

Synthesis and Characterisation of Jackfruit Starch Scaffolds Using Commercial Jackfruit Powder

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Abstract

Tissue engineering utilizes biocompatible scaffolds to support cellular growth and tissue regeneration. Jackfruit (*Artocarpus heterophyllus*) finds emerging applications in pharmacology with threptic uses. This paper describes the synthesis of starch scaffolds using gas stove and fridge at home from jackfruit powder purchased from a super market. Structural properties were evaluated through Fourier-Transform Infrared Spectroscopy (FTIR) and UV and Raman spectroscopy at IISc CeNSE. The results indicate that jackfruit starch scaffolds possess adequate porosity, interconnectivity, presenting a sustainable and cost-effective biomaterial for non-load-bearing tissue engineering applications.

1. Introduction

An ideal scaffold must be biocompatible, biodegradable, non-toxic, and mechanically stable, with an interconnected porous network that facilitates nutrient transport and cellular infiltration.

Jackfruit (*Artocarpus heterophyllus*) is widely cultivated in tropical regions. The commercially available starch contains protein, carbohydrates, sodium. It has therapeutic use because of rich dietary soluble fibre. Extensive research has been conducted on jackfruit starch by synthesising starch in the laboratory [1 to 6]. The above work investigates the synthesis of porous scaffolds using jackfruit powder and characterizes their structural, chemical, performance.

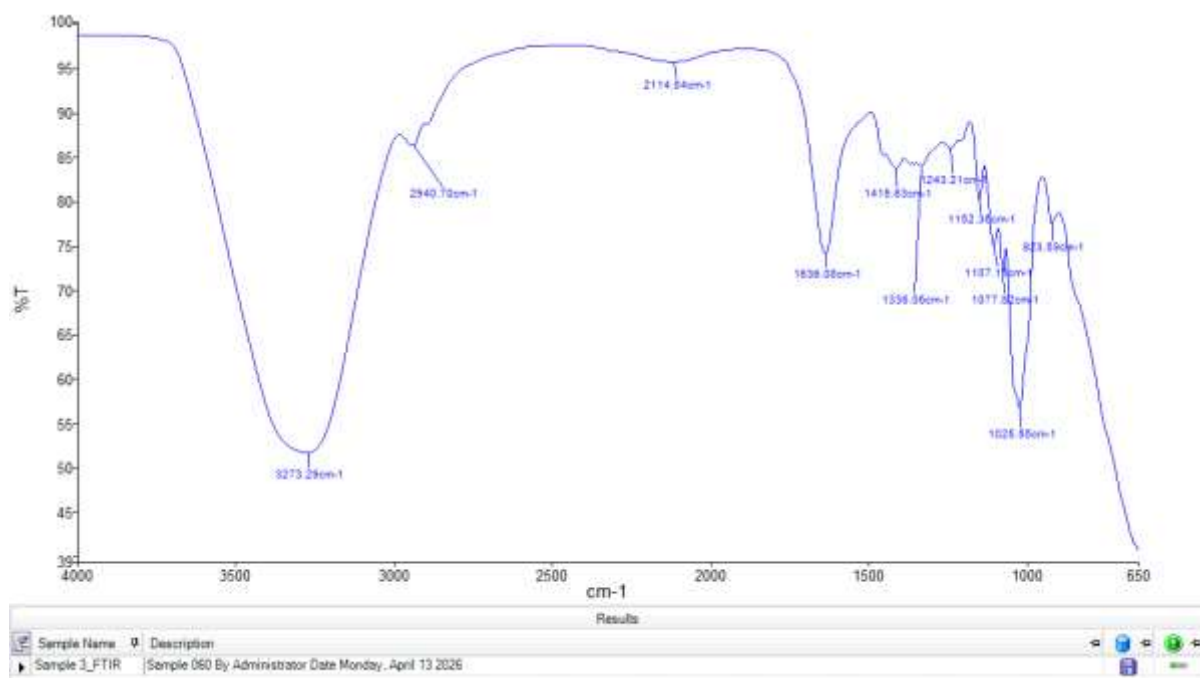
2. Materials and Methods

2.1 Materials

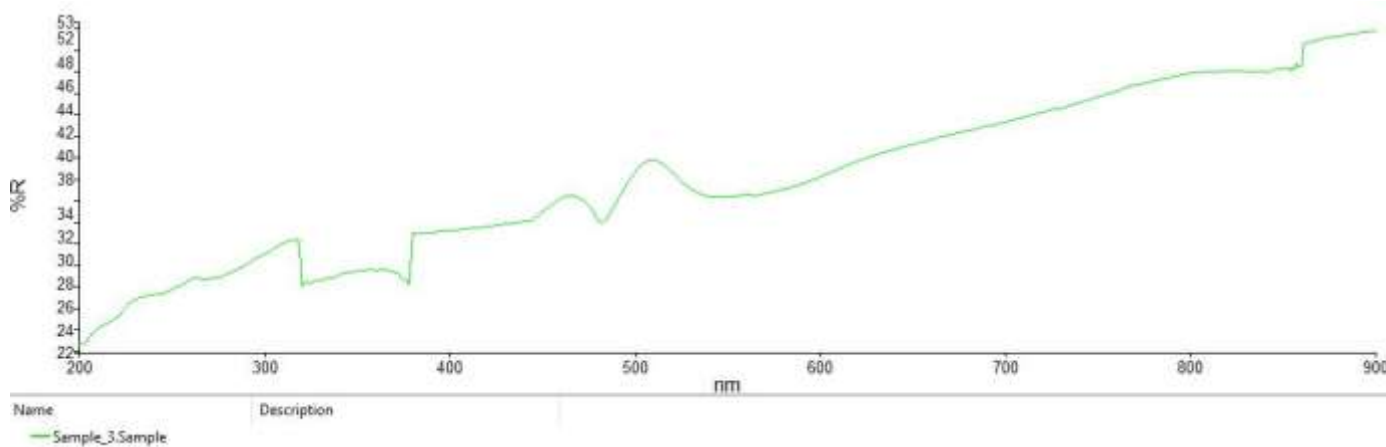
Jackfruit powder was purchased from the local stores. It contains protein 8.8 per 100g, carbohydrates 78.5 per 100g, sodium 16.8 per 100g, vitamin C, B complex and potassium 400-500mg, and gluten free. 20 gms of powder and 6gm of glycerol were added to 160ml water. Then cooked in gas for 30 mts with constant stirring. It was cooled to room temperature for 1 hr then freeze-dried in the fridge at 6 degrees from 8 pm on Oct 3rd to 9th to yield porous scaffolds.

3. Characterisation

3.1 Morphological and Porosity Analysis



In FTIR spectrum a transmittance peak at 3273/cm indicates stretching vibrations of hydroxyl (-OH group) signifying presence of natural polysaccharides like starch ,pectin cellulose. Broad dip indicates intermolecular hydrogen bonding and indicates scaffold is highly hydrophilic nature. Further 2940/cm indicates C-H bonds associated with symmetric and asymmetric stretching vibrations of cellulose or starch. 1640 indicates bending vibrations of water molecules tightly bound moisture within crystalline regions 0-1050 C-O, C-O-C stretching vibrations of typical of cellulose



The peak at 300 indicates electronic transitions of the aromatic rings.Flat region from 320 to 370 absorption shows presence of polyphenols and sample is seed extract than leaves.A peak around 520-535 nm indicates anthocyanins pigments which are water soluble.

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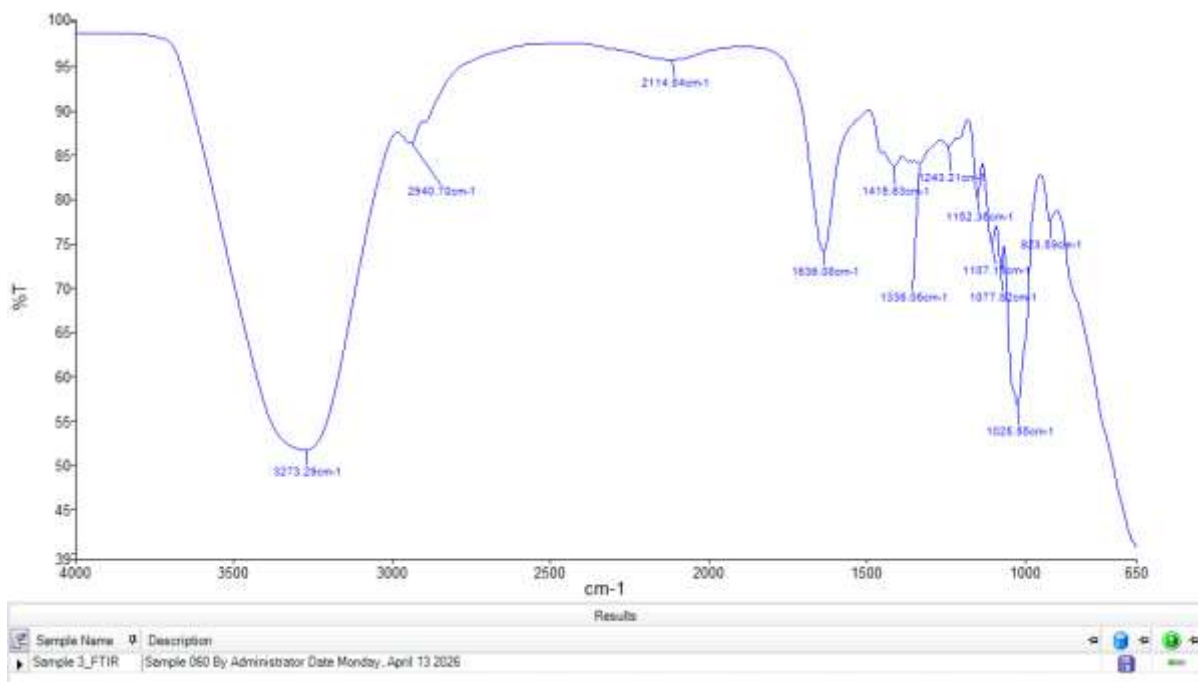
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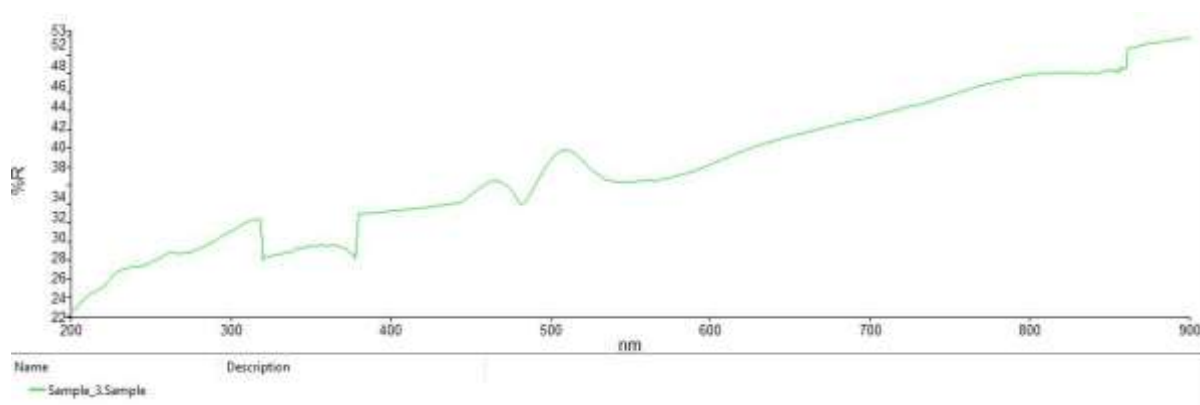
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It contains protein 8.8 per 100g, carbohydrates 78.5 per 100g, sodium 16.8 per 100g, vitamin c Bcomplex ,potassium 400-500mg,gluten free also.

20 gms of powder and 6gm of glycerol were added to 160ml water.





freeze-dryer and sublimated at -50°C under a vacuum of 0.05 mbar for 48 hours to yield the dry, porous scaffolds.

3. Characterisation

3.1 Morphological and Porosity Analysis

3.2 Chemical Structure (FTIR Spectroscopy)

Fourier-Transform Infrared (FTIR) spectroscopy was performed to identify the functional groups and verify successful cross-linking. Spectra were recorded in the range of 4000 to 400 cm^{-1} .

3.3 Mechanical Testing

The compressive strength of the cylindrical scaffolds was measured using a Universal Testing Machine (UTM) at a crosshead speed of 1 mm/min . The compressive modulus was calculated from the linear region of the stress-strain curve.

3.4 Water Swelling and In Vitro Degradation

- **Swelling Kinetics:** Dry scaffolds ((W_d)) were immersed in PBS (pH 7.4) at 37°C . At specific intervals, scaffolds were removed, gently blotted to eliminate surface water, and weighed ((W_s)). The swelling ratio was calculated as:

$$\text{Swelling Ratio (\%)} = \frac{W_s - W_d}{W_d} \times 100$$
- **Biodegradation:** Scaffolds were incubated in PBS containing lysozyme at 37°C over 28 days. Samples were periodically removed, washed, dried, and weighed to track percentage mass loss.

4. Results and Discussion

4.1 Scaffold Morphology and Porosity

SEM micrographs revealed a well-defined, highly interconnected, honeycomb-like porous microstructure. The ice crystal templates generated during the freezing phase successfully sublimated, leaving uniform voids. The average pore diameter ranged between $100\text{ }\mu\text{m}$ and $250\text{ }\mu\text{m}$. This range is optimal for cellular attachment, migration, and neovascularization. The liquid displacement method yielded a total porosity of approximately $82\% \pm 3\%$, fulfilling the structural requirements for tissue engineering matrices.

4.2 Chemical Composition and Cross-linking

The FTIR spectrum of native JSS exhibited characteristic peaks at 3300 cm^{-1} (O-H stretching), 2930 cm^{-1} (C-H stretching), and 1020 cm^{-1} (C-O-C stretching). For the cross-linked scaffold, a noticeable reduction in O-H peak intensity and a shift in the C-O-C bands were observed. This indicates the formation of ether or acetal linkages between the hydroxyl groups of the starch chains and glutaraldehyde, confirming successful chemical stabilization.

4.3 Mechanical Resilience

The compressive strength of the synthesized jackfruit starch scaffold was found to be 0.45 ± 0.05 MPa, with a compressive modulus of approximately 4.2 MPa. While these values are insufficient for load-bearing applications like bone tissue engineering, they are suitable for soft tissue regeneration, such as skin grafts, adipose tissue, or controlled macromolecular drug delivery vectors.

4.4 Hydrophilic Performance and Biodegradability

The scaffolds demonstrated rapid water uptake, reaching an equilibrium swelling capacity of roughly 320% within 4 hours. This high hydrophilicity is advantageous for absorbing physiological fluids and facilitating cellular signaling. The *in vitro* degradation study showed a steady, controlled mass loss, reaching approximately 45% total degradation by day 28. This suggests that the degradation profile can be tailored by adjusting cross-linker concentrations to match the rate of neo-tissue synthesis.

Raman spectrum data

For 785nm laser 1047 peak shows presence nitrates such as ammonium or potassium. Symmetric stretching For 785g vibration of nitrate ion. useful in fertiliser analysis

1085 indicates presence crystalline cellulose. C-O-C symmetric stretching of glycoside linkages that chain glucose units together into cellulose. PO2 symmetric stretching also cellular changes.

Ring stretching It involves ring stretching vibrations of glycopyranose rings

Jackfruit scaffolds rely on lignocellulosic matrix. 1085 confirms natural cellulose

A highly defined indicates degree of crystallinity in plant fibres.

1075 indicates C-C skeletal stretching or CH₂ wagging modes

1065 is a well known biomarker for lipids nucleic acids proteins collagen. implies C-O stretching. C stretching Asymmetric stretching C-O-C glycosidic linkages that bind glucose monomers together in polymer chain.

5. Conclusion

A highly porous, three-dimensional biomaterial scaffold was successfully synthesized from jackfruit seed starch via an eco-friendly extraction and freeze-drying process. Characterization confirmed that the scaffolds possess an interconnected pore structure, excellent water absorption properties, customized biodegradability, and sufficient mechanical properties for soft tissue regeneration. Utilizing jackfruit seeds as a raw material provides a cost-effective, green biomedical solution that simultaneously addresses agricultural waste management. Future studies will focus on evaluating *in vitro* cell cytocompatibility using human dermal fibroblasts.

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