Screening of Mediterranean agro-food by-product powders as potential reinforcing fillers of biocomposites for footwear

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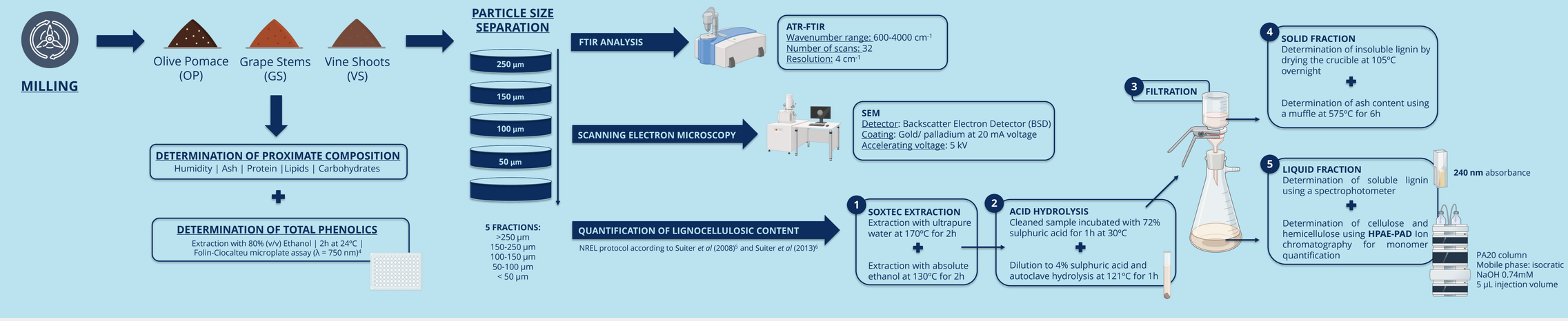
Introduction

Plastic materials account for 4.5% of global greenhouse gas emissions since several industries are highly dependent on them[1]. If no new policies are implemented, plastic demand is expected to double by 2050.[1] The footwear industry, for example, uses plastic materials broadly in various shoe components. Between 38 - 71 % of shoes are made from plastic or rubber, for example, in the upper part (polyurethane leather), but principally in their lower part (insole, sole and outsole).[2] Consequently, the footwear industry has a significant environmental footprint, generating substantial CO_2 emissions and non-biodegradable plastic waste that accumulates in ecosystems.[2] The incorporation of fillers deriving from Mediterranean agro-food by-products has emerged as a solution to produce biocomposites due to their lignocellulosic content.[3]

Objective

This work aims to produce and compare the composition and particle size of three different agro-food by-product powders — **olive pomace (OP), grape stem (GS), and vine shoots (VS)**, key crops in Mediterranean countries — as potential **lignocellulosic fillers** for footwear biocomposites.

Methods



Results: Particle size distribution

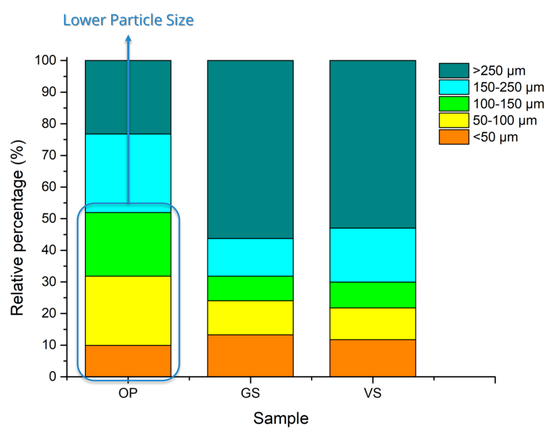


Figure 1. Particle size distribution of Olive Pomace (OP), Grape Stalks (GP) and Vine Shoots (VS) in the five different fractions.

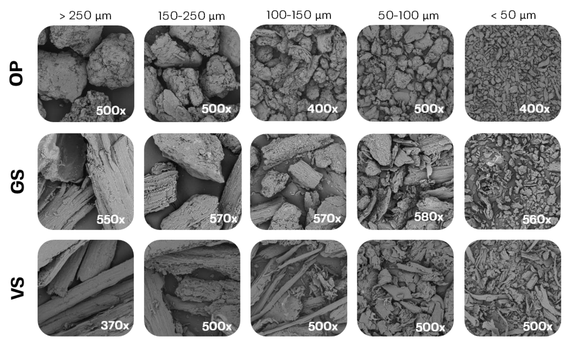
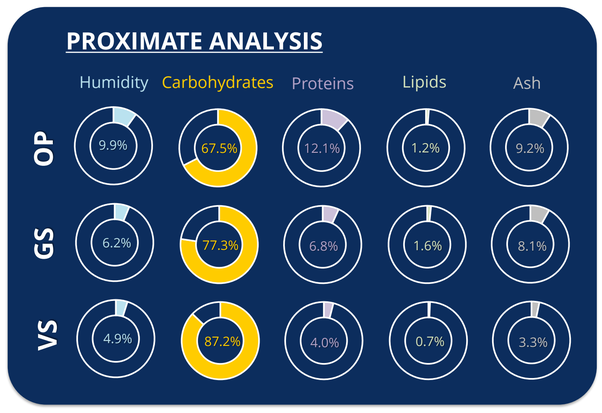


Figure 2. SEM Images of different particle sizes of the three agro-food by-products.

Results: Chemical composition



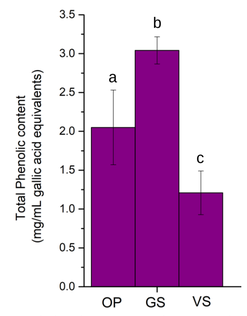


Figure 4. Total phenolic content results expressed in mg/mL of gallic acid equivalents. Statistical analyses were performed using R. Differences between samples were assessed by one-way ANOVA based on data normality (Shapiro-Wilk) and variance homogeneity (Levene's test). Tukey's post-hoc test was used for multiple comparisons at $p < 0.05$.

LIGNOCELLULOSIC COMPOSITION

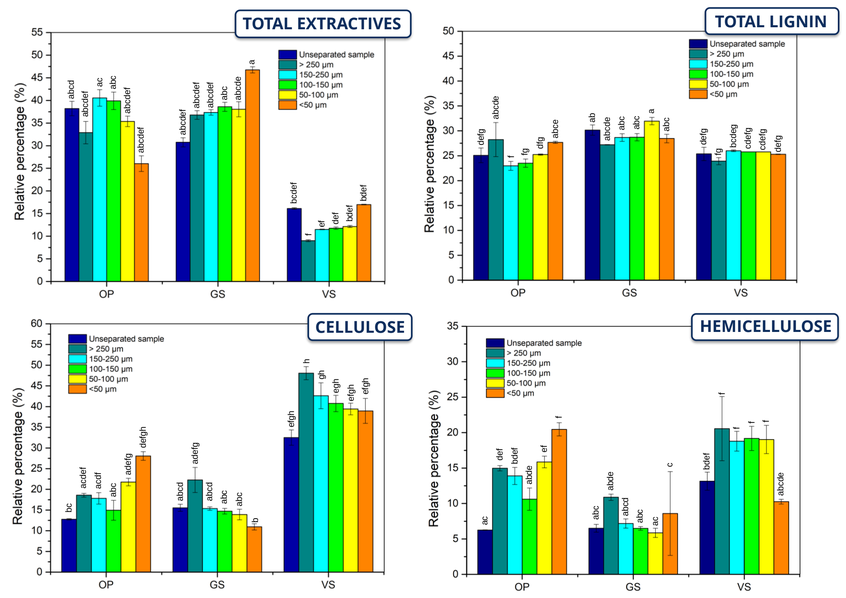


Figure 5. Graphical representations of the lignocellulosic composition in terms of Total Extractives, Total Lignin, Cellulose and Hemicellulose contents. Statistical analyses were performed using R. Differences between samples were assessed by Kruskal-Wallis based on data normality (Shapiro-Wilk) and variance homogeneity (Levene's test). Dunn's test was used for multiple comparisons at $p < 0.05$.

Results: FTIR analysis

Figure 3. FTIR spectra of five different size fractions for each agro-food by-product (OP, GS, and VS). Some regions that correspond to specific vibration modes of lipids, proteins, and carbohydrates are highlighted in all spectra.

Conclusions

- Particle size is an important factor that influences the chemical composition and its future incorporation potential in biomaterials for footwear;
- All FTIR spectra showed higher intensity in the carbohydrate's region, which is corroborated by its chemical composition, mainly high fiber content;
- All samples showed potential as lignocellulosic fillers, especially Vine Shoots (VS);
- VS exhibited the higher cellulose content and lower extractives;
- The remaining biomasses could potentially require an extractive removal for improved performance.

Acknowledgments

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