution with continuous stirring to prevent lumps. Let the gel hydrate for 15–20 minutes.
2. **Drug Incorporation:** Dissolve Ornidazole in a small volume methanol. Add this to the gel with continuous stirring.
3. **pH Adjustment:** Adjust pH to 6.5–7 using dilute sodium hydroxide (0.1N).
4. **Volume Makeup:** Make up to 100 mL with distilled water and stir until homogeneous.

5. **Gauze Impregnation:** Dip sterilized banana pseudo stem fiber gauze pads (5 × 5 cm) into the formulation for 10–15 minutes. Remove excess solution and dry the pads under hot air oven at 40–45°C.
6. **Final Sterilization:** Used ethylene oxide sterilization (avoid heat sterilization after drug loading).

Table 1: Formulation variables of medicated gauze pad

Ingredients	F1 (g)	F2 (g)	F3 (g)	F4 (g)	F5 (g)
Ornidazole	0.5 g	1.0 g	2.0 g	1.0 g	1.5 g
Psyllium husk	1.0 g	2.0 g	3.0 g	2.0 g	2.0 g
Gum Tragacanth	1.0 g	1.0 g	1.0 g	1.0 g	1.0 g
PEG 4000	1.0 g	2.0 g	3.0 g	4.0 g	2.0 g
Methyl paraben	0.1 g	0.1 g	0.1 g	0.1 g	0.1 g
Distilled Water	100 ml	100 ml	100 ml	100 ml	100 ml

E. Evaluation of medicated gauze pad:

1. Physical appearance: The prepared formulation of medicated gauze pad checks the color, uniformity, texture etc.

2. Weight uniformity: Select three individual gauze pads randomly from the batch. Remove any dust or surface contamination (if present). Weigh each pad individually using a calibrated analytical balance. Record the weights.

3. Thickness measurement and Folding Endurance: Place the gauze pad on a flat surface. Measure the thickness using a Vernier calliper at different locations. Record all readings. Fold the gauze pad repeatedly at the same point manually until it breaks or develops a visible crack/tear. Count and record the number of folds required for each pad to break. Repeat for all samples and calculate the mean folding endurance.

4. Surface pH: Cut the gauze pad into small pieces. Immerse 1 gauze pad in 10 mL of distilled water in a beaker (1:10 w/v). Stir gently and let it stand for 1 hour at room temperature. Measure the pH of the clear solution using a calibrated pH meter. Calibrate the pH meter using pH 4.0, 7.0, and 9.2 buffer solutions before use.

5. Swelling Properties: Swelling properties of the prepared pad were measured in a physiological buffer solution of pH 7.2. Four cm² (2 × 2 cm) samples of the film were cut and weighed (W₁). The sample was placed in Petri dish containing Phosphate buffer (pH 7.2) was

covered with a lid, allow to swell at room temp. and swollen sutures were then weighed at determined time intervals (W_2). The degree of swelling index in the film was calculated as

$$\text{Swelling index (\%)} = \frac{(W_2 - W_1)}{W_1} \times 100$$

6. Tensile strength (mechanical strength): By varying the load, it was possible to manually determine the tensile strength of commercial suture, raw banana fiber, degummed fiber, and drug coated fibers. secure both ends of test strips in tensile tester.

$$\text{Tensile strength (N/mm}^2\text{)} = \frac{\text{Force at break (N)}}{\text{Cross sectional area (mm}^2\text{)}}$$

7. In-vitro drug release: The antibacterial medication [ornidazole] release profile was evaluated in PBS at pH 6.3, 6.8, and 7.7, which corresponds to various skin pH values ranging from comparatively low to high pH during wound healing. Micro centrifuge tubes holding 1ml of the buffers were filled with a 2-cm gauge pad (F3) and continuously shaken at 37 °C. An aliquot of 0.1 ml was recovered at various time intervals (24, 48, 72, 96, 120, and 144 hr.) to measure the absorbance of each sample using a UV spectrophotometer at various wavelengths (290 nm, pH 6.3, 289 nm, pH 6.8, and 287 nm, pH 7.7). PBS was simultaneously added in an equal amount to each of the micro centrifuge tubes. The ratio of the drug released over time to the amount placed onto the gauge pad was used to calculate the release percentage.

$$\text{In vitro drug release (\%)} = \frac{\text{amount_released}}{\text{Initial drug load}} \times 100$$

8. Antibacterial testing: Antibacterial activity against *S. aureus* bacteria by Disc diffusion method. The inoculums of the microorganism were prepared from the bacterial cultures. 15ml of nutrient agar (Hi media) medium were poured in clean sterilized petri plates and allowed to cool and solidify. 100µl of broth of bacterial strain was pipette out and spread over the medium evenly with a spreading rod till it dried properly. Once the agar was hardened, then sample (F3) was placed on the plate in the manner and the plates were incubated at 37°C for 24hr. Antibacterial activity was evaluated by measuring the diameter of the zone of inhibitions (ZI).

9. Scanning electron microscopy: The surface morphology of the medicated gauze pad prepared using banana pseudo stem fiber was examined using Scanning Electron Microscopy (SEM). A small piece of the gauze (2×2 cm) was cut, dried, and mounted on an aluminium stub using double-sided carbon tape. The sample was then coated with a thin layer of gold using a sputter coater to make it conductive. SEM imaging was carried out at an accelerating voltage of 10–15 kV under high vacuum. Images were captured at various magnifications to observe fiber structure, surface roughness, and the presence of drug or polymer coatings.

10. Sterilization and Sterility testing: Sterilization is a critical step in the preparation of

wound dressings and biomedical devices, ensuring the complete destruction of microorganisms including bacteria, fungi, viruses, and spores. medicated gauze pads come in direct contact with wounds, sterilization is necessary to prevent secondary infections, ensure safety, and maintain the therapeutic efficacy of the incorporated drug.

Ethylene Oxide (EtO) Sterilization

- ❖ Pre-conditioning: Gauze pads sealed in permeable pouches, humidified at 50–60% RH and 35–40 °C for ~12 h.
- ❖ Sterilization: Exposed to EtO gas (400–800 mg/L) at 37–55 °C, 50–70% Relative humidity for 3–4 h in sterilizer.
- ❖ Aeration: Sterilized pads kept at 40–50 °C for 24–48 h to remove toxic EtO residues.
- ❖ Packaging: Sterile pads stored in airtight sterile pouches until further use.

Result and Discussion:

UV – Visible Spectroscopy: Determination of Maximum wavelength in methanol: The absorption maxima of ornidazole was found to be 318 nm in methanol.

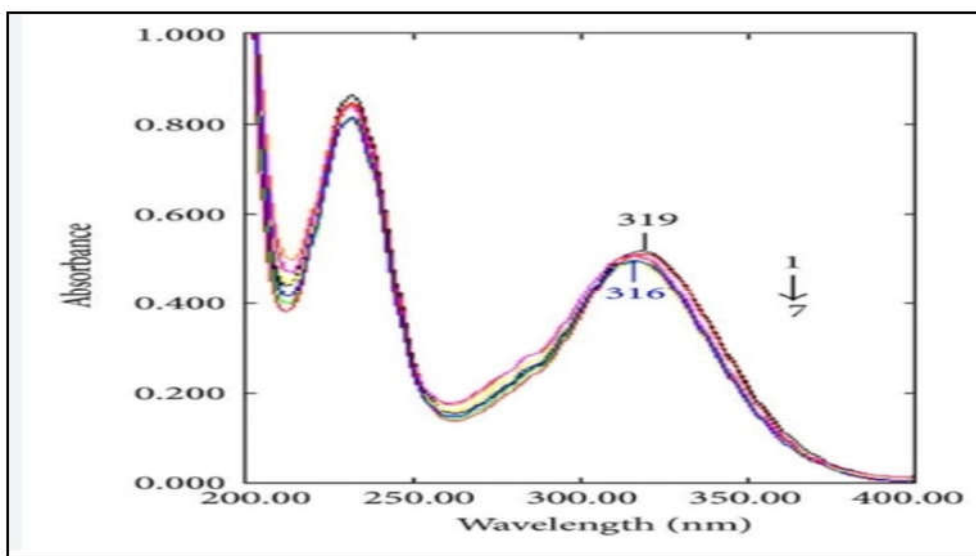


Fig. no. 1: Absorbance maxima of Ornidazole

Preparation of standard calibration Curve: The sample of different concentration was analysed at 318 nm using UV spectrophotometer against methanol

Table No.2: Calibration table of Ornidazole

Sr.no.	Concentration(µg/ml)	Absorbance (at 318nm)
1.	05 µg/ml	0.136
2.	10 µg/ml	0.291
3.	15 µg/ml	0.439

4.	20 µg/ml	0.595
5.	25 µg/ml	0.749
6.	30µg/ml	0.911

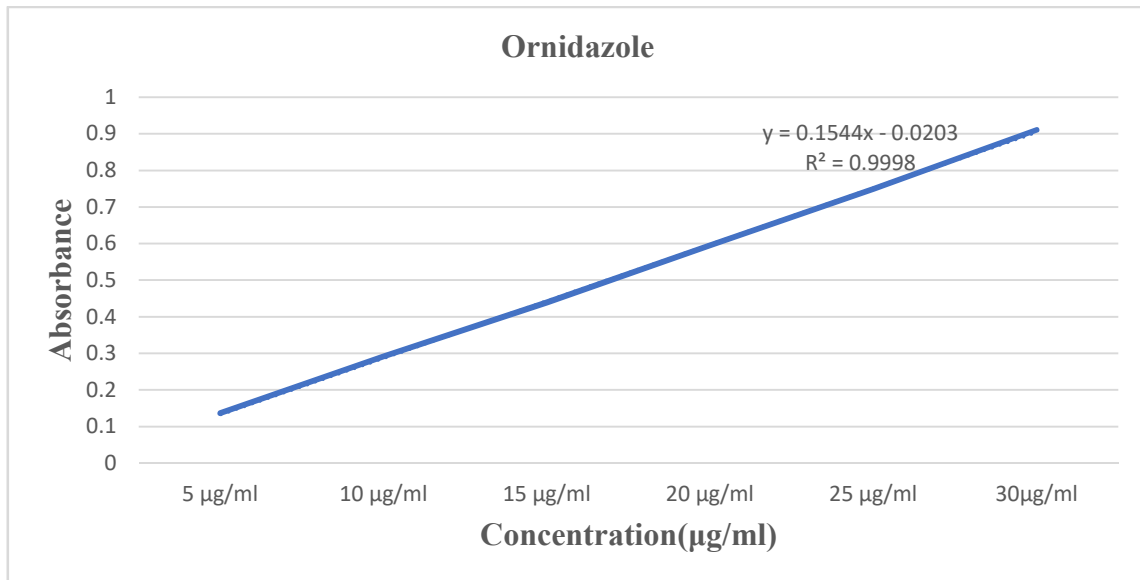


Figure No. 2: Calibration curve of Ornidazole

Compatibility study by FTIR: Drug polymer interaction was studied by FTIR Spectroscopy. The spectra were recorded for pure ornidazole and with the polymer mixture. The spectra were recorded for ornidazole and physical mixture of drug with polymers using FTIR and polymer are found compatible with the drug.

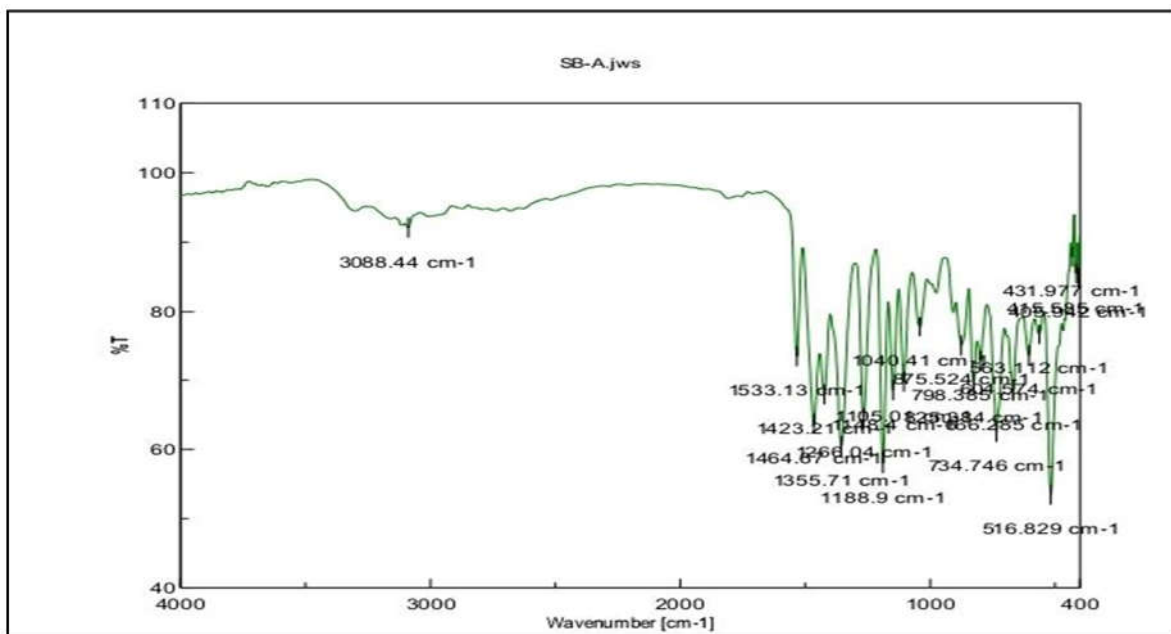


Figure No.3: FTIR spectrum of Ornidazole

Table No.03: Frequency of FTIR of Ornidazole

Characteristics Band	Wave Number (cm ⁻¹)	Range for band width (cm ⁻¹)
=C.H stretch alkenes	3088.44	3100-3000
C=C stretch aromatic compounds	1533.13	1440-1625
C-H bending	1423.21	1450-1375
C=N	1464.07	1280-2200
C-CL stretch	516.829	<600
C=N	431.977	1280-2200
=C.H bend alkenes	734.746	995-685

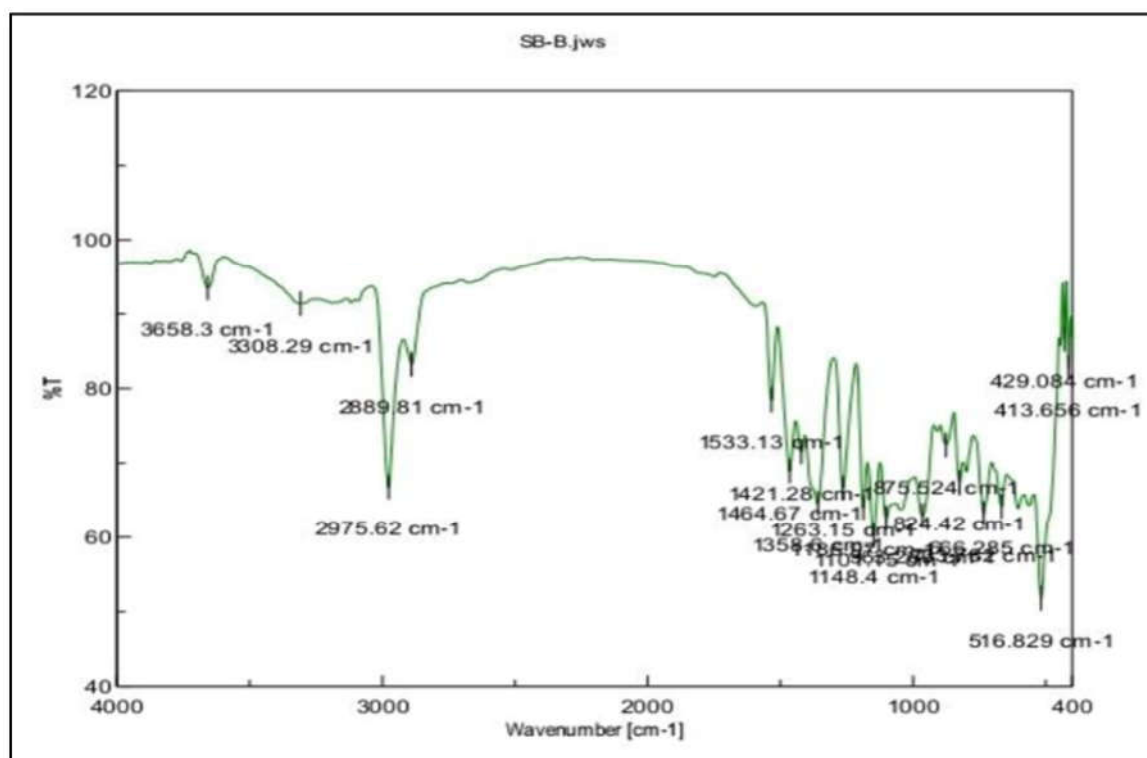


Figure No.4: FTIR Spectrum of ornidazole and psyllium husk

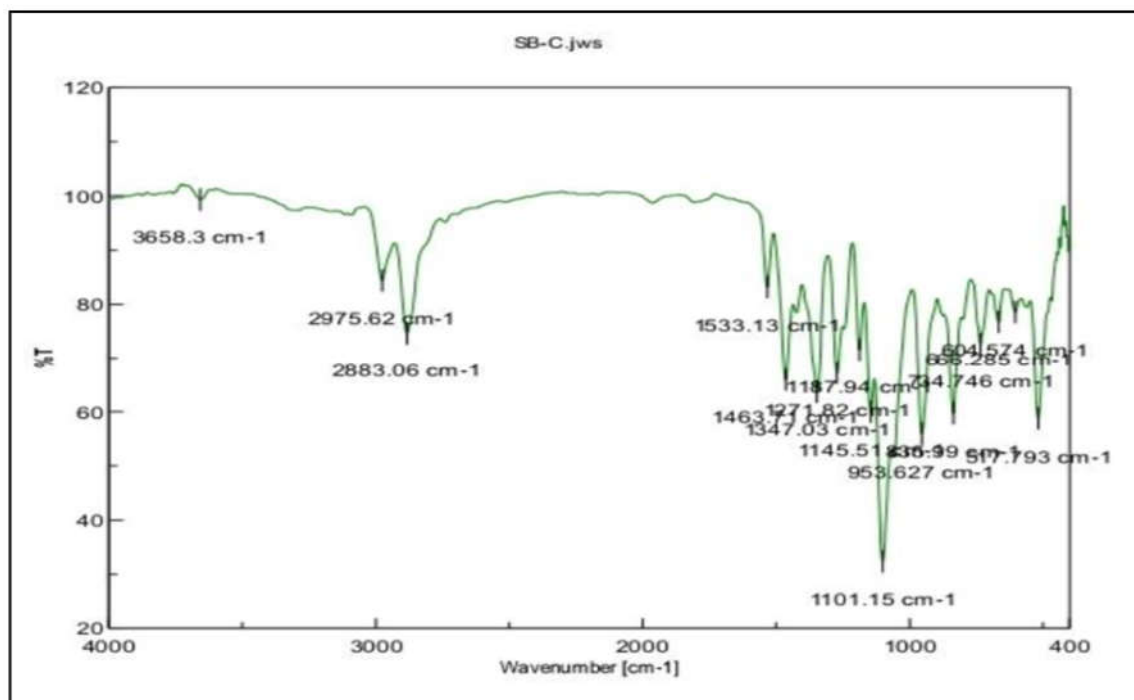


Figure No.5: FTIR spectrum of ornidazole & polyethylene glycol4000

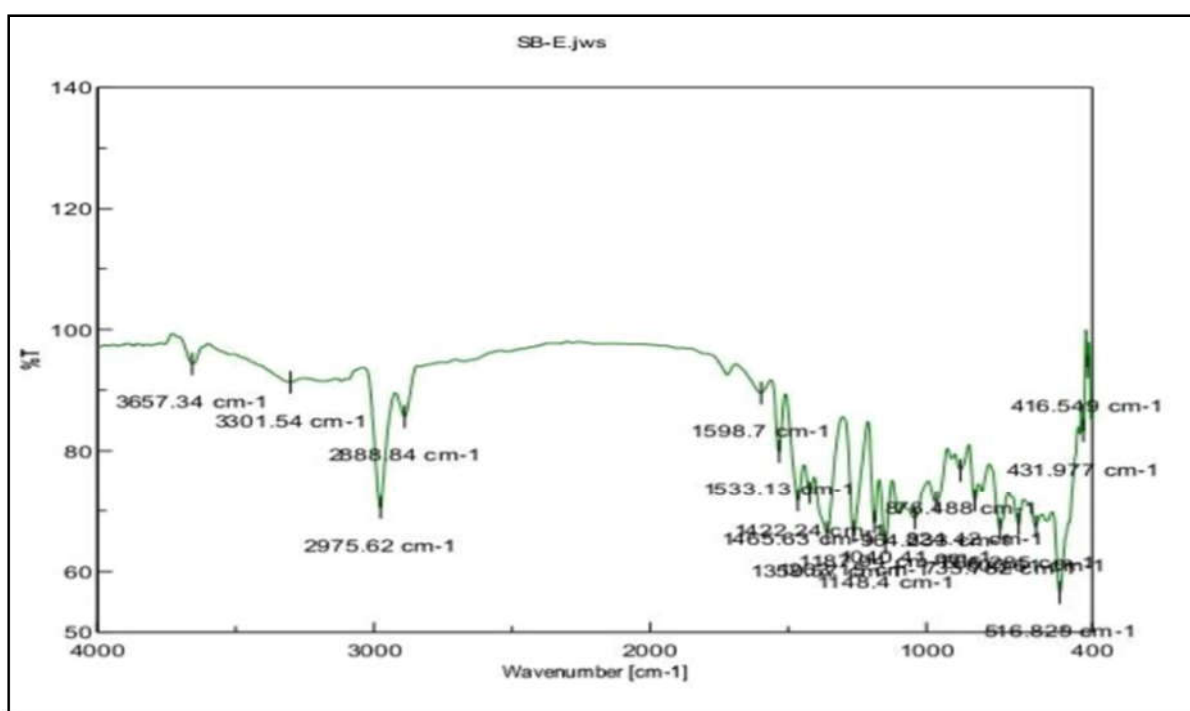


Figure No.6: FTIR spectrum of ornidazole & gum tragacanth

Physicochemical evaluation:

Table No.4: Physicochemical Parameter

Sr.no.	Batch no.	Physical appearance (colour, texture, uniformity)	Weight (mg)	Thickness (mm)	Folding endurance (amt. of folds)	Surface pH
1.	F1	Light brown, Smooth, uniform, no cracks	86±3.2	0.24±0.02	10± 20	5.8
2.	F2	Pale yellow, Smooth and flexible	112±2.8	0.31±0.01	5± 10	6.1
3.	F3	Yellowish brown, smooth, Uniform, slightly sticky	128±4.0	0.38±0.02	15 ± 35	5.6
4.	F4	Light yellow Homogenous, visible defects	119±3.5	0.35±0.01	20± 32	6.2
5.	F5	Creamy, Clear flexible	108±3.0	0.30 ±0.02	5 ± 12	5.5

Swelling index: A higher swelling index indicates a good swelling property. Which is essential for effective wound management.

Table No.5: Swelling index

Batch	Initial weight (g)	Final weight (g)	Swelling index (%)
F1	1.00 g	2.41 g	141%
F2	1.00 g	2.85 g	185%
F3	1.00 g	2.20 g	120%
F4	1.00 g	2.65 g	165%
F5	1.00 g	2.30 g	130%

Tensile strength:**Table No.6: Tensile properties of different sutures made from banana pseudo-stem and the commercially available suture**

Sr. No.	Sample	Toughness (MPa)
1.	Commercial product	2239.43±66.86
2.	Raw Banana fiber	217.58±30.60
3.	Degummed fiber	843.95±226.82
4.	Drug coated fiber:	
a.	1% coated fiber(F1)	1353.20±77.94
b.	2% coated fiber(F2)	1360.46±129.79
c.	3% coated fiber(F3)	1120.85±200.02

In-vitro drug release: In all of the investigated pH ranges, drug-coated gauge pad showed a biphasic release pattern with a slow and persistent release of ornidazole for up to 144 hours. Drug release started at pH 7.7 at 24 hours and rise gradually as the incubation period lengthened. The slope of the curve attained a plateau at 82.86% after 144 hours of incubation. Additionally, the gauge pad exhibits a similar pattern in the drug release at pH 6.3 and 6.8, where a release of 62.05% and 69.28%, respectively, was noted. The sustained drug release is facilitated by the use of the natural base materials psyllium husk and gum Tragacanth as the drug loading agent. Gum tragacanth has the capacity to keep the loaded medication in the wound region for an extended period of time. The most desirable quality for rapid wound healing is sustained release since it helps keep the wound's aseptic state for a longer period of time. According to studies, an alkaline atmosphere speeds up hydrolytic breakdown, which improves the way drugs are released. In this investigation, the same outcome was obtained by releasing the maximal amount of the medication (82.86%) at an alkaline pH of 7.7.

Table No.7: In-Vitro Drug Release Profile

Sr. no	Time (hr)	% Drug Release (pH 6.3)	% Drug Release (pH 6.8)	% Drug Release (pH 7.7)
01	0	0	0	0
02	24	18.74	23.76	28.58
03	48	21.65	31.13	39.41
04	72	32.11	39.45	51.33

05	96	43.29	51.09	58.69
06	120	56.31	59.22	71.05
07	144	72.05	75.28	88.86

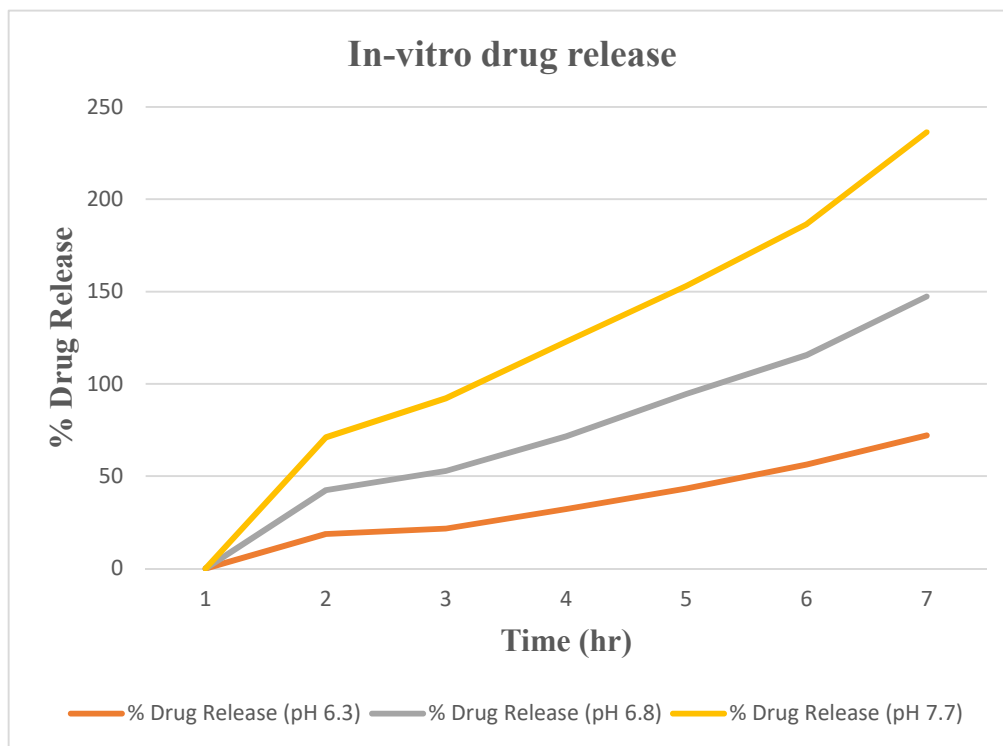


Fig.no. 7: In vitro drug release Plot

Antimicrobial testing:

Table No. 8: Antibacterial activity of sample (F3) against s. aureus

Sr. no	Sample	Disc	Day1	Day2	Day3	Day4
			Zone Diameter (mm) S aureus	Zone Diameter (mm) S aureus	Zone Diameter (mm) S aureus	Zone Diameter (mm) S aureus
1	Sample: Gauge pad with drug	1×1	2.1	1.3	00	00

Conclusion: The given sample(F3) used for the antibacterial activity by using bacterial strain S aureus it showed moderate activity.

Scanning electron microscopy:

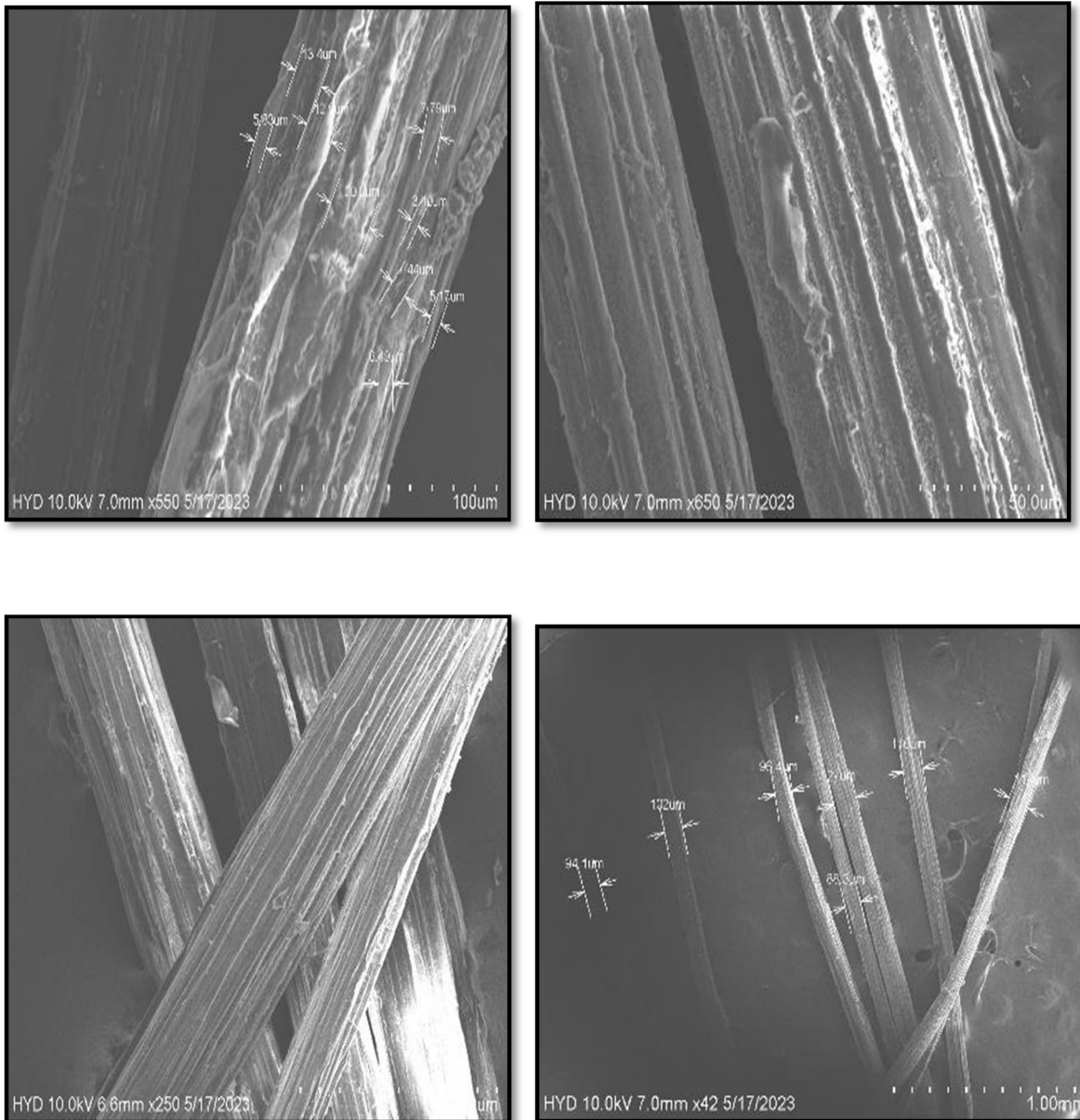


Figure No.8: SEM Micrographs (A, B, C, D) of Uncoated Gauge Pad

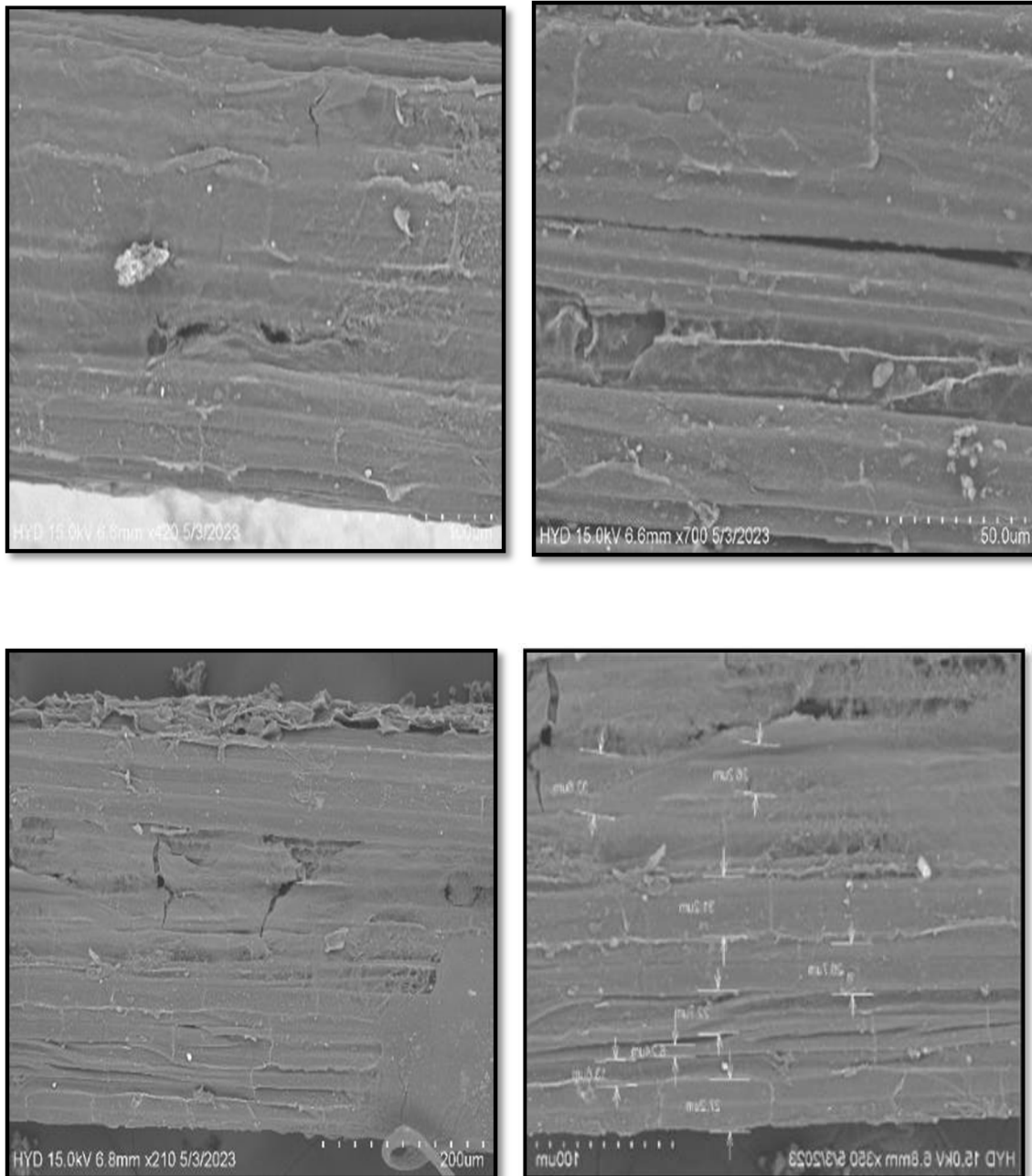


Figure No.9: SEM Micrographs (A, B, C, D) of coated Gauge Pad

The above figures show the FESEM images of dug coated gauge pad derived from pseudo-stem sutures and raw gauge pad. The surface morphology of raw gauge pad is rough and uneven. The existence of lignocellulose components including lignin, hemicellulose, and cellulose, which are mostly made of carbon and oxygen, is what's causing the roughness, as was validated by SEM-EDX research. Following alkali treatment, the diameter of the banana gauge pad shrank and the surface of the suture became smooth, regular, and frictionless. The entire banana gauge pad bundle was broken down into tiny fibrils as a result of alkali treatment, which also strengthened the adhesion between the fibers and the matrix. Due to the elimination of lignin and hemicellulose, banana gauge pad surface becomes smooth and frictionless after degumming. Coated banana gauge pad had smooth, consistent fiber surfaces along their whole length after coating, as can be shown in Figure.

Sterility Testing:

Table No. 9: Sterilization of Gauze pad using Ethylene Oxide Method

Sample	Fluid Thioglycollate Medium (Anaerobes)	Soybean Digest (Aerobes/Fungi)	Casein Medium	Observation
F1 (Unsterilized Gauze)	Turbidity observed (microbial growth)	Turbidity observed		Not Sterile
F2 (EtO Sterilized Gauze)	growth	No growth		Sterile
F3 (EtO Sterilized Gauze)	No growth	No growth		Sterile
F4 (EtO Sterilized Gauze)	No growth	growth		Sterile
F5 (EtO Sterilized Gauze)	No growth	No growth		Sterile
Positive Control (contaminated sample)	Turbidity observed	Turbidity observed		Not Sterile
Negative Control (sterile media)	No growth	No growth		Valid Test

Observations:

- ❖ Unsterilized samples (F1) showed microbial growth, proving natural contamination of fibres.
- ❖ EtO sterilized samples (F3 and F5) remained clear throughout the 14-day incubation period, confirming complete sterilization.
- ❖ Controls validated the test (positive control showed growth, negative remained sterile).
- ❖ EtO sterilization effectively eliminated both aerobic and anaerobic microorganisms without damaging fibre structure or drug stability.
- ❖ Ornidazole retained its drug content and release profile after EtO exposure, confirming no significant degradation.
- ❖ EtO sterilization was safe, efficient, and suitable for thermolabile drugs like Ornidazole.

Conclusion : In the current work, an effort was made to create a perfect gauge pad from suture derived from leftover banana pseudo stem waste that matched the qualities of commercially available product. The produced suture has strong tensile strength, demonstrates prolonged drug release, and was found to be only marginally biocompatible with human erythrocytes. In vitro testing revealed that the gauge pad dipped in Ornidazole which is derived from banana suture had strong antibacterial efficacy against contagious microorganisms. The results of this study may also aid in the development of banana farmers by enhancing the value of agricultural trash and so minimizing environmental harm.

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