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Optimizing Pectin-Stabilized Albumin-Based Foams for Enhanced Support Bath Stability in In-Foam Embedded Bioprinting

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ABSTRACT

Embedded bioprinting permits complex geometries to be produced by printing bioinks directly into a reservoir containing a supporting matrix material. This technique typically uses viscoplastic gel suspensions as the supporting material which has several limitations, most notably poor nutrient delivery and oxygenation to the cells being printed. To overcome these challenges, our group has developed an in-foam bioprinting technique, wherein a nutrient enriched albumin-based foam is used as the supporting matrix. The foam used in this technique however lacks stability and degrades rapidly, limiting its application for longer prints. In this study, the addition of pectin is used to stabilize the foam support. The foam was prepared by dissolving albumin and pectin powders in either DI water or cell culture media and mechanically mixing at 2000 rpm for 2 minutes. Three compositions were studied: 8% w/v albumin (Alb8), 8% w/v albumin with 1% w/v pectin (Alb8Pec1) and 8% w/v albumin with 2% w/v pectin (Alb8Pec2). A rheometer with concentric cylinder geometry was used to perform rheological characterizations of the foam. A 2% w/v chitosan hydrogel was used for printability studies and was embedded with L929 fibroblasts for cell studies. The cell-laden bioink was extrusion bioprinted into the different foams as well as a traditional gelatin microparticle support bath. Cell viability was measured through live/dead assays using calcein and ethidium homodimer-1 to stain the live and dead cells respectively.

Increasing pectin concentration increases foam stability in terms of delaying bubble coalescence and liquid drainage. The foams containing pectin maintained the important rheological properties that are required by support baths such as shear thinning behavior and recovery properties. Low viscosity and slow crosslinking chitosan hydrogels were printed into the foam with excellent printability. The samples printed in the foams containing pectin exhibited higher cell viability compared to those printed in albumin-only foam. When compared to a traditional gelatin microparticle support bath, in-foam bioprinting had higher cell viability when cell-encapsulated constructs were left in the supports for 3 and 5 hours. Cell-laden constructs printed in Alb8Pec1 exhibited the highest cell viability showing an improvement from both Alb8 and traditional gelatin-based supports.

Pectin increases foam stability, maintains good support bath properties and allows for higher cell viability compared to traditional embedded bioprinting techniques, such as gelatin microparticles. These results suggest that in-foam bioprinting has a promising future in the development of tissue constructs that are currently unattainable with existing technologies.