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"Waste a second!" Novel Use of Food Waste for the Development of Advanced Nanomaterials

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Abstract

Since ancient times, humankind has exploited the diversity of plant life for a wide range of applications, including food, textile manufacturing, and the treatment of various diseases. However, among millions of tons of generated biomass, nowadays agriculture and health food industries face waste management and disposal issues worldwide (Santana-Méridas et al., 2012). In this context, the potential recirculation of wasted biomass is one of the major challenges for the scientific community exploiting their potential to be transformed into added-value products with biological and industrial significance (Tuck et al., 2012). Among wasted biomass, polymeric materials derived from natural and sustainable resources, have garnered particular attention due to their inherent biocompatibility, strong stabilizing activity, and abundance. The use of polymers obtained from natural sources offers an ideal platform for the fabrication of advanced materials for medical purposes. For example, protein-based nanostructures have found numerous applications in tissue engineering and drug delivery owing to their excellent biocompatibility and biodegradability. The presence of functional groups (such as amine, carboxyl, hydroxyl, and phenolics) within the protein structure provides inherent advantages over polysaccharides, which often require chemical modifications to form stable nanostructures (Abakumov et al., 2018). In our research, different food waste sources were employed to explore novel possibilities for the fabrication of nanomaterials with potential biomedical and industrial applications. Specifically, Cucurbita pepo L. (pumpkin) seeds waste and Serenoa repens (saw palmetto) fruits waste were utilized as sources of polysaccharides, proteins, and long-chain fatty acids. Purple corn cobs and unripe tomato fruits and leaves have been used as a source of bioactive molecules such as anthocyanins and tomatine, respectively. Nanoformulations were produced through simple, mild, scalable, and cost-effective procedures capable of generating advanced materials with strong activity, thanks to the combination of bioactive molecules stabilized and delivered by biogenic macromolecules. The obtained nanomaterials morphologies and dimensions were investigated through Transmission and Scanning Electron Microscopy (TEM, SEM) and Dynamic Light Scattering (DLS), confirming their nanometric size and spherical shape. Finally, biological investigations have revealed enhanced activity facilitated by the presence of the nanocarrier, which enhances the bioavailability of the active agents protecting them from degradation and hence improving the lifespan of the formulations.

Keywords: Nanomaterial, Delivery system, Proteins, Polysaccharides

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