ATR-FTIR Analysis of Thermoplastic Rubber Plates Containing Food Byproduct Particles: effect of particle size and production order

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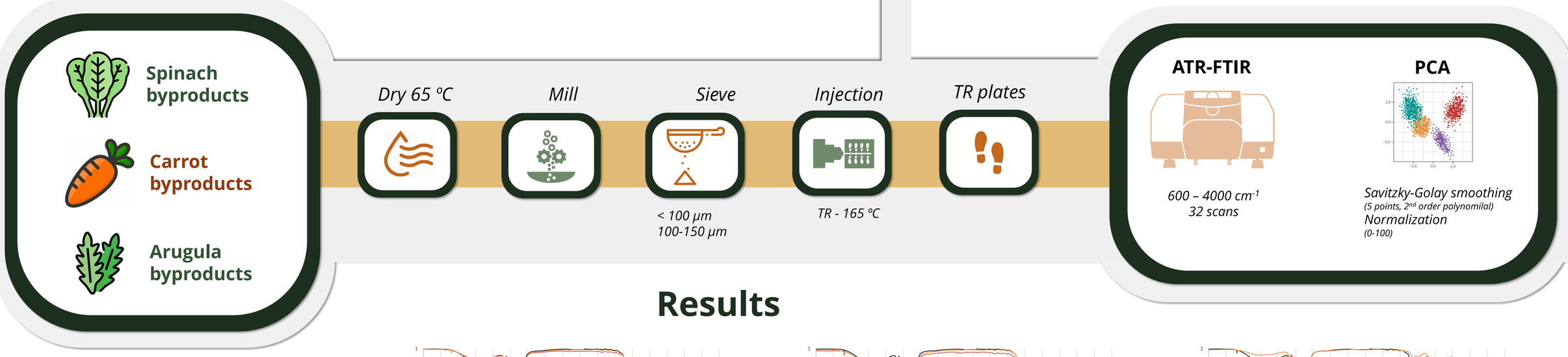
Introduction

The shoemaking industry's heavy reliance on non-renewable resources and traditionally environmentally harmful processes presents a critical challenge in an increasingly eco-conscious world. In fact, embracing sustainability is not just a good industrial practice or a regulatory recommendation, it is also a key factor for product and brand differentiation. Moving towards circular industrial processes that reduce the need for petrol-derived plastic materials, is a possible solution1-3. The use of biobased fillers is an example. In this sense, the food industry presents itself as an interesting potential partner, as food byproducts (that otherwise have no use) can act as bioloads while adding other technological advantages like improving materials resistance or even function as pigments.

Objectives

- Evaluate the feasibility of incorporating dried carrot, spinach, and arugula byproducts into transparent thermoplastic rubber (TR)
- Assess structural changes in TR plates after byproduct incorporation.
- Evaluate the effect of particle size and plate production order on spectral patterns.

Methods



Results

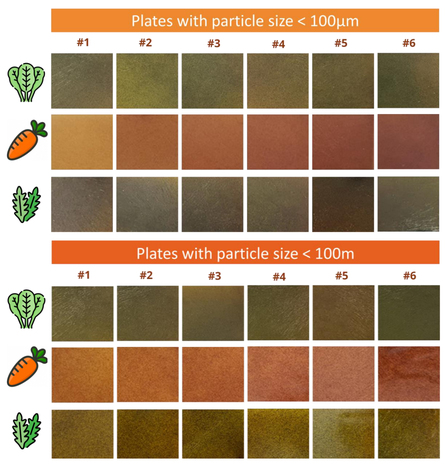


Figure 1. *Close up photograph of TR plates produced containing spinach, carrot and arugula byproducts with particle sizes < 100 µm and 100-150 µm. The number on the plates indicates the order in which they were produced.*

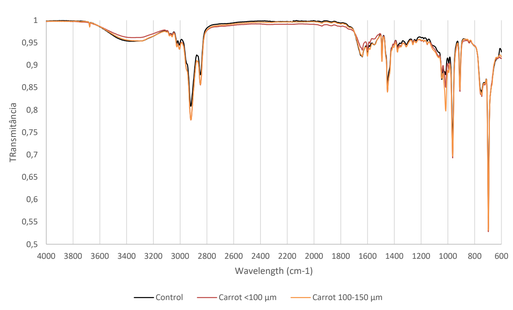


Figure 2. *ATR-FTIR spectra of TR plates containing carrot byproducts.*

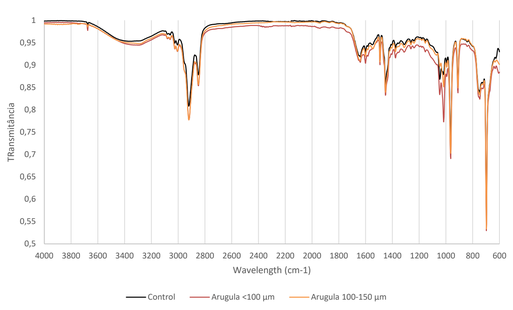


Figure 2. *ATR-FTIR spectra of TR plates containing arugula byproducts.*

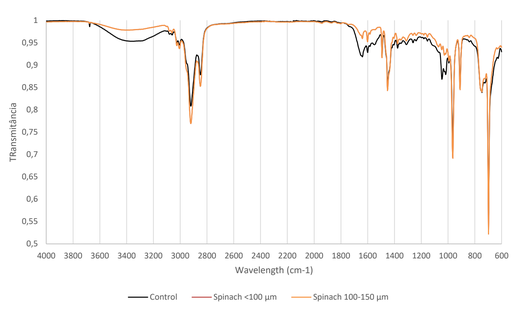


Figure 2. *ATR-FTIR spectra of TR plates containing spinach byproducts.*

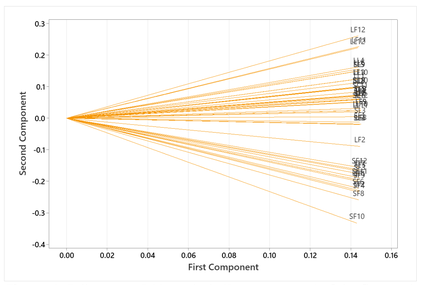


Figure 4. *Full spectra PCA analysis (2 components) of the first and last TR plates containing carrot samples containing different particle size. . T, control; SF, <100 µm 1st plate; SL, <100 µm 6th plate; LF, 100-150 µm 1st plate; LL, 100-150 µm 6th plate.*

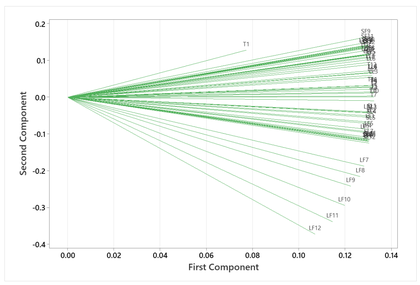


Figure 3. *Full spectra PCA analysis (2 components) of the first and last TR plates containing arugula samples containing different particle size. . T, control; SF, <100 µm 1st plate; SL, <100 µm 6th plate; LF, 100-150 µm 1st plate; LL, 100-150 µm 6th plate.*

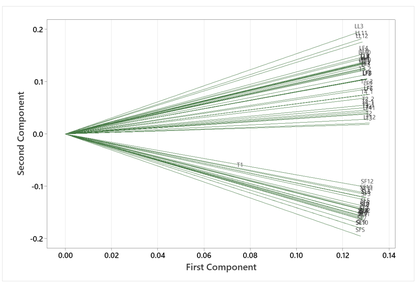


Figure 5. *Full spectra PCA analysis (2 components) of the first and last TR plates containing spinach samples containing different particle size. . T, control; SF, <100 µm 1st plate; SL, <100 µm 6th plate; LF, 100-150 µm 1st plate; LL, 100-150 µm 6th plate.*

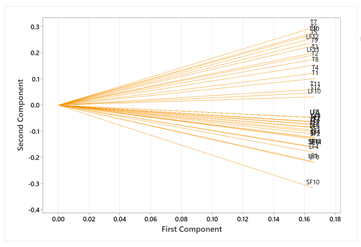


Figure 9. *Full spectra PCA analysis (2 components) of the first TR plates containing carrot samples containing different particle size. T, control; SF, <100 µm 1st plate; LF, 100-150 µm 1st plate.*

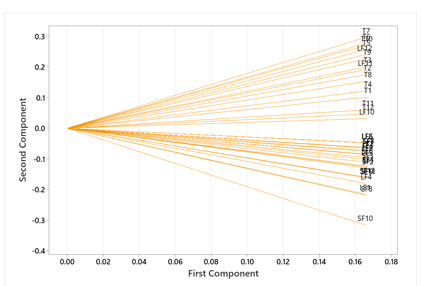


Figure 7. *PCA analysis (2 components), considering the spectra between 4000-3500, 3000-2500 and 1700-600 cm-1 of the first and last TR plates containing arugula samples containing different particle size. . T, control; SF, <100 µm 1st plate; SL, <100 µm 6th plate; LF, 100-150 µm 1st plate; LL, 100-150 µm 6th plate.*

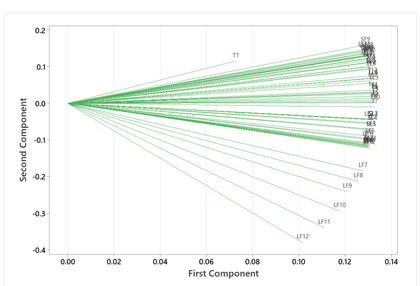


Figure 6. *PCA analysis (2 components), considering the spectra between 4000-2500 and 1700-600 cm-1 of the first and last TR plates containing arugula samples containing different particle size. . T, control; SF, <100 µm 1st plate; SL, <100 µm 6th plate; LF, 100-150 µm 1st plate; LL, 100-150 µm 6th plate.*

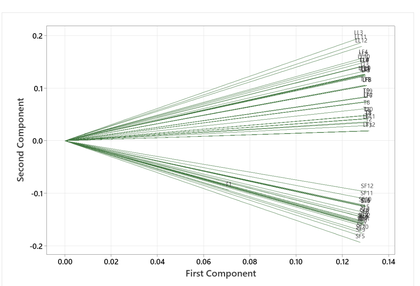


Figure 8. *PCA analysis (2 components) considering the spectra between 4000-2500 and 1700-600 cm-1 of the first and last TR plates containing spinach samples containing different particle size. . T, control; SF, <100 µm 1st plate; SL, <100 µm 6th plate; LF, 100-150 µm 1st plate; LL, 100-150 µm 6th plate.*

Conclusions

- No significant differences were observed between the different arugula samples
- In spinach, two populations were observed. Particle size had a significant impact but not the production order. Smaller particles were grouped separately from the control and larger ones.
- In carrot, the processing order had a significant impact. In the first plate produced, TR plates with carrot were different from control plates, but similar between themselves, when considering the last plates produced (#6) larger particles were similar to the control with only the TR plates with the smaller carrot particle size being different

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