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THERMALLY PROCESSED EGGSHELLS AS A RENEWABLE SOURCE OF CALCIUM CARBONATE FOR INDUSTRIAL USE

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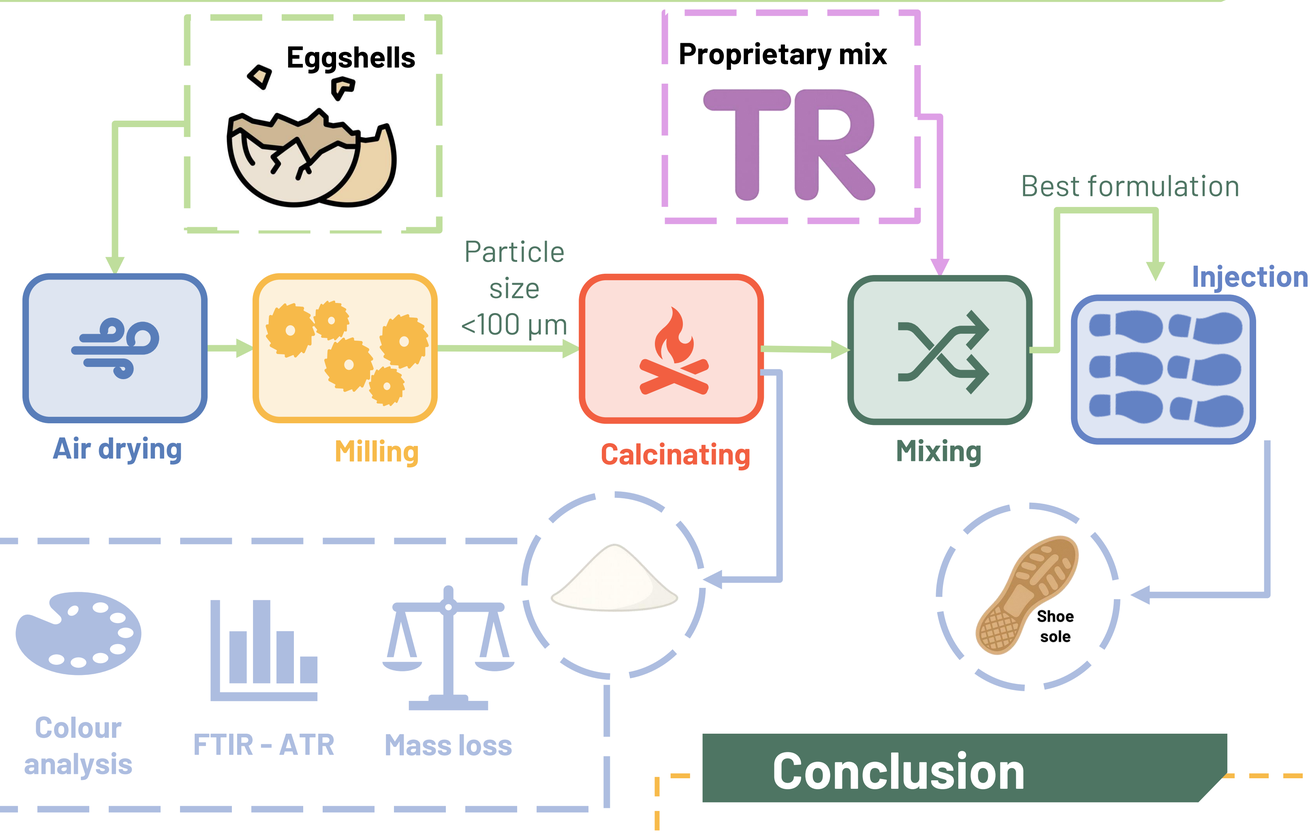
Introduction

Calcium carbonate ($CaCO_3$) is a vital industrial material used extensively in pharmaceuticals, food production, construction, and environmental remediation. Current $CaCO_3$ sourcing methods, primarily reliant on mining limestone and chalk, present significant environmental challenges, including habitat destruction, high energy consumption, and carbon emissions. To address these concerns, this study explores the potential of agrifood waste, specifically eggshells, as a circular and sustainable source of $CaCO_3$. Eggshells, are a rich and readily available biogenic source of $CaCO_3$ thus, exploiting them as an alternative source of $CaCO_3$ can reduce waste production while providing an eco-friendly alternative for the shoemaking industry. However, when considering its incorporation into thermoresistant plastic, like the one used to produce shoe soles, its protein content can represent a limitation to its application, as previous works have shown it to be correlated with non-compliant soles. Thus, the current work exploited the transformation of eggshells into an enriched mineral substrate for incorporation into thermoplastic materials used in the production of shoe soles.

Materials & Methods



Results

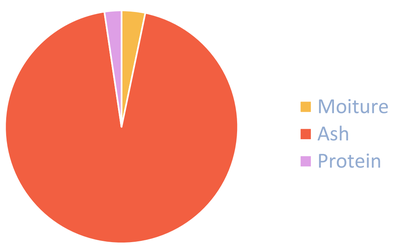


Figure 1. Centesimal composition of the eggshell powder before thermal treatment.

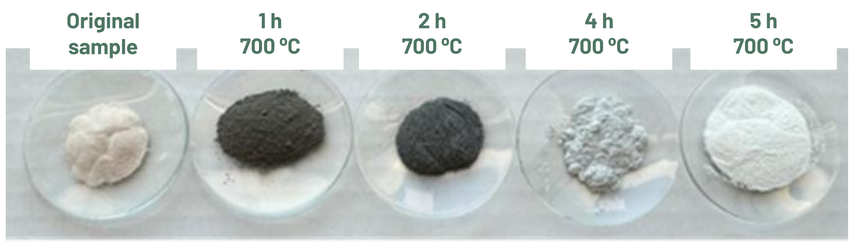


Figure 2. Photograph of the eggshell powder after the different thermal treatments.

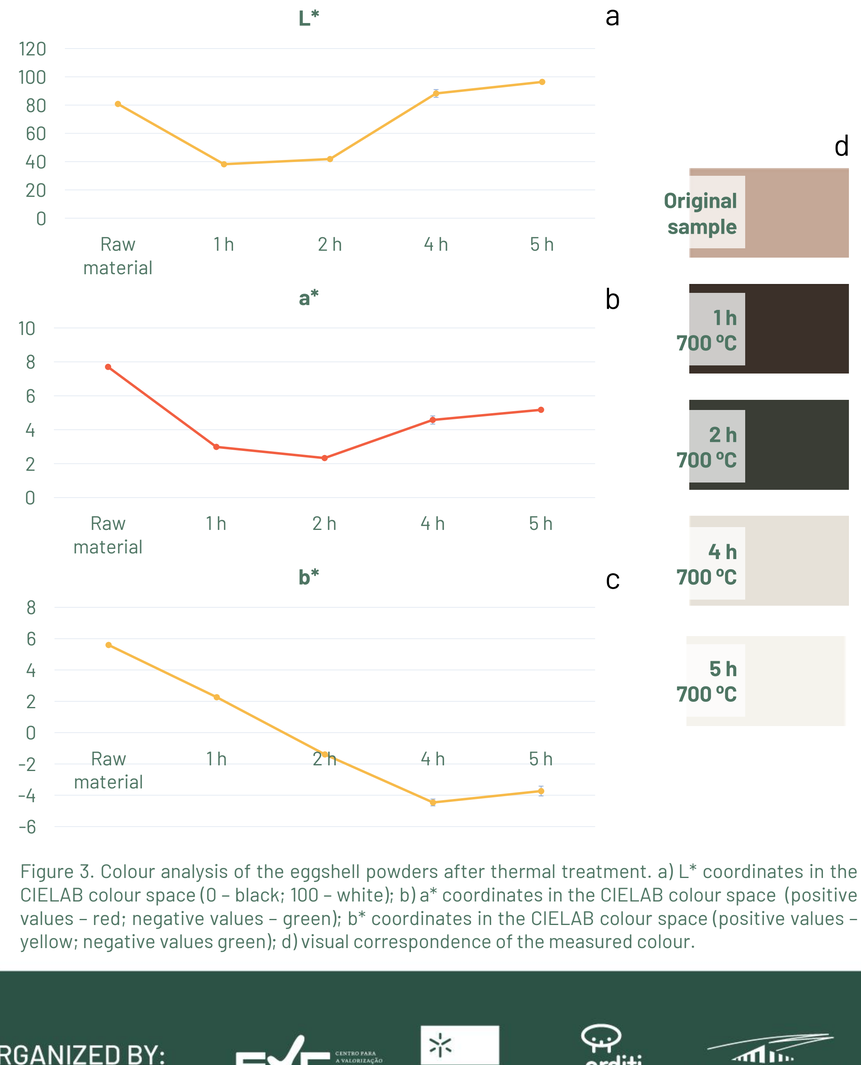


Figure 3. Colour analysis of the eggshell powders after thermal treatment. a) L* coordinates in the CIELAB colour space (0 – black; 100 – white); b) a* coordinates in the CIELAB colour space (positive values – red; negative values – green); b* coordinates in the CIELAB colour space (positive values – yellow; negative values green); d) visual correspondence of the measured colour.

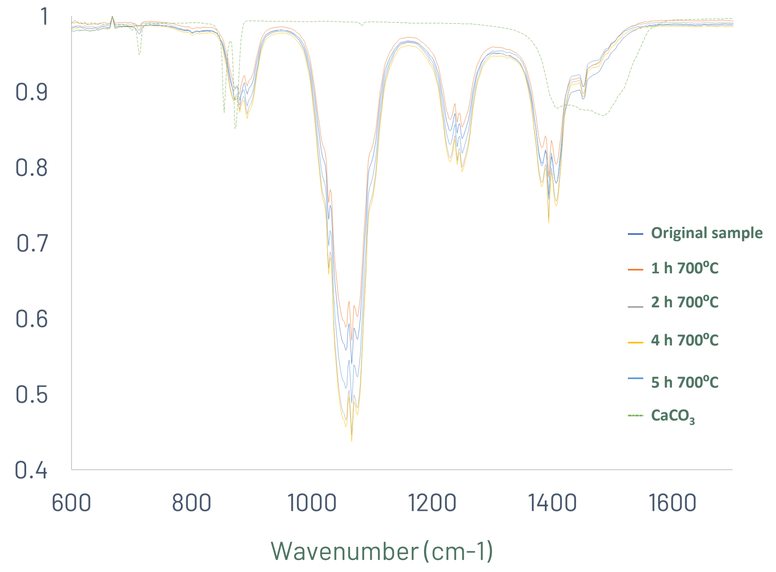


Figure 4. FTIR-ATR spectra of the different eggshell powders before and after thermal processing.

Figure 4. Mass yield of each thermal process.

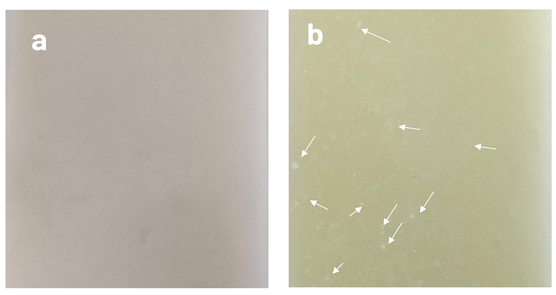


Figure 5. Close-up picture of TR samples containing eggshell without treatment (a) and after 5 h at 700ºC (b). Arrows mark examples of clumps of eggshell material.

Conclusion

- FTIR-ATR confirmed the progressive decomposition of organic matter and crystallization of the inorganic matrix with the increase in incineration time, namely peaks associated with C–H (2800–3000 cm^{-1}) and O–H (3300 cm^{-1}) diminished with time, indicating the partial combustion of organic residues. The sharp peaks at 1400–1500 cm^{-1} and 870 cm^{-1}, characteristic of carbonate groups, became more defined after prolonged incineration, reflecting increased purity and crystallinity of the $CaCO_3$.
- The incineration yields revealed a significant reduction in mass over time, with values of 92.3%, 89.34%, 59.5%, and 55.09% for 1 h, 2 h, 4 h, and 5 h treatments, respectively. Colour changes correlated with the organic matter decomposition, transitioning from beige (raw) to dark grey (1–2 h), light grey (4 h), and white (5 h). The white colour at 5 h, coupled with FTIR data, confirms the removal of organics and carbonaceous residues, yielding relatively pure $CaCO_3$ comparable to industrial standards.
- Incorporation into TR plates is viable but homogenization must be improved and the yellow-tone corrected.

Acknowledgments

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