Analysis of the Mechanical Properties of Biomaterials found in Nature for the production of Bone Tissue Scaffold

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Abstract

During this investigation, the mechanical properties of three biomaterials found in nature (carrots, bamboo, and grapes) were evaluated to determine if they could serve as prototypes for a biocompatible, biodegradable, and non-toxic decellularized scaffold. This scaffold has the potential to accelerate bone tissue growth and enhance fracture healing when impregnated with specific growth factors. In the future, this project could be tested with in vivo samples, depending on its results, if the cells adhere to the material and proliferate, it could aid individuals who suffer from bone injuries, particularly the elderly population. Moreover, it could replace the costly and painful process of bone grafts, enabling a transition to a safe, easy-to-create, painless, and, above all, effective technology.

Background and Introduction

Decellularization is the process of removing the cellular components from a tissue or organ while preserving its extracellular matrix structure. After the cellular components are removed the scaffold is obtained. The preserved matrix can then serve as a framework for tissue regeneration or as a platform for cell seeding in various applications, including organ transplantation and tissue engineering.

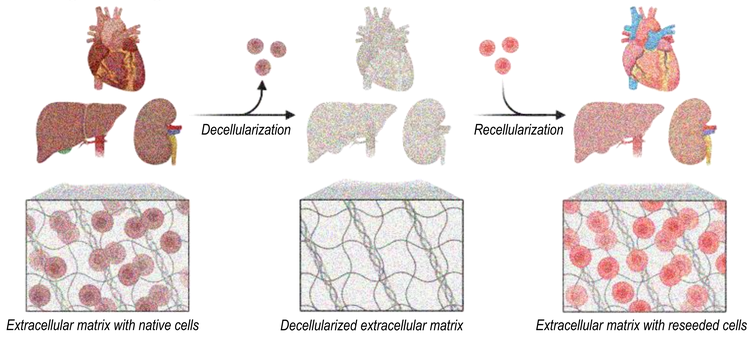


Figure 1: Decellularization and Recellularization of Whole Organs

Bones undergo constant remodeling throughout life, adapting to the demands placed on them. However, as individuals age, the ability to regenerate bone tissue diminishes, leading to an increase in age-related fractures which are projected to increase nationally from 2.1 million in 2005 to over 3 million fractures in 2025, solely on the basis of growth in the elderly population most at risk.

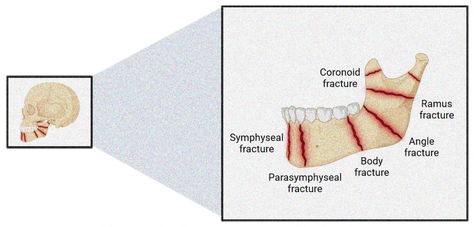
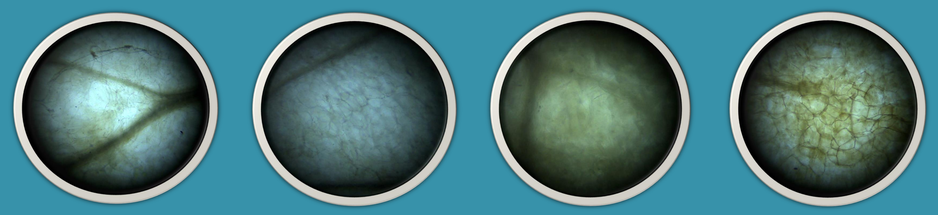
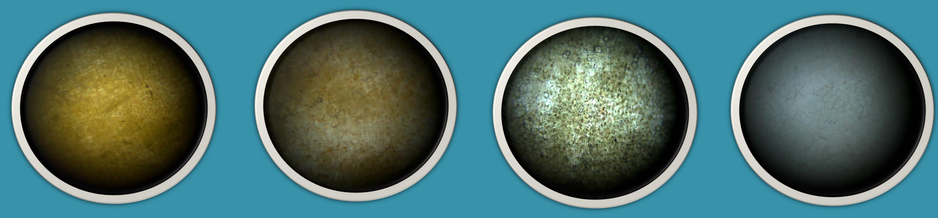
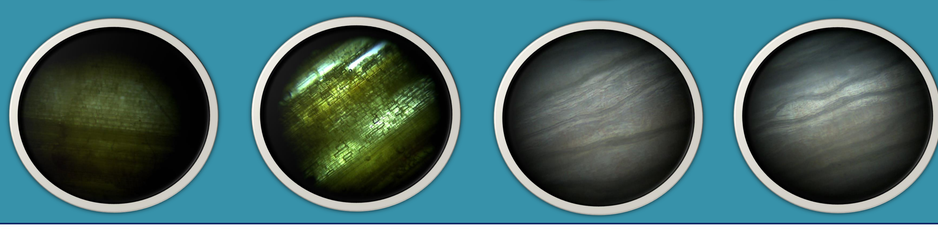


Figure 2: Frequent Mandibular Fractures by Location

Results

Material	Immersed Solution: Normal	Sodium Dodecyl Sulfate	70% Isopropyl Alcohol	Phosphate Buffered Saline
Grapes				
Carrots				
Bamboo				

Discussion

- Initial microscopic examination showed no changes; significant changes occurred after immersion in 70% isopropyl alcohol and distilled water rinsing.
- Total time for scaffold prototype creation: **Grapes 9 days, carrots 15 days, bamboo 21 days.**
- Maximum stress and load capacities of scaffold prototypes:
  - **Bamboo: 100.23 lbs & 6.56 MPa**
  - **Carrot: 102.43 lbs & 0.25 MPa**
  - **Grapes: 218.81 lbs & 4.84 MPa**
- Inconsistencies in stress and load application due to varying scaffold forms.

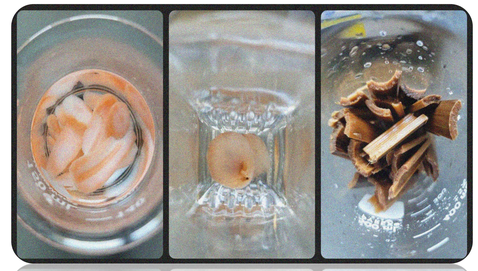
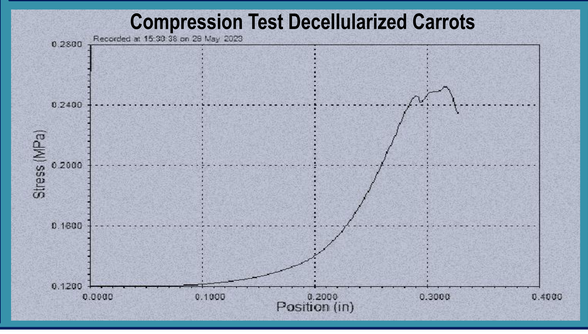
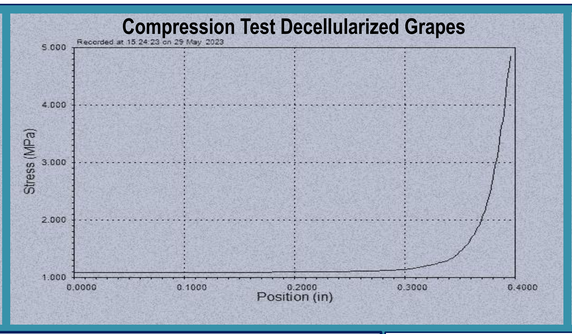


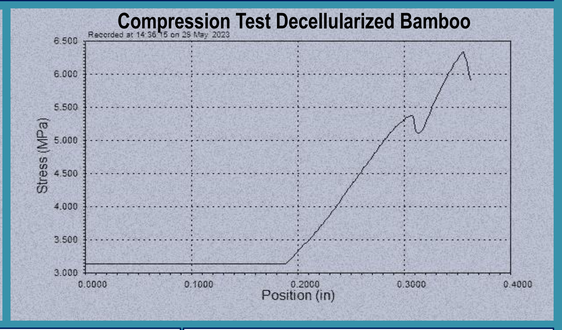
Figure 3: Prototype scaffolds in Phosphate Buffered Saline

Future Work

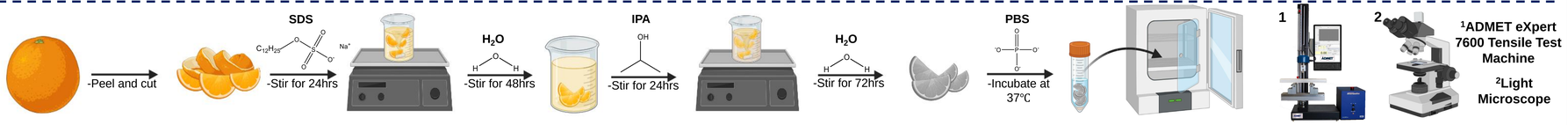
- Add stem cells to the scaffold and impregnate it with growth factors to test cell adherence and promotion of cell growth.
- Conduct in vivo tests to assess the effectiveness, biocompatibility, and viability of growing bone tissue in fractured bones.
- Continue to characterize the mechanical properties of the prototypes and the pore size.
- Calculate scaffold degradation rate to match bone tissue formation, by weighing before implantation and tracking mass loss over time.







Methods and Characterization



[1]ADMET eXpert 7600 Tensile Test Machine

[2]Light Microscope

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