Recovery of nanostructured cellulose from agrifood residues

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The exploitation of by-products to recover biologically active compounds, such as polyphenols, antioxidants, proteins, dietary fibers, sugars, and flavors and exploit them for further applications has recently attracted increasing attention. The tomato processing industry represents an interesting case study for enhancing and integrating synergic solutions for waste management, considering that tomato is one of the most widely cultivated vegetable crops in Mediterranean countries. Nowadays, tomato pomace (TP), representing ~3-4% of the fresh processed tomatoes weight, is partially exploited for the extraction of lycopene, or as feedstock for anaerobic digestion to produce biogas. However, TP, consisting of peels, seeds, and fibrous residues, can also be exploited to recover cellulose because it is a good source of complex carbohydrates composing the lignocellulosic plant cell wall (approximately 65%dry basis of TP).
This work proposes a biorefinery approach for the utilization of TP by combining chemical hydrolysis and physical high-pressure homogenization (HPH) treatments, aiming to achieve the isolation of cellulose with tailored morphological properties, along with the valorization of the value-added compounds contained in the biomass. The cellulose extraction efficiency has been evaluated at different combination of chemical and physical processes, i.e. when the HPH treatment is applied directly on the raw material, after the acid hydrolysis and after alkaline hydrolysis. Moreover, the isolated cellulose is deconstructed to obtain cellulose nanoparticles. The size reduction enhances the properties of this polymer: the nanocellulose has low density, higher stiffness, higher tensile strength, transparency and a higher exposition of hydroxyl groups on the surface for functionalization. The chemical and structural features of cellulose isolated from TP with different combination of treatments were analyzed through light scattering for particle size distribution, optical and scanning electron microscopy, and FT-IR analysis. HPH pretreatment at different level not only promoted a slight increase in the yield of cellulose extraction but contributed to directly obtaining defibrillated cellulose particles, characterized by smaller irregular domains containing elongated needle-like fibers. Moreover, the selected mild chemical process produced side streams rich in bioactive molecules, evaluated in terms of total phenols and reducing activity. The liquors recovered from the hydrolysis of TP exhibited a high biological activity.