

Innovative food-grade bioinks: different applications of natural polymers in 3D bioprinting

M.C.Evangelisti^{1*}, F.Luzi¹, A. Duménigo González², S. Greco^{2,3}, P. Ciarmela², A.Mazzoli¹

¹ Department of Science and Engineering of Matter, Environment and Urban Planning (SIMAU), Università Politecnica delle Marche, UdR INSTM, Via Brecce Bianche, 60131 Ancona, Italy

² Department of Experimental and Clinical Medicine, Università Politecnica delle Marche, Ancona, Italy

³ Link Campus University, Department of Life, Health and Health Professions Sciences, Rome, Italy

***Corresponding:** m.c.evangelisti@pm.univpm.it

3D bioprinting has become the most powerful means for developing physiologically relevant models for tissue engineering, disease modeling, and regenerative medicine. The selection of bioinks that replicate tissue-specific characteristics and mimic the appropriate native cellular environment is a key factor in this process. This work explores the versatility of natural polymers, such as sodium alginate and gelatin, focusing on the use of food-grade materials as a strategy to produce biocompatible and high-performing scaffolds while drastically reducing production costs.

We present different applications of these lab-formulated natural matrices. In the field of disease modeling, a perfectly transparent hydrogel composed of 2.5% sodium alginate and 0.5% gelatin was developed and validated using human uterine leiomyoma cells. This formulation successfully supported cell survival, self-organization into compact spheroids, and typical extracellular matrix deposition. Its optical properties allowed for the direct evaluation of cellular behavior and treatments via optical microscopy and immunohistochemistry. Furthermore, sodium alginate was also combined with crystalline nanocellulose to produce a specialized matrix replicating cartilage tissue, specifically designed for the 3D bioprinting of an external auricular pinna.

This approach not only ensures excellent quality in terms of cell compatibility and mechanical parameters but also aligns with the 3Rs principles by offering valid animal-free alternatives. Our findings confirm that food-grade natural polymers are a robust and sustainable tool for diverse biofabrication needs.

Keywords: 3D bioprinting, bioink, tissue engineering, sodium alginate, gelatin, nanocellulose, spheroids.