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Bioflavonoids Derived from Mandarin Processing Wastes: Functional Hydrogels as a Sustainable Food Systems

Authors : Niharika Kaushal, Minni Singh

Abstract : Fruit crops are widely cultivated throughout the World, with citrus being one of the most common. Mandarins, oranges, grapefruits, lemons, and limes are among the most frequently grown varieties. Citrus cultivars are industrially processed into juice, resulting in approx. 25-40% by wt. of biomass in the form of peels and seeds, generally considered as waste. In consequence, a significant amount of this nutraceutical-enriched biomass goes to waste, which, if utilized wisely, could revolutionize the functional food industry, as this biomass possesses a wide range of bioactive compounds, mainly within the class of polyphenols and terpenoids, making them an abundant source of functional bioactive. Mandarin is a potential source of bioflavonoids with putative antioxidative properties, and its potential application for developing value-added products is obvious. In this study, 'kinnow' mandarin (Citrus nobilis X Citrus deliciosa) biomass was studied for its flavonoid profile. For this, dried and pulverized peels were subjected to green and sustainable extraction techniques, namely, supercritical fluid extraction carried out under conditions pressure: 330 bar, temperature: 40˚ C and co-solvent: 10% ethanol. The obtained extract was observed to contain 47.3±1.06 mg/ml rutin equivalents as total flavonoids. Mass spectral analysis revealed the prevalence of polymethoxyflavones (PMFs), chiefly tangeretin and nobiletin. Furthermore, the antioxidant potential was analyzed by the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method, which was estimated to be at an IC_{50} of 0.55µg/ml. The pre-systemic metabolism of flavonoids limits their functionality, as was observed in this study through in vitro gastrointestinal studies where nearly 50.0% of the flavonoids were degraded within 2 hours of gastric exposure. We proposed nanoencapsulation as a means to overcome this problem, and flavonoids-laden polylactic-co-glycolic acid (PLGA) nano encapsulates were bioengineered using solvent evaporation method, and these were furnished to a particle size between 200-250nm, which exhibited protection of flavonoids in the gastric environment, allowing only 20% to be released in 2h. A further step involved impregnating the nano encapsulates within alginate hydrogels which were fabricated by ionic cross-linking, which would act as delivery vehicles within the gastrointestinal (GI) tract. As a result, 100% protection was achieved from the pre-systemic release of bioflavonoids. These alginate hydrogels had key significant features, i.e., less porosity of nearly 20.0%, and Cryo-SEM (Cryo-scanning electron microscopy) images of the composite corroborate the packing ability of the alginate hydrogel. As a result of this work, it is concluded that the waste can be used to develop functional biomaterials while retaining the functionality of the bioactive itself.

Keywords : bioflavonoids, gastrointestinal, hydrogels, mandarins
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