Masters Thesis Information Showcase
Spring Semester-2026
Year 2026

Department: Biomedical Engineering
Programme: Masters in Engineering
Specialization: Biomedical Engineering

1	**Title of the Thesis** Synthesis and Characterization of Fish Skin Derived Hydrogels
2	**Abstract** (min 300 to 500 words) Hydrogels are three-dimensional polymeric networks capable of absorbing and retaining large amounts of water while maintaining their structural integrity. Due to their excellent biocompatibility, biodegradability, and moisture-retention properties, hydrogels have gained considerable attention for biomedical applications, including wound dressings, tissue engineering, and drug delivery systems. However, the development of sustainable and cost-effective hydrogels from natural resources remains an important area of research. Fish processing industries generate substantial quantities of skin waste, which contains valuable structural proteins that can be utilized for the development of environmentally friendly biomaterials. This study aimed to synthesize and characterize a composite hydrogel using fish skin-derived proteins, sodium alginate, and tapioca starch. Fish skin was subjected to cleaning, povidone treatment, sodium chloride washing, and decellularization to remove cellular components while preserving structural proteins. The extracted fish skin proteins were dissolved in acetic acid and incorporated into a polymer blend containing sodium alginate and tapioca starch. The resulting hydrogel was formed through calcium-mediated crosslinking and characterized using various analytical techniques. Protein extraction was confirmed using the Bicinchoninic Acid (BCA) assay. The physicochemical properties of the hydrogel were evaluated using Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), swelling studies, contact angle analysis, Differential Scanning Calorimetry (DSC), and mechanical testing. The results confirmed the successful extraction of proteins from Singhara fish skin and the formation of a stable composite hydrogel. FTIR analysis identified characteristic functional groups of fish proteins, sodium alginate, and tapioca starch, confirming intermolecular interactions within the hydrogel network. SEM analysis revealed a porous and interconnected microstructure that supports efficient water absorption. Swelling studies demonstrated excellent water uptake capacity, while contact angle analysis indicated a highly hydrophilic surface. DSC analysis further demonstrated good thermal stability, suggesting strong interactions among the hydrogel components. Mechanical characterization indicated that the synthesized hydrogel possessed sufficient structural integrity for potential biomedical applications. The fish skin protein–sodium alginate–tapioca starch composite hydrogel exhibited favorable physicochemical, mechanical, and thermal properties, demonstrating its potential

	as a sustainable biomaterial for biomedical applications. This study highlights the effective utilization of fish skin waste as a renewable source of functional proteins and provides a foundation for future research on advanced hydrogel systems for tissue engineering and wound healing applications.
3	**Impact on SDG#___"** (min 500 words) **SDG 3: Good Health and Well-being** This research directly contributes to **Sustainable Development Goal (SDG) 3: Good Health and Well-being** through the development of a natural polymer-based composite hydrogel with potential biomedical applications. Hydrogels have become increasingly important in the healthcare sector due to their ability to absorb and retain large amounts of water, maintain a moist environment, and provide structural support for tissue repair. These properties make them highly suitable for applications such as wound dressings, tissue engineering, and controlled drug delivery systems. The hydrogel developed in this study, composed of fish skin-derived proteins, sodium alginate, and tapioca starch, exhibited favorable physicochemical properties that support its potential use as a biomaterial. The synthesized hydrogel demonstrated high swelling capacity, a porous interconnected structure, excellent hydrophilicity, and good thermal stability. These characteristics are desirable for wound healing applications, where maintaining adequate moisture, absorbing wound exudates, and allowing oxygen and nutrient transport are essential for promoting tissue regeneration. Furthermore, the use of naturally derived fish proteins enhances the biodegradability and biocompatibility of the hydrogel, reducing dependence on synthetic polymers that may cause adverse biological responses. The incorporation of renewable biomaterials into biomedical products supports the development of safer, environmentally friendly, and cost-effective healthcare solutions. Although this study focused primarily on the synthesis and physicochemical characterization of the hydrogel, the results provide a strong foundation for future investigations involving in vitro and in vivo biological evaluations. Such studies may facilitate the development of advanced wound dressing materials and tissue engineering scaffolds capable of improving patient outcomes and overall quality of life. Therefore, this research contributes to the advancement of biomedical engineering while supporting innovations that promote human health and well-being. **SDG 13: Climate Action** This study also contributes to **Sustainable Development Goal (SDG) 13: Climate Action** by encouraging the sustainable utilization of biological waste generated by the fish processing industry. Large quantities of fish skin are typically discarded after processing, contributing to environmental pollution and inefficient waste management. However, fish

	skin is a valuable source of structural proteins that can be extracted and converted into high-value biomaterials rather than being disposed of as waste. In this research, proteins extracted from Singhara (catfish) skin were successfully utilized to fabricate a composite hydrogel. This approach demonstrates an effective strategy for converting fish processing by-products into value-added materials, thereby promoting resource efficiency and supporting a circular economy. Utilizing fish skin waste reduces the environmental burden associated with waste disposal while minimizing the need for non-renewable raw materials commonly used in synthetic biomaterial production. The hydrogel developed in this study is composed entirely of naturally derived polymers, including fish skin proteins, sodium alginate, and tapioca starch, all of which are biodegradable and environmentally sustainable. The use of biodegradable materials helps reduce long-term environmental pollution associated with conventional petroleum-based polymers and aligns with global efforts to promote sustainable material development and climate-conscious innovation. Overall, this research demonstrates how biomedical engineering can address both healthcare and environmental challenges by transforming an underutilized biological waste into a functional biomaterial. By promoting sustainable resource utilization, reducing waste generation, and encouraging the development of biodegradable biomaterials, this study supports the objectives of SDG 3 and SDG 13 while providing a foundation for future research in sustainable biomedical material development.
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6	**Graphical Abstract**

Synthesis and Characterization of Fish Skin Protein-Based Composite Hydrogel

A Sustainable Approach for Biemedical Applications

1 Fish Skin

Singhara (Catfish) skin collected as a by-product

2 Povidone Treatment

Treated with povidone for cleaning and surface decontamination

3 NaCl Washing

Washed with sodium chloride solution to remove impurities

4 Decellularization

Decellularized to remove cellular components while preserving proteins

5 Protein Extraction

Proteins extracted in acetic acid solution

6 Composite Preparation

Fish Skin Proteins + Sodium Alginate + Tapioca Starch

7 Hydrogel Formation

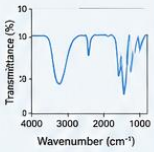
Crosslinking to form stable composite hydrogel

8 Characterization

Comprehensive analysis of hydrogel properties

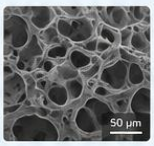
Characterization and Key Properties

FTIR



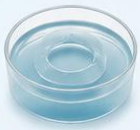
- Confirms presence of protein, alginate and starch functional groups
- Indicates intermolecular interactions in the hydrogel

SEM



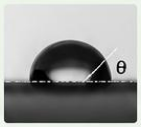
- Porous and interconnected structure
- Suitable for water absorption and nutrient transport

Swelling Test



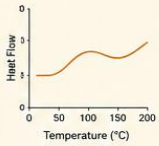
- High water absorption capacity
- Maintains a moist environment

Contact Angle



- Low contact angle
- Indicates high hydrophilicity

DSC



- Shows good thermal stability
- Strong interactions among hydrogel components

Tensile Test

- Adequate tensile strength
- Suitable for biomedical applications

✓ Biocompatible
✓ Biodegradable
✓ High Swelling

✓ Good Thermal Stability
✓ Adequate Mechanical Strength
✓ Porous Structure

A Sustainable Natural Composite Hydrogel with Potential for Biomedical Applications

Turning Fish Skin Waste into Advanced Biomaterials for a Healthier Tomorrow and a Sustainable Planet