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Valorisation of lignocellulosic wastes for environmental applications. The NIRALIG project

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Introduction

The high production of wastes generated in the Valencian agricultural sector, particularly during rice and tiger nut harvesting, and the new legislative restrictions proposed in the EU to get adequate disposal practices, generate the need to develop new strategies for the recovery of these lignocellulosic wastes. Lignocellulosic biomass is one of the most abundant renewable resources on the planet and is considered a first-rate raw material for "green chemistry". It has been proposed to obtain liquid fuels or for the development of bio-based materials for different sectors, such as the agro-food, cosmetic, chemical or pharmaceutical; following a circular economy strategy. In this context, the main goal of the NIRALIG project is the development of intelligent and multifunctional systems in biopolymeric matrices extracted from rice and tiger nut crop residues with the addition of nanomaterials obtained from the said lignocellulosic residues. This project runs from November 2022 to July 2025 and will result in the design, processing, characterization and validation of advanced biomaterials with specific functionalities. Among them, smart materials for their use in natural and agricultural environments stand out, since they are able to modify their shape, size or functional properties under certain stimuli such as the presence of chemical compounds, pH, temperature, light, etc. These outstanding properties make them ideal to be applied in the agricultural sector, both in the soil and in the control of pollution in irrigation water. In this way, it is possible to add value to these materials, improving post-harvest treatments and at the same time providing solutions to environmental problems that affect crops, such as the need to control the release of biofertilizers in the soil or the adsorption of heavy metals in irrigation water, to prevent them from reaching the plants and being absorbed by them.

Experimental

Rice and tiger nut wastes were characterized by following AOAC and TAPPI official methods. Key parameters such as ash, fat, protein and moisture contents were determined. Microwave (MAE) and ultrasound-assisted (UAE) sustainable extraction methods were used to optimize polyphenols extraction. The use of ionic liquids (ILs) and natural deep eutectic solvents (NADES) was considered as green solvents. The influence of experimental MAE and UAE factors on total phenolic content (TPC), antioxidant activity (ABTS) and extraction yield in the obtained extracts

was evaluated. Phenolic profile of these extracts was also obtained by HPLC-DAD/MS. Greener protocols were also optimized by MAE for cellulose extraction and cellulose nanocrystals (CNC) synthesis compared to the conventional ones in terms of yield and crystallinity. Finally, preliminary tests on lignin extraction by MAE were also performed.

Results and Discussion

MAE and UAE showed good performance in extracting valuable chemicals from tiger nut and rice harvesting wastes. A complete monosaccharides profile for tiger nut residues was obtained with glucose and xylose as the main sugars present in their composition. In addition, methyl oleate was the main fat present in this plant waste. MAE showed higher results in terms of TPC and antioxidant capacity compared to UAE. Therefore, MAE was selected as the extraction technique to further study the possibilities of ILs and NADES as greener solvents. NADES showed better performance in the extraction and they were selected for further developments in the NIRALIG project. In addition, CNCs obtained by MAE showed a crystallinity index around 75%, reducing extraction time, number of steps and the concentration of reagents.

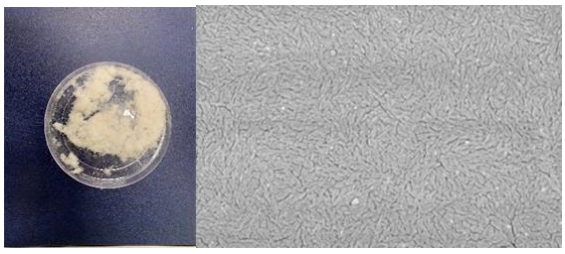

Figure1. Cellulose nanocrystals obtained from tiger nut wastes.

Conclusions

The potential of MAE and UAE techniques for the extraction of bioactives, cellulose and lignin from tiger nut and rice wastes have been demonstrated as a green and fast strategy for the valorisation of these agro-wastes. The functional compounds obtained will be further used in the development of advanced smart nanomaterials with environmental applications, as proposed in the NIRALIG project.

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Biography

Alfonso Jiménez, Chemistry PhD (1996). Full Professor in the University of Alicante (Spain) from 2001. He has participated in 49 research competitive research projects with public financing (35 of them as Principal Investigator), including 6 consecutive national projects and 5 international projects. Editor of 19 books and co-author of 154 research papers with and h index 44. He has been chairman in the 8 editions of the BIOPOL conference series.