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Sustainable Packaging from Coffee Silverskin: Development of Cellulose-Based Films

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Introduction

Coffee silverskin (CS) is the thin tegument covering green coffee beans and is one of the main by products of coffee bean roasting. However, CS has a great potential as functional ingredient owing to its chemical composition. In particular, the high content of insoluble dietary fibres (lignin, cellulose and hemicellulose)[1] represents an opportunity for the generation of new materials in the form of stand-alone films and micro- nano-sized fillers in (bio)polymers.
The rECOBIOpack project (https://recobiopack.it/) aims to fully valorise CS, developing a functional packaging material and adding circularity in the coffee value chain.

rECOBIOpack

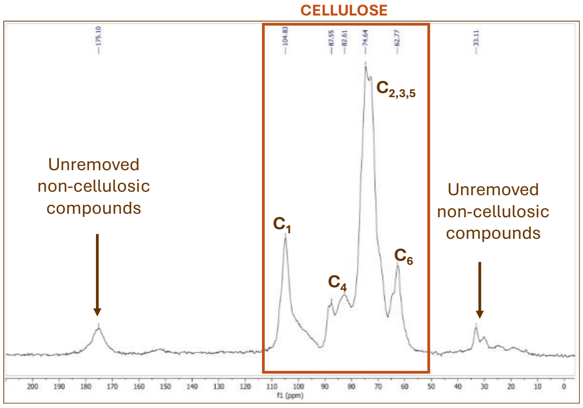

Figure 1: ^{13}C NMR spectra of the purified CS cellulose

Materials/Methods

CS deriving from a mixture of Arabica coffee beans was subjected to supercritical CO_2 (sc-CO_2) extraction at industrial scale (ILSA S.p.A., Arzignano, Italy) to remove the lipidic fraction[2]. Afterwards, the biomass voided of lipids was subjected to two steps of purification for the recovery of cellulose[3]. An alkaline hydrolysis was carried out using 20% NaOH solution to mainly remove hemicellulose. Then, a bleaching step with 1% $NaClO_2$ solution was performed to remove lignin. The obtained cellulose was characterized in terms of yield, morphology (Scanning Electron Microscopy) and purity (Solid-state ^{13}C Nuclear Magnetic Resonance).
Finally, cellulose was dispersed in ultrapure water at different concentrations (0.5%, 1% and 1.5%) and homogenized using a GEA PandaPLUS Lab Homogenizer at 700 bar for 10 cycles. The obtained suspensions were employed for the preparation of cellulose films by solution casting.

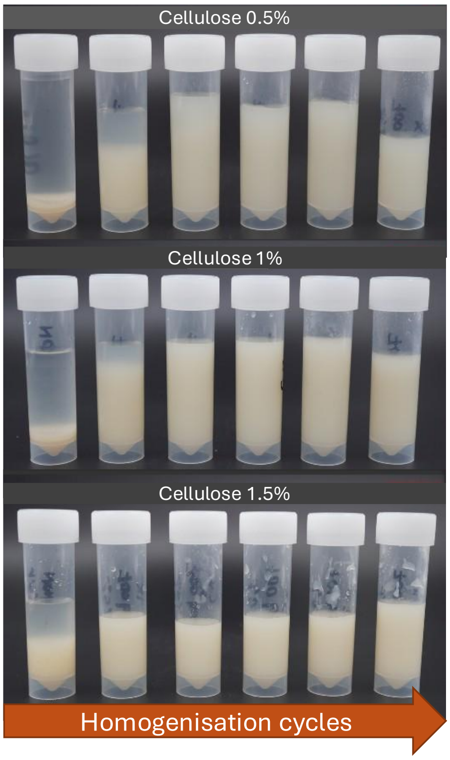

Figure 2: Suspension of cellulose at 0.5%, 1% and 1.5% of cellulose obtained after different cycles of homogenization (from 0 to 10 cycles).

Results/Discussion

8 kg of CS were processed at industrial scale using sc-CO_2 to remove the lipidic fraction. The resulting CS was extracted for the cellulosic fraction.
A yield of 21 ± 4 % was obtained, in line with the results reported in the literature[1]. The ^{13}C NMR analyses still showed traces of hemicellulose and lignin (Figure 1), while microscopy confirms the fibrillar morphology of cellulose.
The suspension of cellulose obtained after the homogenization process (Figure 2) presented an even distribution of microfibrils and resulted stable since no phase separation due to settling or aggregation occurred over time (more than 3 months).
The generated cellulose films exhibited promising properties as packaging material.

Conclusion/Perspectives

This work presents the first efforts in the preparation of cellulose-based films for packaging applications, with the aim of achieving zero-waste valorisation of CS.
Next steps include the incorporation of additives in the films, such as the lipidic extract obtained using sc-CO2 extraction, to improve the performance of the packaging material.

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References:
1. Lina *et al.* 2014. In: Food and Bioprocess Technology 7, 3493.
2. Scapuzzi *et al.* 2025. In: Sustainable Chemistry and Pharmacy, 45, 102001
3. Rovera *et al.* 2023. In: Frontiers in Sustainable Food Systems, 6,1087867