Team 15

Green Papaya-based Hydrogel Dressing for Debridement of Late-stage Diabetic Foot Ulcers in Grenada

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Introduction

The Caribbean region reports the world's highest lower-extremity amputation rates among diabetic patients at 936 per 100,000 persons [1]. In Grenada, approximately 80% of diabetic foot ulcer patients present at late stages requiring enzymatic debridement [2]. Current treatment costs of $50-150 per week create significant access barriers in a nation with median household income of $8,000 annually [4]. Current solutions which include wound VAC systems and imported antibacterial dressings remain financially prohibitive despite clinical availability. We are developing a green papaya latex-PEG hydrogel wound dressing that targets production costs ≤$10 per treatment while maintaining clinical efficacy through enzymatic debridement and antimicrobial activity, leveraging Grenada's locally-available agricultural resources [4].

Mission Statement

Our mission is to provide affordable, enzyme-based hydrogel wound care solutions that harness papain's natural healing properties to treat diabetic foot ulcers in Grenada, improving access to care, accelerating healing, and reducing amputation rates through sustainable, evidence-based innovation.

Project Timeline

Project Gantt Chart: The following chart outlines the project timeline, highlighting key milestones and task completion.

Design Inputs

Metric No./ Customer Need/Priority	Target Value
Cost Accessibility ($USD)	≤ $10 per dressing
Clinical Efficacy (time until wound closure)	≤ 45 days till wound closure
Necrotic Tissue Size Reduction (% SA)	≥ 20% surface area reduction in first week
Swelling Ratio (% Wt)	800 - 600 % Wt
Total Viable Bacteria Count (CFU)	≤ 10^3 CFU/g
Catalytic Efficiency (k_{cat}/KM)	≥ 10^5 $M^{-1}s^{-1}$
Ease of Use (5 pt. scale)	5 points
Application Time (Minutes)	≤ 5 min
Cell Viability (%)	≥ 90%
Skin Irritation Score (SAS-AD)	≤ 2 (on 0-10 scale)

House of Quality: Illustrates the relationship between customer needs, target specifications, and engineering metrics, translating patient and clinician requirements into measurable design parameters.

Device Concept and Design

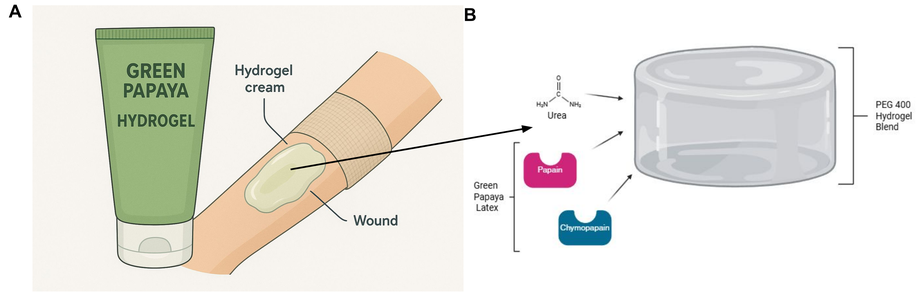
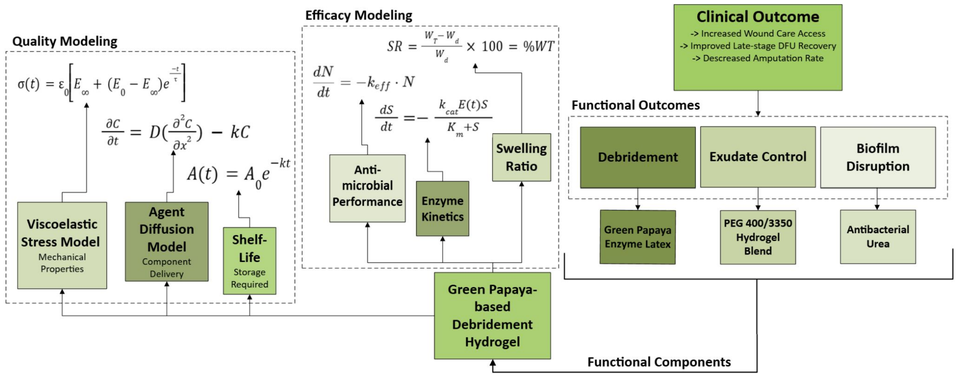


Figure 1. (A) Image of hydrogel application concept. **(B)** Diagram showing hydrogel design with urea, papain, and chymopapain as active ingredients. The hydrogel is reapplied every 48 hours to align with rural clinic schedules. Latex extraction yields 15-25g per papaya fruit, with each 10 mL dressing requiring approximately 2 fruits.

Product Architecture/Modeling



Antimicrobial Activity	$\frac{dN}{dt} = -k_{eff} \cdot N$
Enzyme Kinetics	$\frac{dS}{dt} = -\frac{k_{cat}E(t)S}{K_m + S}$

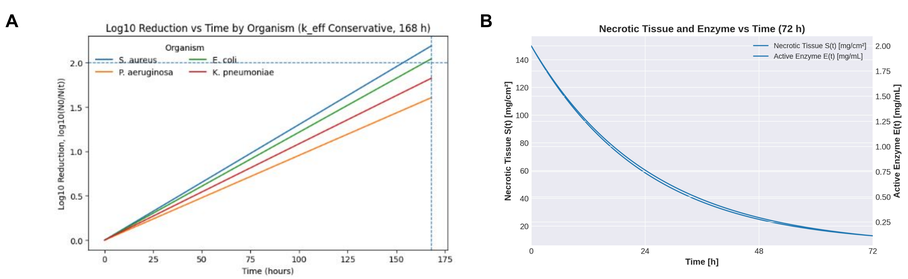


Figure 2. (A) Log_{10} Reduction vs. Time for Four Wound Pathogens ($k_e$ff Conservative, 168-Hour Treatment). **(B)** Substrate areal load S(t) [mg/cm²] and active enzyme E(t) [mg/mL] under Michaelis–Menten kinetics with enzyme decay (k_d).

Final Product Specifications

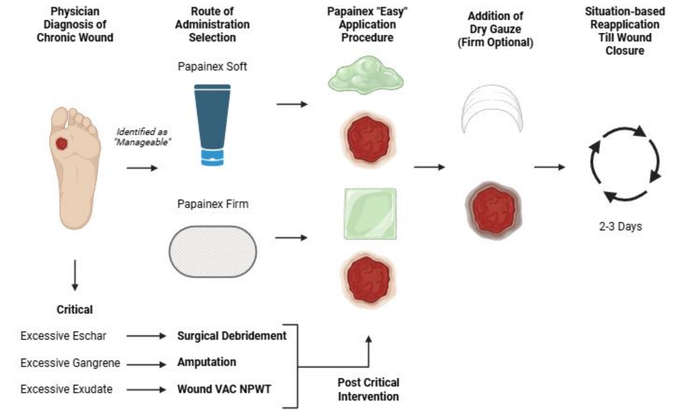


Figure 3. Workflow of Papainex treatment for chronic wounds, showing route selection (soft or firm), application, and reapplication (every 48 hours) until closure, with critical cases requiring surgical or VAC interventions before resuming therapy.

Design for Manufacturing

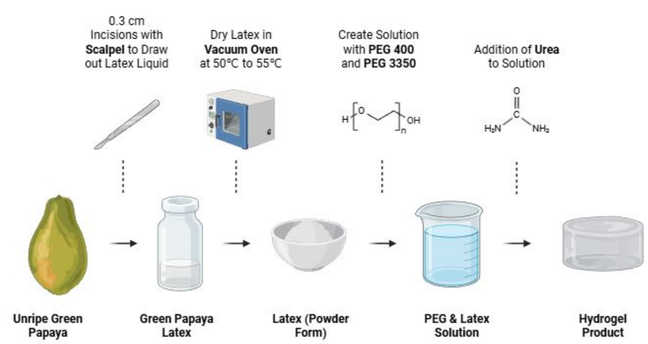


Figure 4. Production workflow for the manufacturing of the green papaya hydrogel. Extraction and concentration of the green papaya latex into crude papain, drives down cost significantly as compared to sourced enzyme components or a full purification process (25% - 30% Yield).

Design Status and Future Work

After initial screening, the green papaya-based hydrogel demonstrated the strongest alignment with project requirements across debridement efficacy, cost accessibility, and local sourcing feasibility. We are currently refining our technical models to validate PEG ratios for optimal mechanical properties, enzymatic agent diffusion, and swelling capacity before initiating experimental validation of product specifications.

Acknowledgements

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References