Technologies for the development of health products based on up-cycling of agro-food by-products

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The agro-industrial processing produces large volumes of wastes and by-products. In recent years, wastes and by-products have attracted attention as an excellent renewable source of active compounds with beneficial effects for the human health. However, in that respect a substantial amount of research and complex processes of extraction, characterization and technological transformation are necessary for an efficient use of by-products with the purpose to develop stable and bioactive ingredients for pharmaceutical, food, and nutraceutical products. The main problems for an efficient use are that plant by-products and wastes may be sticky materials, have penetrating smell and unpleasant taste, show critical water solubility and dramatic stability behaviour over time. The present project was aimed to contribute to the zero waste society and country designing and developing new bioactive polymeric particle systems and edible films containing extracts obtained from agro-food wastes and by-products.

In particular, the PhD program involved:

- Selection of wastes/by-products from Campania agro-industries;
- Production, chemical and biological characterization of the extracts from selected wastes/by-products: I) hazelnut shells (HSE), II) hazelnut skins (RHS-H) and III) chestnut spiny burs (CSB-H) polar extracts.
- Design, development, technological and biological characterization of new polymeric microparticle systems loaded with HSE.
- Design, development and characterization of active edible films loaded with RHS-H and CSB-H and evaluation of their functional efficacy.

Polyphenol-rich extracts (HSE, CSB-H, and RHS-H) were produced by exhaustive maceration and Pressurized Liquid Extraction (PLE) from the wastes. The quali/quantitative analysis of the extracts was carried out by chromatographic (Sephadex LH-20, RP-HPLC-DAD, HPLC-HRMS) and spectroscopic techniques (NMR).

With the aim to overcome stability and bioavailability problems, new microparticulate powders loaded with the antioxidant and chemopreventive raw HSE extract were produced by spray drying. Pre-formulation studies allowed to select the appropriate multipolymeric matrix composed of coating polymers and loading carriers (proline, medium viscosity hydroxyethyl cellulose, and pectin). The influence of instrumental and operating (temperature, air and fluid flow, pressure, nozzle diameter liquid feed viscosity and pH) process conditions on yield and encapsulation efficiency was evaluated. The produced engineered particles were characterized in terms of active HSE loading (HPLC-DAD), particles dimension (Laser Light Scattering), morphology (SEM and FM), thermal behavior (DSC), water dissolution release (USP II), preservation of bioactivity (DPPH test, MTT assay) and stability under harsh storage conditions (ICH-Guide Lines). The developed HSE particle system is water-soluble, easy handling and functional powder that can be used in topical or oral dosage forms, as adjuvant in the treatment or prevention of melanoma and cervical cancers.

CSB-H and RHS-H with antioxidant and antimicrobial activity were used to design an edible pullulan-based films by Casting technique. The effect of extracts on the film mechanical properties, thickness, infrared spectroscopy characteristics (FTIR-ATR), optical properties (UV-Vis transmittance), and biological activity was studied. The developed CSB-H and RHS-H films are shown to be an interesting tool to extend foodstuffs shelf life, being able to protect from the influence of external environmental and biotic factors (oxidative processes and microorganism spoilage).