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Sea Urchins Waste Valorization: Functional Collagen-based Biomaterials for Skin Regeneration

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Abstract

In the framework of the modern societal challenges, the principles of circular economy concern designing out waste, regenerating ecosystems and keeping items in use. In relation to these waste recycling and valorization pillars, our projects aim at developing innovative and eco-friendly collagen-based composite biomaterials to be used for skin regeneration from a food by-product, sea urchins wastes. In particular, collagen - in its native form - was obtained from part of the sea urchins waste, named peristomial membrane (surrounding the mouth of the animal). The remaining carbonatic matrix, constituted by tests and spines, was then employed to extract and isolate polyhydroxynaphtoquinones, a class of small polyphenols characterized by potent antioxidant activities (Di Benedetto et al., 2014, Marzorati et al., 2021). Collagen and antioxidants were then combined to obtain functional biocomposite materials, in which the structural properties of collagen fibrils are integrated with antioxidant additional features in order to promote skin regeneration. Composite biomaterials were characterized in terms of morphology, mechanical properties, degradation kinetics, polyphenols kinetics of release and antioxidant activity. Scanning Electron Microscopy indicated that composite biomaterials were morphologically similar to the simple collagen-based counterpart, with homogeneous fibrils organization pattern in the absence of undesired aggregates. Porosity was confirmed to be ideal for cells infiltration, settlement and growth. Surprisingly, polyphenols kinetics of release pointed out that polyhydroxynaphtoquinones antioxidants remained adsorbed onto the matrix of biomaterial, without any significant release. This aspect was investigated also *in silico* by using Tight Binding Molecular Dynamics. Some of the representative constituents of such systems, in particular a couple of glycine-arginine-aspartic acid tripeptides and the most abundant polyhydroxynaphtoquinone present in the extract, were simulated in presence of water as a solvent and a quite strong bond was found, explaining the stability of these compounds. Subsequently, the antioxidant activity of composite biomaterials was evaluated using ABTS assay directly on the solid composite materials. Results confirmed

that a strong antioxidant activity was maintained on the collagen-based scaffold, after freeze-drying even without any antioxidants release in solution. Overall these data indicate that sea urchin wastes can be profitably exploited to obtain valuable molecules and develop innovative biomimetic and bioactive biomaterials, potentially effective in the promotion of tissue regeneration. As a future perspective, 3D bioprinting will be selected as modern technology to produce collagen-based biomaterials with enhanced mechanical properties, tunable morphologies and personalized scaffold shapes.

Keywords: Sea Urchins Waste; Collagen; Antioxidant; Regenerative Medicine

References

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