Exploring Grain Silo Residues as Lignocellulosic biomass source for sustainable footwear biomaterials

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Introduction

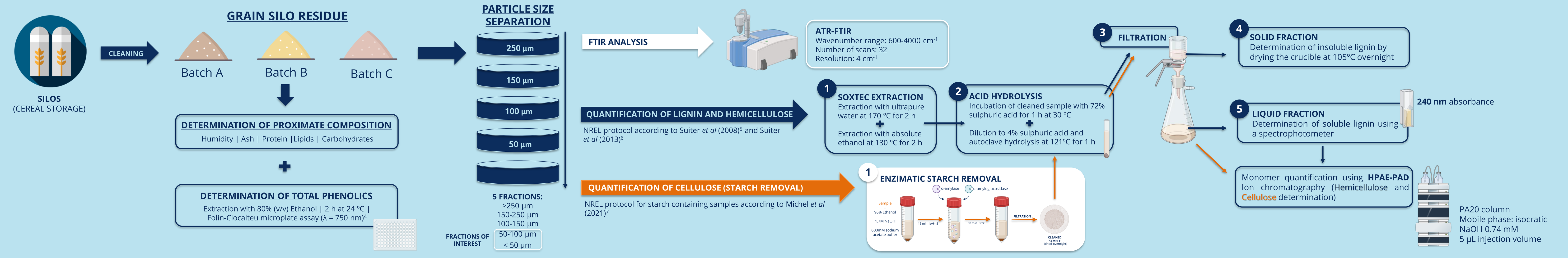
Over the years, the replacement of plastic-based materials has become crucial in alleviating the environmental footprint of various industries.[1] The footwear industry currently relies on certain petrol-derived materials such as glues, rubbers, and leather, which demand more sustainable alternatives.[2] Lignocellulosic matrices (cellulose, hemicellulose, and lignin) are known to be good filling agents, due to their structural properties including tensile strength, stiffness, and impact resistance.[1] Therefore, using sustainable feedstocks with lignocellulosic materials, like cereals, offer a promising option for the development of new biomaterials for the shoe-making industry.[3] On a larger scale, cereals can be stored and transported in silos, which, when cleaned, accumulate grain silo residues. This agro-food by-product is variable in terms of different cereals, particle sizes, and composition which may compromise its application in footwear.

Objectives

This work aims to highlight grain silo powder residues as a source of **lignocellulosic fillers** for the footwear industry, considering composition and particle size variations along an array of different batches.

8 DECENT WORK AND ECONOMIC GROWTH · 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE · 12 RESPONSIBLE CONSUMPTION AND PRODUCTION · 13 CLIMATE ACTION · 17 PARTNERSHIPS FOR THE GOALS

Methods



Results: Particle size distribution

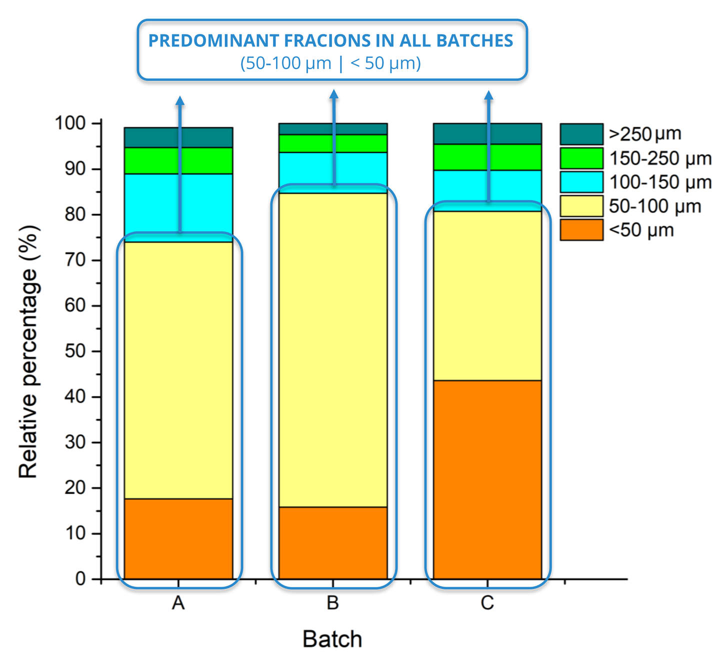


Figure 1. Particle size distribution the three grain silo residue batches (A, B, and C) in five different fractions.

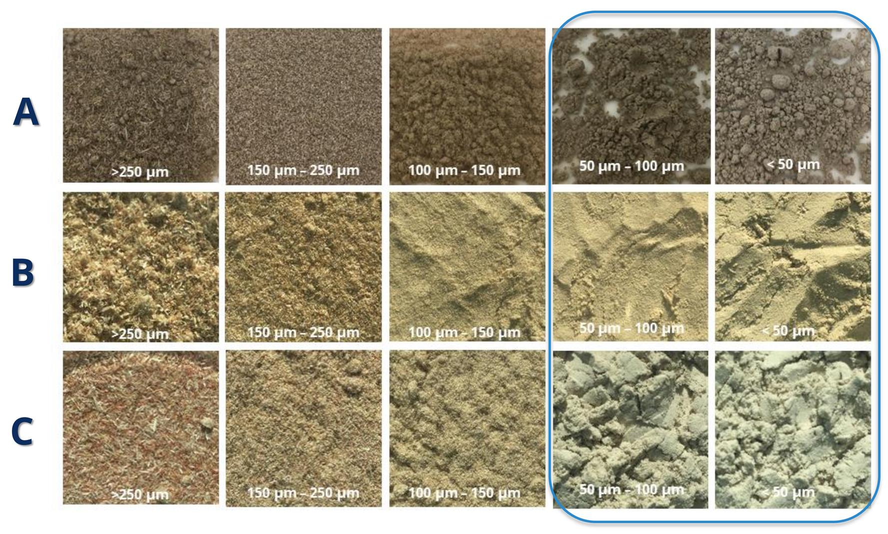


Figure 2. Representation of different particle sizes of the three batches of grain silo residues.

Results: FTIR analysis

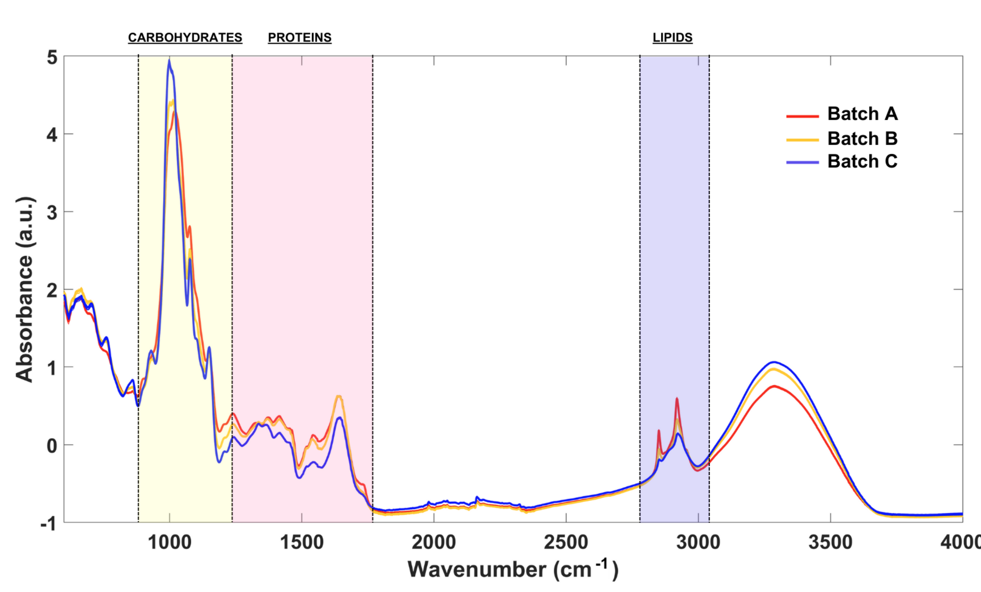


Figure 3. FTIR spectra of the lower size fractions of the three grain silo residue batches (A, B, and C).

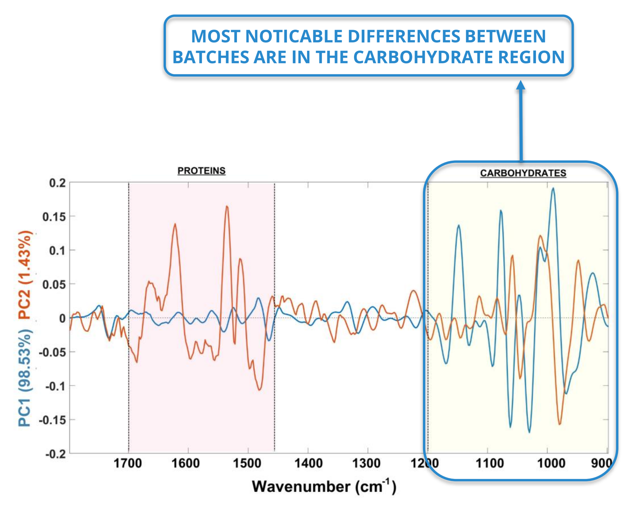
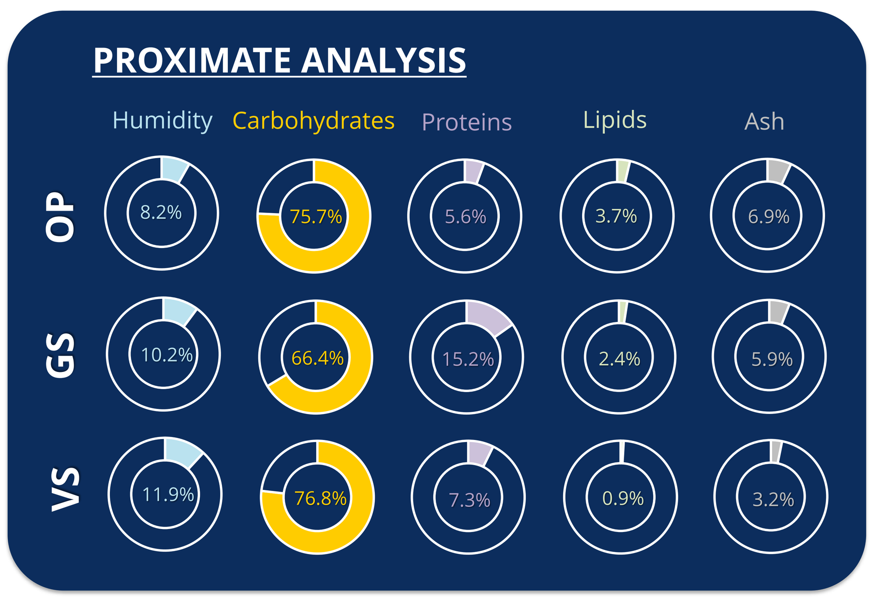


Figure 4. PCA loadings results.

Results: Chemical Composition



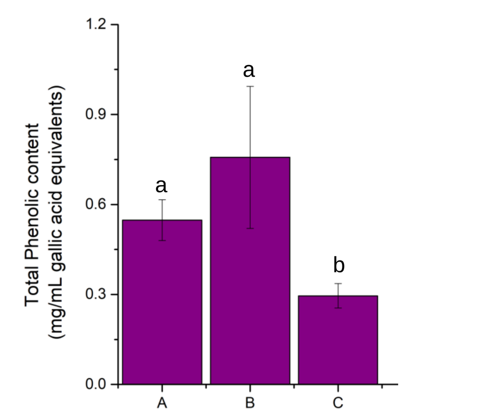


Figure 5. Total phenolic content results expressed in mg/mL of gallic acid equivalents. The statistical analyses were carried out using R software. The significance of the differences between samples was determined by Kruskal-Wallis or one-way analysis of variance (ANOVA) according to the normality of data distribution (Shapiro-Wilk test) and homogeneity of variances (Levene's test). Box-Cox transformations were applied to normalize the data where needed. Test multiple comparisons were made at those statistically significant variables using Dunn's method or Tukey's posthoc test (normal data) at the p < 0.05 significance level.

LIGNOCELLULOSIC COMPOSITION

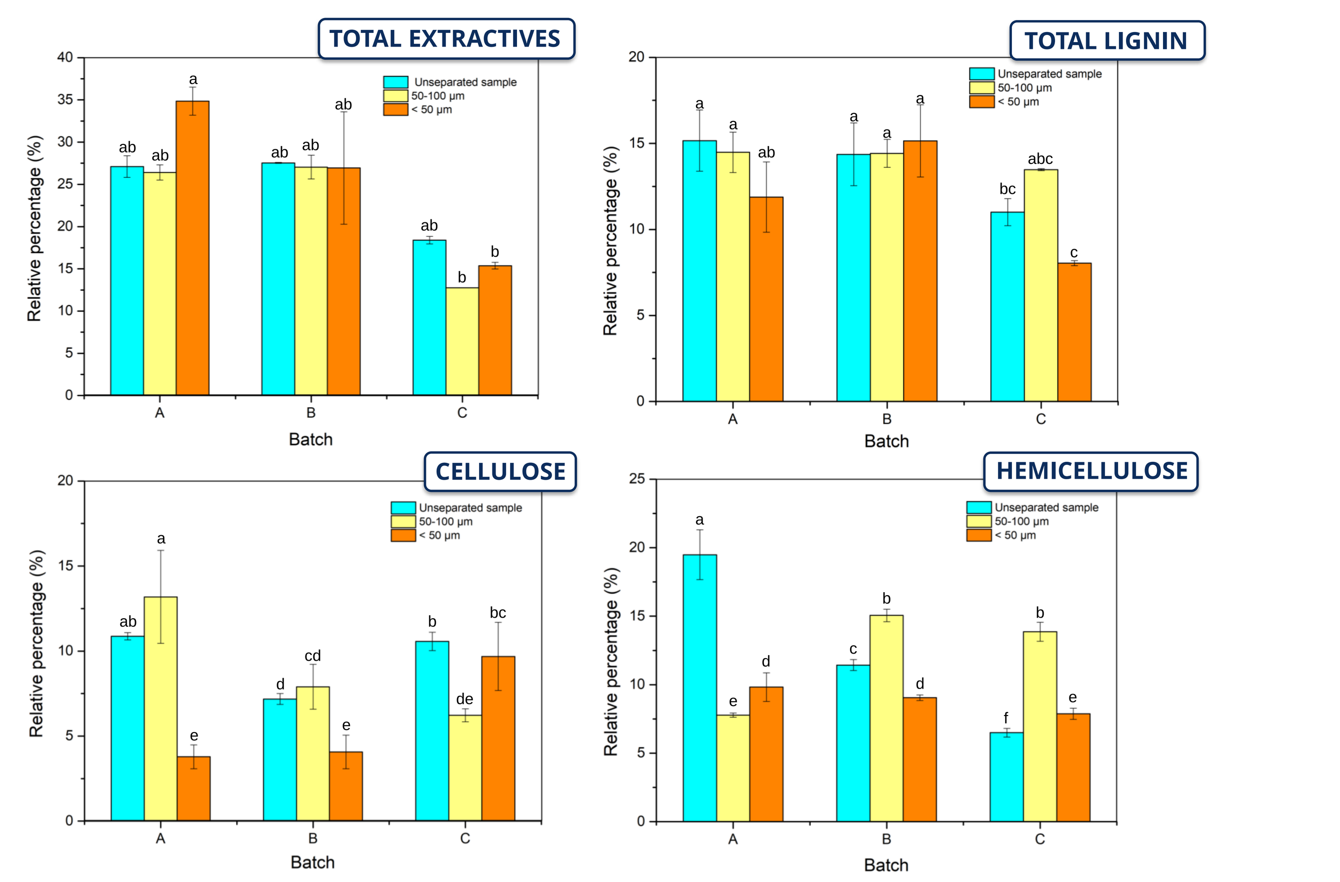


Figure 6 Graphical representations of the lignocellulosic composition in terms of Total Extractives, Total Lignin, Cellulose and Hemicellulose contents. The statistical analyses were carried out using R software. The significance of the differences between samples was determined by Kruskal-Wallis or one-way analysis of variance (ANOVA) according to the normality of data distribution (Shapiro-Wilk test) and homogeneity of variances (Levene's test). Box-Cox transformations were applied to normalize the data where needed. Test multiple comparisons were made at those statistically significant variables using Dunn's method or Tukey's posthoc test (normal data) at the p < 0.05 significance level.

Conclusions

- The majority of all batches is predominantly comprised of small particle size fractions which are ideal for incorporation in shoe-based materials;
- Different batches of silo powders have significant differences in lignocellulosic content which may result in variability of their incorporation performance;
- Lower particle size (<50 μm) showed lower cellulose content and higher extractives, whereas intermediate (50-100 μm) and unfractionated samples showed higher cellulose in all batches;
- In conclusion, all batches have incorporation potential, however, their variability may conditionate its application feasibility. For a good industrial application, it is necessary to analyse more batches in order to get a better knowledge on the effect of the composition in the incorporation and to achieve a standardization.

Acknowledgments

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