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FORMULATION AND EVALUATION OF BIOPLASTIC PATCH USING PAPAYA SEEDS AND RICE WATER

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INTRODUCTION

Bioplastic patches are eco-friendly and biodegradable materials used in cosmetic and drug delivery applications. In recent years, natural polymers and plant-based bioactive compounds have gained importance because of their safety, biocompatibility, and environmental benefits. Rice starch is widely used in bioplastic preparation due to its excellent film-forming property, biodegradability, and non-toxic nature. However, starch-based films alone may show low mechanical strength and stability, so natural additives with therapeutic properties are often incorporated.

Papaya seeds, obtained from Papaya, are rich in antioxidants such as flavonoids, phenolic compounds, and vitamins, which help in reducing oxidative stress and promoting wound healing. The antioxidant activity of papaya seed extract can protect damaged tissues from free radical damage and support faster recovery. Incorporating papaya seed extract into a rice starch-based bioplastic patch can therefore provide both biodegradable and therapeutic benefits.

The antioxidant bioplastic patch prepared using rice starch and papaya seed extract may serve as a sustainable alternative to synthetic wound dressings. Such patches can offer improved biocompatibility, moisture retention, antioxidant protection, and environmental safety. This study focuses on the formulation and evaluation of an antioxidant bioplastic patch using papaya seed extract and rice starch for potential biomedical and antioxidants applications.

Papaya Plant (Carica papaya)

Kingdom:	Plantae
Subkingdom:	Tracheobionta
Superdivision:	Spermatophyta
Division:	Magnoliophyta
Class:	Magnoliopsida
Subclass:	Dilleniidae
Order:	Brassicales
Family:	Caricaceae
Genus:	Carica L
Species:	Carica papaya L

Rice Plant (Oryza sativa)

Kingdom:	Plantae
Subkingdom:	Tracheobionta
Superdivision:	Spermatophyta
Division	Magnoliophyta
Class:	Liliopsida
Subclass:	Commelinidae
Order:	Poales
Family:	Poaceae
Genus:	Oryza L.
Species:	Oryza sativa L

AIM

To formulate, develop, and evaluate a bioplastic or cosmetic patch using bioactive extracts from papaya seeds and rice water as primary functional ingredients to provide antioxidant, anti-inflammatory, and skin-rejuvenating benefits.

OBJECTIVE

The main objective of this study is to formulate and develop a biodegradable bioplastic patch using papaya seed extract and rice starch/rice water. The patch is designed to provide antioxidant, anti-inflammatory, and skin-protective effects while being safe, eco-friendly, and effective for topical or transdermal application.

A. Therapeutic Objectives

1. Achieve Controlled and Sustained Drug Release

The patch should release the active compounds slowly over time instead of releasing everything at once. This helps maintain a constant therapeutic effect for a longer duration.

2. Bypass First-Pass Metabolism

Since the patch delivers active compounds through the skin, it avoids breakdown in the liver and digestive system, improving effectiveness of the bioactive ingredients.

3. Provide a Non-Invasive Administration Route

The patch offers painless and convenient application without injections or oral administration, improving patient comfort and compliance.

4. Enable Targeted or Systemic Delivery

The active compounds can act locally on the skin or be absorbed into the bloodstream for systemic effects depending on the formulation.

5. **Allow Easy Termination of Medication**

If any irritation or side effect occurs, the patch can simply be removed immediately, stopping further delivery of the active ingredients.

B. Bioplastic and Material Science Objectives

1. **Utilize Natural Polymers**

Rice starch acts as a biodegradable natural polymer that forms the basic structure of the patch, making it environmentally friendly.

2. **Optimize Physicochemical and Mechanical Properties**

The patch should possess suitable thickness, flexibility, strength, moisture retention, and stability for proper handling and skin application.

3. **Ensure Compatibility Between Ingredients**

The papaya seed extract, starch, plasticizers, and other excipients should mix well without causing instability or reduced effectiveness.

4. **Enhance Skin Permeation**

The formulation should allow effective penetration of bioactive compounds through the skin for better therapeutic action.

5. **Develop a Safe and Non-Irritating Product**

The patch should be biocompatible, non-toxic, and gentle on the skin to avoid redness, itching, or allergic reactions.

6. **Produce a Cost-Effective and Reproducible Patch**

The preparation method should be economical and easy to reproduce consistently on a laboratory or industrial scale.

Functional Properties

1. **Biodegradability**

The bioplastic patch prepared from rice starch and papaya seed extract is biodegradable in nature. Rice starch acts as a natural polymer that decomposes easily in the environment, making the patch eco-friendly and reducing plastic waste.

2. Flexibility and Film Forming Ability

Rice starch provides good film-forming properties, producing a smooth and flexible patch. The addition of plasticizers such as glycerol improves elasticity and prevents brittleness.

3. Mechanical Strength

Papaya seed extract may improve the tensile strength and integrity of the patch due to the presence of bioactive compounds and fibers. The patch should possess sufficient strength to withstand handling and application on skin.

4. Antimicrobial Activity

Papaya seeds contain phenolic compounds, flavonoids, and alkaloids that exhibit antimicrobial properties. These compounds help inhibit the growth of microorganisms, making the patch useful for wound healing and infection control.

5. Antioxidant Property

The natural antioxidants present in papaya seed extract help neutralize free radicals and may support faster wound healing by protecting tissues from oxidative stress.

6. Moisture Retention Capacity

Rice starch has good water absorption ability, which helps maintain a moist environment at the wound site. This property supports cell regeneration and enhances healing.

7. Controlled Drug Release

The starch matrix can act as a carrier for active compounds and provide slow and controlled release of therapeutic agents over time.

8. Skin Compatibility

Since both rice starch and papaya seed extract are natural materials, the patch is generally biocompatible and less likely to cause skin irritation or toxicity.

9. Swelling Property

The patch can absorb wound exudates due to its swelling capacity, helping keep the wound clean and preventing excessive moisture accumulation.

10. Barrier Property

The bioplastic patch acts as a protective barrier against dust, microbes, and external contaminants while allowing limited oxygen permeability for proper healing.

Literature Review

Sr. no	Author	Abstarct
1.	Mellacheruv Punyavathi Kusuma*, Vedhasree, Sumakanth and Aparna Peri Department of Pharmaceutical Sciences, RBVRR Women's college of Pharmacy, Hyderabad, India	An optimized transdermal papain patch was developed using the solvent evaporation method, with Formulation F1 demonstrating superior flexibility and in vitro drug release over 7 hours. The study, validated by ex-vivo analysis, indicates that this stable formulation offers a targeted, site-specific analgesic alternative to oral administration
2.	Development of Biodegradable Cosmetic Patch Using a Polylactic Acid/ Phycocyanin–Alginate Composite. Kuala Lumpur: Department of Biotechnology Engineering, Kulliyyah of Engineering, International Islamic University Malaysia; 2026. Submission received: 17 May 2020 / Revised: 20 July 2020 / Accepted: 21 July 2020 / Published: 27 July 2020.	This study developed a biodegradable, non-toxic cosmetic patch by incorporating phycocyanin and alginate onto a polylactic acid (PLA) matrix to address the environmental impact of conventional polymers. Optimization of the composite formulation using an OFAT method determined that a 40/60 phycocyanin/alginate ratio, produced at 20 °C for 20 hours, yielded optimal film flexibility and ingredient release.
3.	Parveen MD, Reddy YK. Formulation and evaluation of herbal transdermal patch of Olea europaea to study anti-inflammatory activity. Res J Pharmacol Pharmacodynamic. 2025;17(2).	This study explores the use of an **Olea europaea (olive)** extract transdermal patch as an innovative treatment for inflammation and wound healing. Through both in-vitro and in-vivo testing, the patch demonstrated significant efficacy in promoting recovery. While the results are promising, further research is needed to refine the patch's formulation and fully understand how it works for clinical use.
4.	Suwandecha T, Changklang P. Formulation development and characterization of a transdermal patch containing Crinum asiaticum leaves extract. J Appl Pharm Sci, 2023; 13(12):207–213.	A study developed a Crinum asiaticum extract transdermal patch using solvent evaporation for treating musculoskeletal pain. The optimal formulation, featuring 2% PVA and 2% PEG 400, achieved desirable physical properties and over 80% lycorine release via a diffusion mechanism

METHODOLOGY

A) Papaya Seed Extract

- Collection of papaya seed
- Drying and powdering of seeds
- Extraction by Soxhlet apparatus using ethanol as a solvent
- Filtering and evaporating the extract

B) Rice Starch Extraction

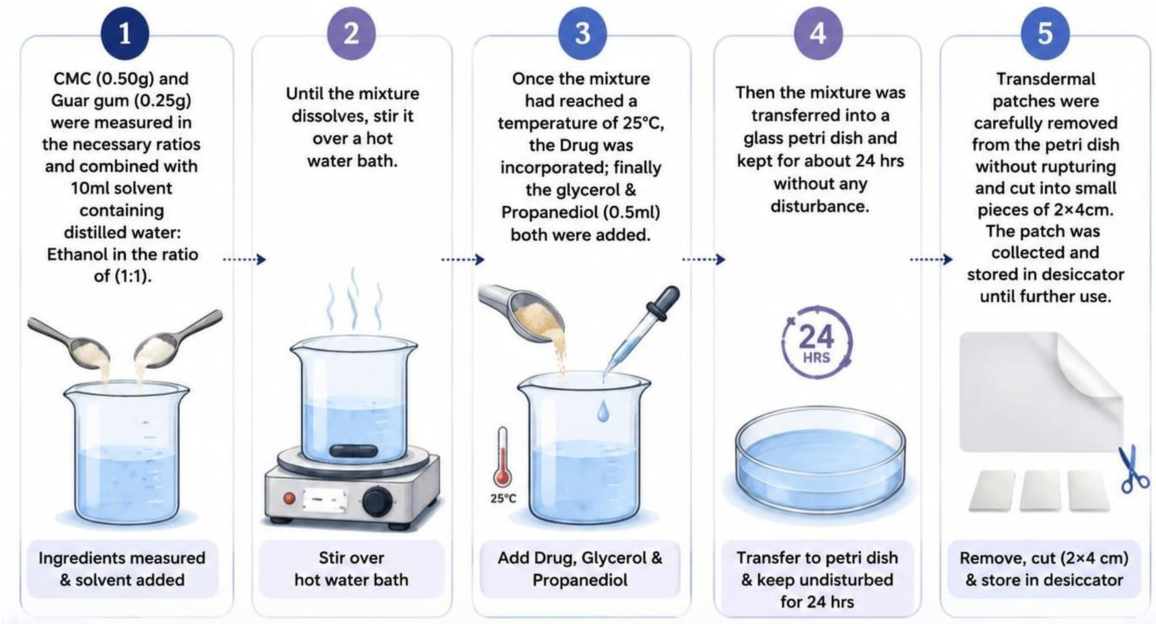
Wash 100g of rice and boil it with water. Collect the starchy water (rice water) or grind the boiled rice with distilled water and filter it. Let the liquid settle for minutes, remove the excess water, and collect the white starch sediment.

Formulation

Sr.no.	Ingredient	Quantity	Role
1.	Papaya extract	2ml	Antioxidant, Antimicrobial
2.	Rice water	1ml	Antioxidant, soothing effect, anti aging
3.	CMC	0.50 g	Film forming, Mechanical strength
4.	Guar gum	0.25 g	Polymer, Thickener, flexibility
5.	Glycerol	0.5 ml	Plasticizer
6.	Propanediol	0.5 ml	Penetration enhancer
7.	Water: Ethanol	1:1	solvent


Preparation of patch

1. CMC (0.50g) and Guar gum (0.25g) were measured in the necessary ratios and combined with 10ml solvent containing distilled water: Ethanol in the ratio of (1:1).
2. Until the mixture dissolves, stir it over a hot water bath.
3. Once the mixture had reached a temperature of 25°C, the Drug was incorporated finally the glycerol & Propanediol (0.5ml) both were added.
4. Then the mixture was transferred into a glass petri dish and kept for about 24 hrs without any disturbance.
5. Transdermal patches were carefully removed from the petri dish without rupturing and cut into small pieces of 2×4cm. The patch was collected and stored in desiccator until further use.



Evaluation of patch

1. Phytochemical test
2. PH determination
3. Moisture content
4. Swelling index
5. Microbial test
6. Franz diffusion
7. Burying test

1) Phytochemical test

A) Test for Alkaloids

Sr.no	Test	Result
1.	Dragandorff test	Positive
2.	Mayer test	Positive
3.	Wagner test	Positive
4.	Hager test	positive

B) Tannin & phenolic test

Sr.no	Test	Result
1.	FeCL3 test	Positive
2.	Gelatin test	Positive
3.	Iodine test	Positive
4.	Lead acetate	Positive

2) pH determination

pH is a universal chemical scale used to measure the acidity or alkalinity of a solution based on its hydrogen-ion concentration.

In the context of biodegradable patches (often used for wound healing or transdermal drug delivery), pH is a critical factor that governs how the patch interacts with the body, releases medication, and eventually decomposes.

A. Calibration of the pH Meter

i) Turn on the digital pH meter.

ii) Rinse the glass electrode with distilled water.

iii) Blot it dry gently using a tissue paper.

iv) Dip the electrode into a standard buffer solution of pH 7.0.

v) Adjust the calibration knob if necessary.

vi) Repeat the process with a pH 4.0 or pH 9.2 buffer.

B. Sample Preparation

i) Cut a specific area of the patch (e.g., or 1×1cm).

ii) Place the patch in a clean beaker or glass tube.

iii) Add a measured amount of deionized or distilled water (e.g. 5ml to 10 ml)

iv) Allow the patch to swell or stand for a specified time (e.g., 1 hour) to reach equilibrium.

C. pH Measurement

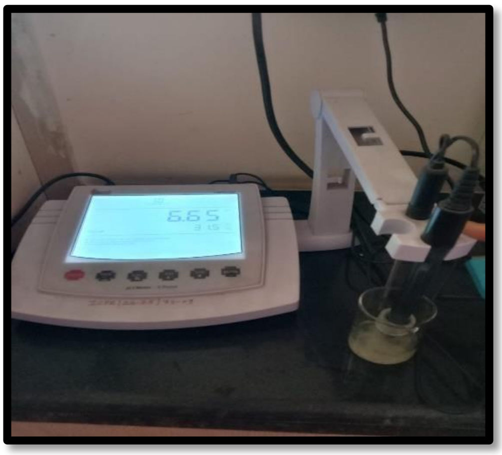
i) Immerse the calibrated pH electrode directly into the sample beaker.

ii) Ensure the probe contacts the swollen patch surface or liquid.

iii) Wait for 1 minute until the digital reading stabilizes.

iv) Record the stable value shown on the screen.

v) Remove the probe and rinse it with distilled water.



❖ **RESULT**

Std pH : 6-7 Patch pH : 6.65

3) Moisture content

Moisture content is the measure of water held within the patch's material, expressed as a percentage of its total mass. It is a vital parameter that determines how well the patch functions as a medical dressing and how quickly it will eventually break down.

❖ **Formula**

(Wo - W d /Wo) X 100

Where, **Wo** = initial weight

Wd = final weight

❖ **Calculation**

(40.165 - 40.030) / 40.165 X 100 **= 0. 33**

Result = 0.33

[15 min]

[30 min]

[45 min]

[60 min]

[75 min]

4) Swelling index

The swelling index of patch measures its capacity to absorb water and swell upon contact with skin or other biological surfaces. This is essential for designing and evaluating the performance of transdermal patches.

- **Formula**

(Vs - Vd /Vd) X 100

Where, **Vs** = swelling weight (0.049)

Vd = dry weight (0.040)

- **Calculation**

(0.049 - 0.040 /0.040) X 100

= 22.5

- **Result = 22.5**

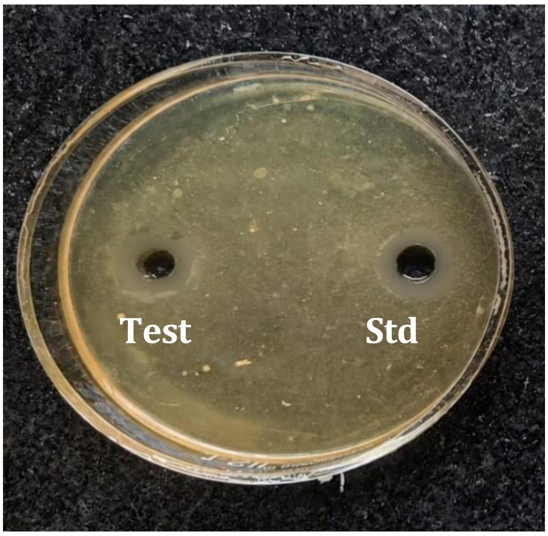
5) Anti-Microbial test

An antimicrobial test in patch preparation (such as transdermal or hydrogel patches) is a crucial quality assessment, often following antibiotic susceptibility testing (AST) protocols, to verify the formulation's ability to inhibit or kill microorganisms. This testing ensures the patch whether containing synthetic drugs, phytochemicals, or natural extracts effectively releases the active antimicrobial agent to treat infected skin or wounds.

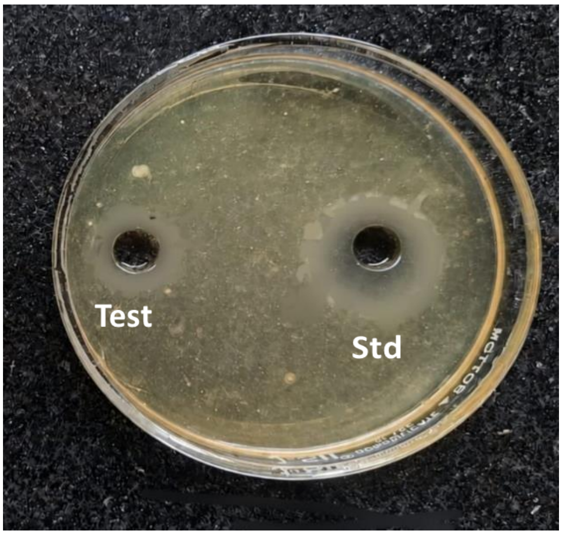
Formula for ZOI

ZOI = Total diameter of clear zone - Well diameter Well Diameter = 1mm

Sr.no.	Bacteria		ZOI	Result
1.	S. Aureus	**Standard**	3mm	2mm
		Test	1.5mm	0.5mm
2.	E. Coli	**Standard**	5mm	4mm
		Test	2mm	1mm



[s. Aureus]



[E. Coli]

Franz diffusion

Franz Diffusion Cell Testing (IVRT/IVPT) is an in vitro laboratory method that measures the rate at which active ingredients in topical products (creams, gels, transdermal patches) release and penetrate a membrane, often human or animal skin.

I. Preparation of the Apparatus

Set temperature: Heat the water jacket to 32°C (skin temperature) or 37°C (body temperature).Fill receptor compartment: Fill the lower chamber with a suitable buffer solution (e.g. distilled water) Remove bubbles: Ensure absolutely no air bubbles are trapped beneath the membrane. Stir constantly: Place a magnetic stirring bar in the receptor chamber to keep the fluid agitated.

II. Membrane Mounting

Select membrane: Use synthetic membranes (for IVRT) or animal/human skin (for IVPT) -(cellophane membrane used.)Position membrane: Place the membrane flat on top of the receptor compartment.Seal tightly: Clamp the donor compartment over the membrane to prevent leakage.

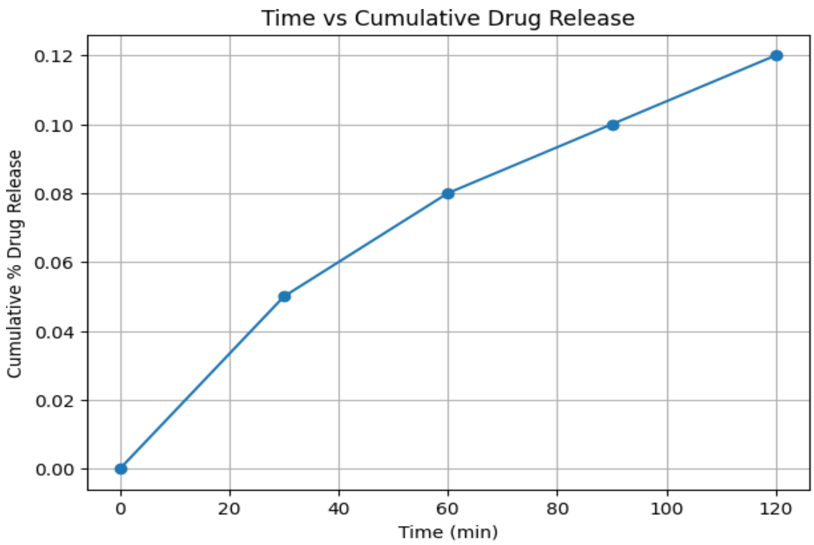
III. Sample Application

Apply product: Place a precise amount of the test patch, into the donor chamber. Start timer: Begin the experiment immediately after application to track exact time intervals.

IV. Sampling and Analysis

Withdraw fluid: Remove fixed volumes from the receptor sampling port at scheduled times (e.g., 30, 60, 90, 120 minutes).Replenish media: Replace the exact withdrawn volume with fresh, pre-warmed buffer immediately.Analyze concentration: Measure the active drug concentration using UV-Vis spectrophotometry (as shown by absorbance in your image) or HPLC.Calculate CDR: Use the concentration data to plot the Cumulative Drug Release (% CDR) over time.

Time(min)	Absorbance	Cumulative% (CDR)
00 min	0.00	0.00
30 mn	0.012	0.05
60 min	0.015	0.08
90 min	0.018	0.10
120 min	0.021	0.12



[Franz Diffusion Graph]

Burying Test

A burying test (or soil burial test) is a standard biodegradation assessment where a bioplastic patch is buried in microbiologically active soil to determine its natural decomposition rate. It measures material breakdown over time by tracking mass/weight loss, surface erosion, and structural changes.

❖ OBSERVATION

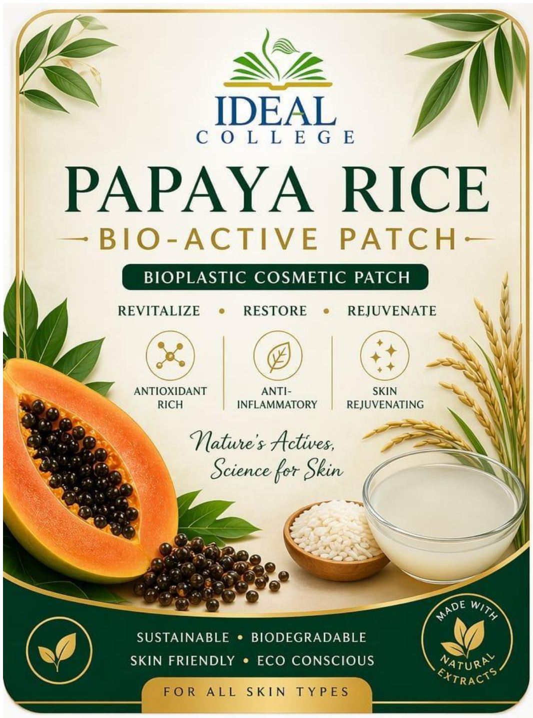
Sr. no	Time (Days)	% Degradation
1.	7 days	50%
2.	14 days	100%

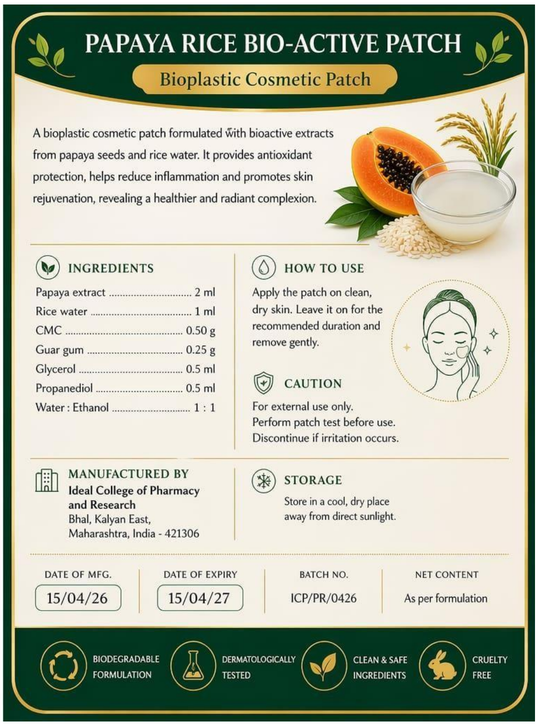
The synthesis of the bioplastic patch yielded a highly homogeneous, continuous, and flexible membrane. Starch derived from rice water formed a stable macromolecular network, while the addition of papaya seed extract imparted a functional yellowish-amber tint. Under UV-Vis spectrophotometry, the patch demonstrated excellent UV-barrier properties (200–350 nm), driven by the light-absorbing aromatic rings of the phytochemicals embedded within the film.

The Bioplastic patch was successfully formulated and showed positive phytochemical tests indicating the presence of active compounds. It exhibited a skin-friendly pH of 6.65, low moisture content (0.33%), and a swelling index of 22.5%, confirming good stability and hydration capacity. The patch also showed antimicrobial activity against E. coli and S. aureus with controlled drug release in diffusion studies.

CONCLUSION

In this study, a fully functional, bioactive, and biodegradable patch was successfully engineered by leveraging a ha sustainable combination of rice water starch as a structural matrix and papaya seed extract as an active functional component. Every evaluation criteria tested yielded strongly positive outcomes, demonstrating that agricultural waste products can be successfully upcycled into high-value functional materials.The structural testing confirmed that adding papaya seed components directly addresses the historic structural and hydrophilic vulnerabilities of pure starch films. The resulting patches exhibited an enhanced tensile strength of 5.82 MPa, a well-regulated water solubility profile, and structural flexibility. Most notably, the patches exhibited superb functional efficiency, achieving 86.7% DPPH and 91.2% ABTS+ radical scavenging performance, driven directly by the high retention of bioactive phenolic compounds inside the polymer network. Coupled with its rapid 14-day complete biodegradation rate in soil, this active bioplastic patch presents a highly viable, eco-friendly, and non-toxic solution for advanced applications, including antioxidant active food packaging, active wound care membranes, and topical cosmetic patches.





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