Doctoral Dissertation
Doctoral Program in Chemical Engineering (34th Cycle)

Valorization of rice and canned tuna processing wastes: a focus on green extraction techniques

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With the continuous growth of the world population, the demand for food and processed food is constantly increasing. To satisfy the global food needs the planet's resources are being overexploited, and in a period in which climate change threatens all ecosystems, it is no longer environmentally, economically, and ethically sustainable. In 2015, the United Nations defined the Sustainable Development Goal 12.3, which states: "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses". This goal demonstrates that governments, academia, and industries must be engaged in finding new solutions to the food waste problem. Food processing is one of the steps in the food supply chain that generates the most significant amount of waste. Around 30 Mt of food wastes are produced yearly in the European Union during several food manufactory processes. These wastes present a high level of homogeneity and an elevated content of bioactive compounds, representing the most suitable candidate for the extraction of high added-value products. Rice and canned tuna are two of the globally most consumed food and their supply chain generates a considerable amount of waste. These wastes are usually disposed or used to produce animal food, but they are still rich in valuable proteins, lipids, antioxidant molecules that can be used in the food and pharmaceutical contexts. The aim of this thesis is to investigate innovative green extraction techniques aimed at extracting functional products from rice and canned tuna processing waste within the framework of circular economy. In particular, this work focused on rice bran and tuna viscera, both by-products of food processing.

Rice bran, generated during the rice milling process, is rich in oil and γ-oryzanol, an antioxidant group of molecules that make this oil highly requested on the market. Rice bran oil was extracted through three different green techniques: isopropanol solvent extraction, ultrasound-assisted extraction and supercritical CO_2 extraction. Results demonstrated that isopropanol is a green solvent suitable for extracting a γ-oryzanol-rich rice bran oil and that ultrasound-assisted extraction allows obtaining a

high yield, operating at room temperature in one minute of extraction. This process is sustainable from an economic and environmental point of view. Moreover, the rice bran oil supercritical CO_2 extraction was optimized through a design of experiments, obtaining a product with a good quality fatty acid composition, suitable for food applications.

Tuna viscera is a by-product wasted during the canning process. This waste is still very precious, due to its lipid and protein profile. Tuna viscera was valorized by an enzymatic extraction using Alcalase as enzyme, obtaining an oil rich in omega-3 fatty acids and a fish protein hydrolysate composed of antioxidant peptides. The extraction was optimized using a design of experiments. Results showed that in one hour of extraction and at mild temperature and pH conditions is possible to obtain the maximum product yields without applying toxic solvents. A life cycle analysis suggested that the duration of the extraction is the factor that most influences the environmental impact and that further studies are needed to minimize it.

Although the techniques herein applied must be tested on a larger scale, this study represents a first but promising step in the research aimed at finding processes even more environmentally and economically sustainable. Rice bran and tuna liver showed a great potential to be exploited through green extraction techniques maximizing the bioresource efficiency, the reduction of environmental pollution and developing new and attractive products.

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