From Plant Seeds to Bone-Mimetic Scaffolds: QSH Composites for Osteoconductive Applications

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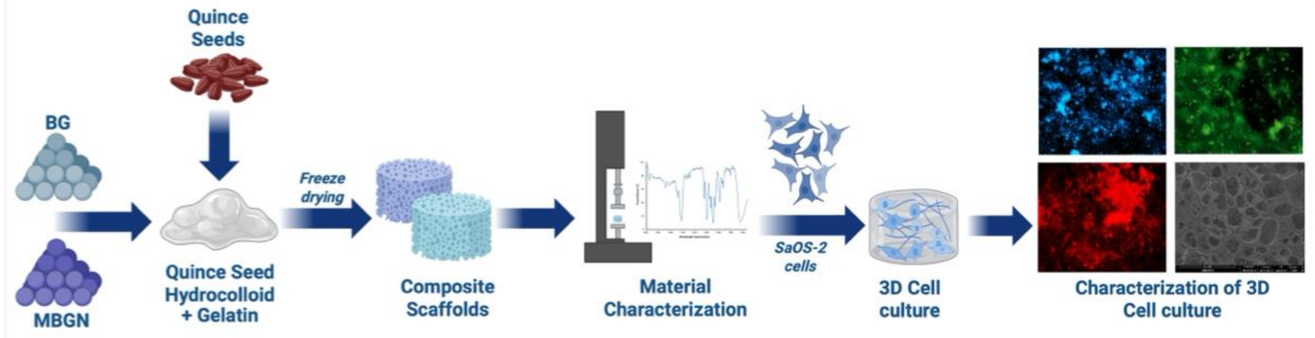
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BACKGROUND & AIM

Natural polysaccharides are increasingly explored in orthoregeneration due to their biocompatibility and tunable physicochemical properties; however, their osteoconductive potential often requires reinforcement with bioactive inorganic phases. **Quince Seed Hydrocolloid (QSH)**, a **plant-derived polysaccharide**, provides a sustainable and biomimetic platform for scaffold fabrication. Here, QSH/Gelatin composites reinforced with either conventional bioactive glass (BG) or mesoporous **bioactive glass nanoparticles (MBGN)** were developed to investigate how bioactive glass architecture influences scaffold performance and mineralized matrix formation.

Aim: To develop and compare QSH-based bioactive composite scaffolds with enhanced osteoconductive and orthoregenerative potential.

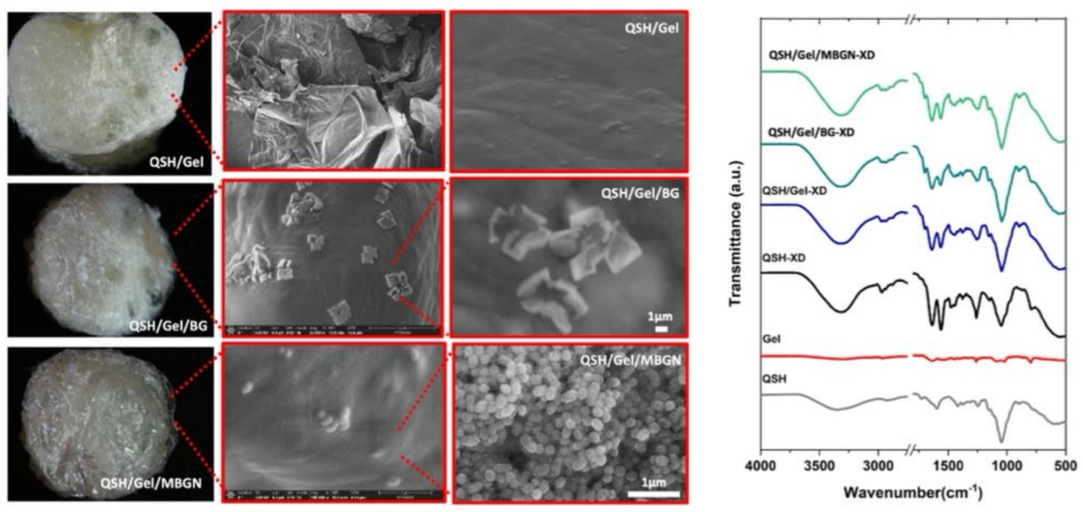
METHOD



*QSH-based composites with BG or MBGN particles were fabricated, characterized, and biologically evaluated to assess their **orthoregenerative** potential.*

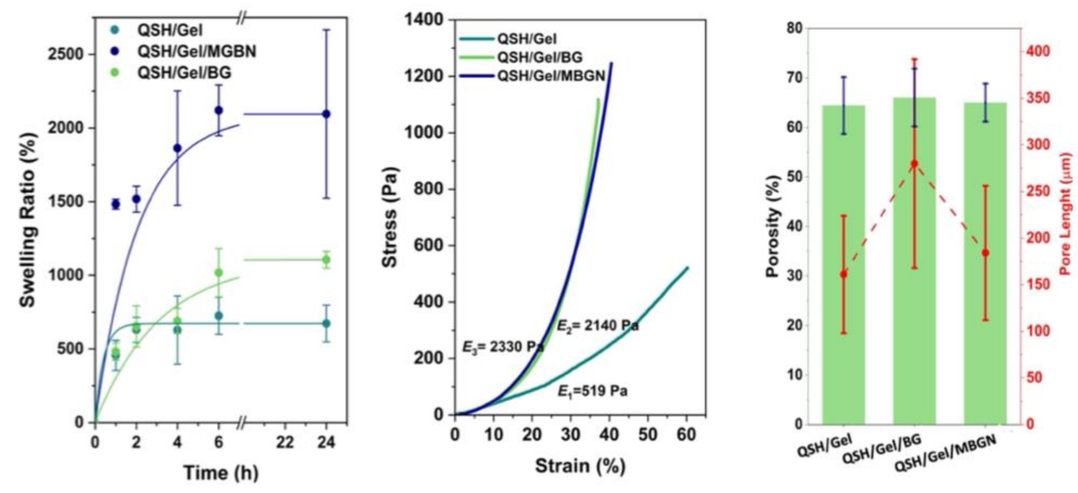
RESULTS : Composite Material Characterizations

Structural and Physicochemical Characterizations



- Porous architectures suitable for orthoregenerative tissue integration were obtained.
- FTIR and SEM–EDX confirmed homogeneous incorporation of bioactive glass phases.
- MBGN reinforcement generated a uniform and biointeractive nano-featured surface.

Physical Properties

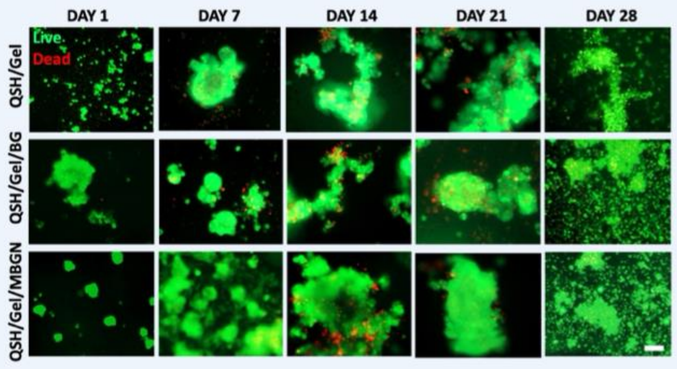


- All scaffolds displayed strong hydrophilicity, supporting fluid exchange and tissue compatibility. Mechanical stability was preserved in all groups.
- MBGN composites showed significantly higher swelling capacity which favors bioactivity.

RESULTS : Biological Performance & Osteoconduction

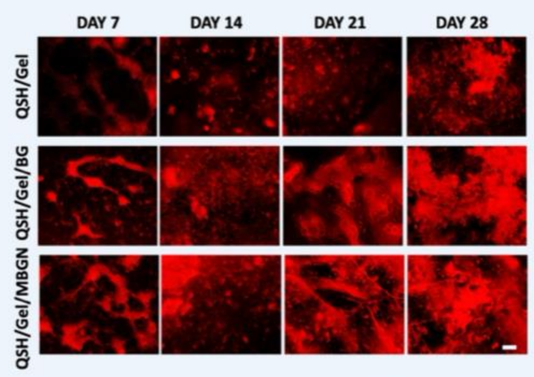
MBGN reinforcement shifts QSH scaffolds from bioactive materials to true orthoregenerative platforms.

Assessment of Cell Viability : Live/Dead Assay



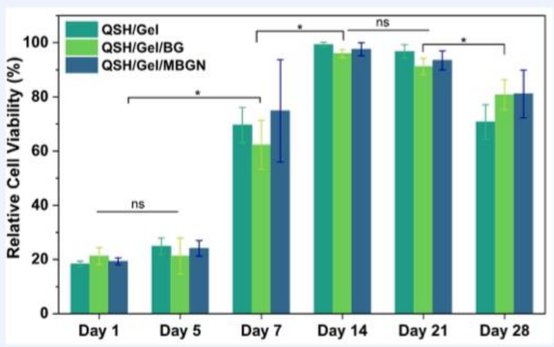
- High cell viability and stable attachment were maintained in all groups.
- Metabolic activity increased over time, indicating sustained cellular proliferation.
- MBGN scaffolds supported enhanced long-term cellular performance.

Matrix Mineralization Revealed by Alizarin Red Staining

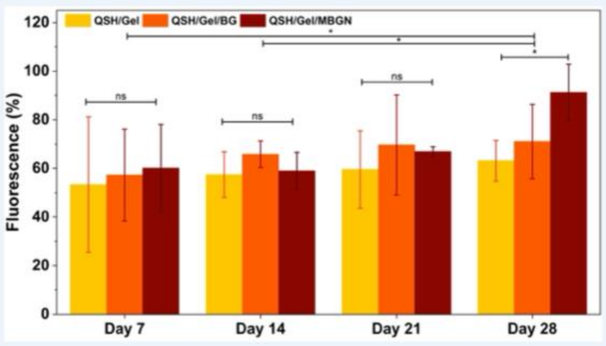


- Mineral deposition progressively increased throughout culture.
- **MBGN** scaffolds exhibited the **strongest mineralized matrix formation**.

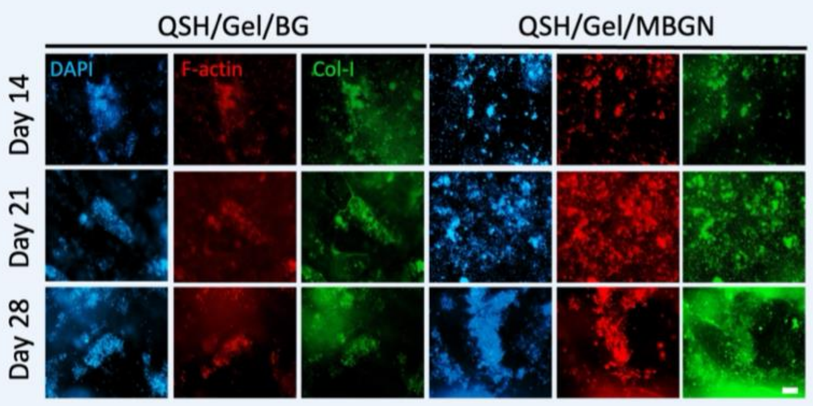
Assessment of Cell Proliferation : Alamar Blue Assay



Fluorescence Analysis of Matrix Mineralization

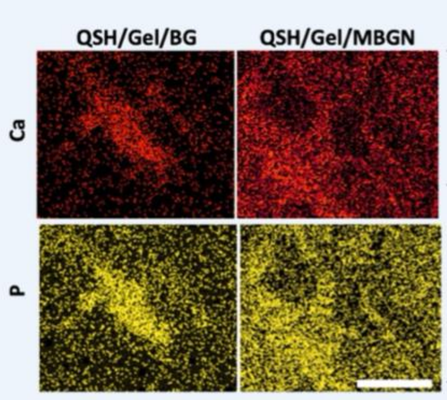


Cell–Matrix Organization Revealed by Immunofluorescence



- Organized cytoskeletal structure and collagen deposition confirmed strong cell–matrix interaction.
- Results indicate formation of a favorable osteoconductive microenvironment.

EDX Elemental Mapping of Cellularized Scaffold Composition



Mineral Deposition (% Atomic)	Samples	
	QSH/Gel/BG	QSH/Gel/MBGN
Ca	60.03	71.67
P	39.97	28.33
Ca/P	1.50	**2.53**

- Calcium–phosphate accumulation confirmed mineralized matrix formation.
- **Higher Ca/P ratios in MBGN scaffolds** indicate improved orthoregenerative potential.

CONCLUSION

- QSH-based composite scaffolds supported cellular activity and matrix organization relevant to orthoregeneration.
- Both BG and MBGN promoted osteoconduction; however, MBGN improved swelling behavior and long-term biological performance.
- Enhanced calcium–phosphate deposition confirmed **stronger mineralized matrix formation**.

From **plant-derived hydrogels** to **orthoregenerative** biomaterials: **MBGN** reinforcement drives superior **osteoconduction and mineralized tissue formation.**

TAKE HOME MESSAGE

MBGN-reinforced plant-derived QSH composites create a highly **osteoconductive**, **mineralization-driven microenvironment**, positioning them as promising next-generation scaffolds for orthoregeneration.

ACKNOWLEDGEMENTS

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