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Alginate and chitosan fibers produced with olive pomace by wet spinning

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Introduction

Olive oil production generates a considerable amount of olive pomace (OP). This residue is made of olive skins, pulp and stones. Furthermore, it is rich in phenolic compounds which comprise antioxidant and antibacterial properties. This research envisages a sustainable valorization of this relevant Mediterranean waste through the inclusion of olive pomace powder to functionalize alginate and chitosan wet spun fibers. Both biopolymers are natural and biocompatible polysaccharides with numerous favourable properties, such as good biodegradation and non-toxicity.

Methodology

① OP dehydration and milling.

② Preparation of spin dopes through homogenization of the OP powder in the solvent solution followed by the addition of biopolymer to the mixture (**Table 1**).

③ Wet spinning of the fibers by dope extrusion at 30 mL/h into the respective coagulation bath (**Figure 1**).

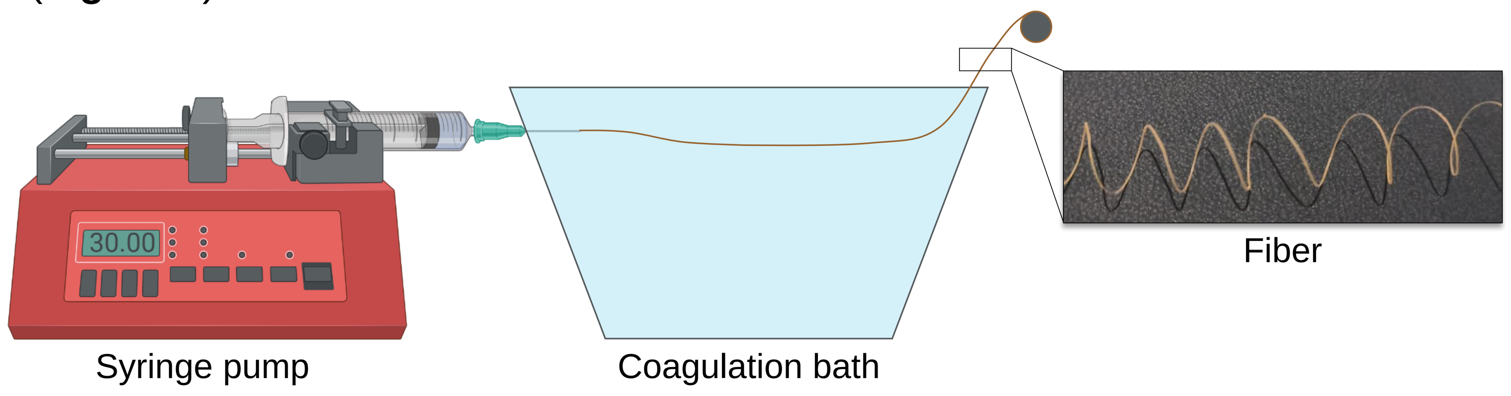

Figure 1 – Schematic representation of wet spinning setup.

Table 1 – Produced fibers and respective experimental conditions of the wet spinning process.

Samples	Biopolymer concentration (% w/v)	OP concentration (% w/v)	Coagulation bath	Dewatering in ethanol for 24 h
AL	3% sodium alginate	-	3% (w/v) calcium chloride	No
AL+0.5OP		0.5%		
AL+1.5OP		1.5%		
CH	3% chitosan	-	10% (w/w) sodium hydroxide/96% (v/v) ethanol (70:30 (v/v))	Yes
CH+0.5OP		0.5%		
CH+1.5OP		1.5%		

Results and Discussion

- **Brightfield microscopy** (Figure 2)

Comparison of pure biopolymer fibers (AL and CH) with OP doped filaments indicates that incorporating the insoluble OP particles modifies the filament surfaces, making them less homogeneous and with greater roughness.

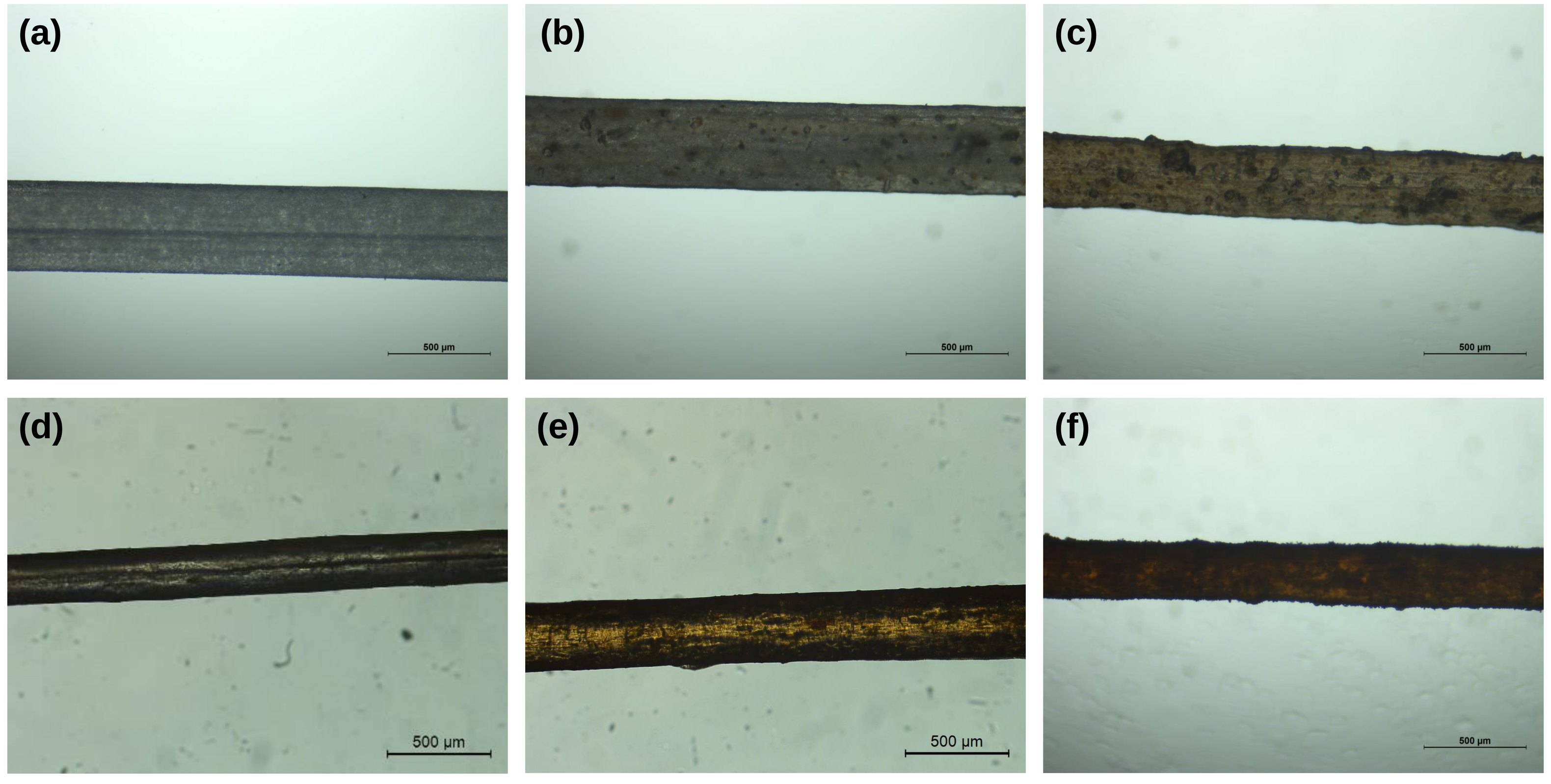

Figure 2 – Micrographs of (a) AL, (b) AL+0.5OP, (c) AL+1.5OP, (d) CH, (e) CH+0.5OP and (f) CH+1.5OP wet spun fibers, captured at 5x magnification using a brightfield microscope.

- **Thermogravimetric analysis (Figure 3)**

The first degradation step recognized in all tested samples corresponds to specimen dehydration. While the main process of mass loss in chitosan fibers occurs in one step, approximately between 234 and 310 ºC, alginate filaments undergo a two-step degradation process between 200 and 307 ºC.

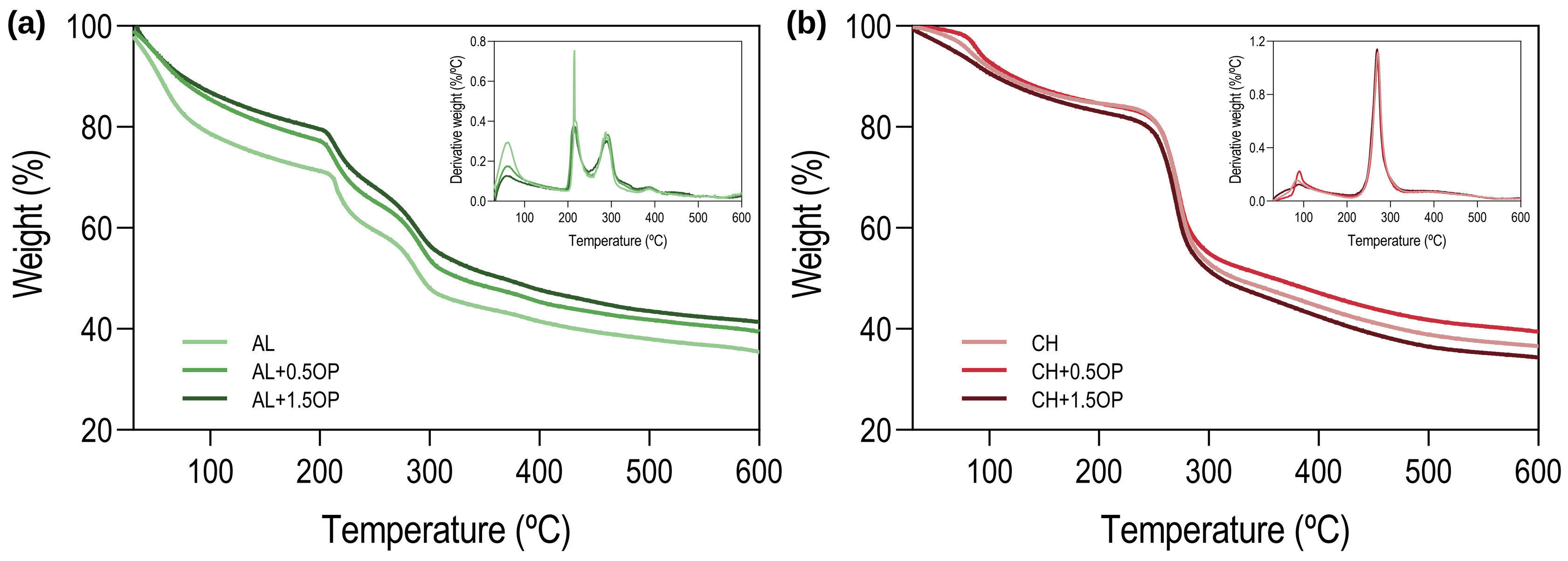

Figure 3 – Thermogramitric analysis curves of (a) AL, AL+0.5OP, AL+1.5OP and (b) CH, CH+0.5OP and CH+1.5OP fibers, obtained from 30 ºC to 600 ºC at 10 ºC/min under nitrogen atmosphere.

- **Linear density and mechanical properties (Table 2)**

OP addition influences significantly the linear density and the mechanical properties of the fibers.

Table 2 – Linear density and tensile properties of the produced fibers.

Fiber	Linear density (tex)	Tensile strength (MPa)	Elongation at break (%)	Young's modulus (MPa)
AL	49.8	15.7	30.0	3.5
AL+0.5OP	56.1	9.0	18.4	1.3
AL+1.5OP	56.8	8.1	18.5	0.3
CH	40.8	37.1	3.0	20.9
CH+0.5OP	57.7	18.4	2.0	11.7
CH+1.5OP	54.8	23.1	1.4	15.0

- **Antibacterial activity (Figure 4)**

OP was evaluated using the shake flask method, and the fibers contact killing efficacy was determined. OP exhibited sterilizing effect, and all filaments demonstrated inhibitory activity. The higher viability reduction observed in doped alginate fibers proves that OP has potential to be used as a natural antibacterial agent.

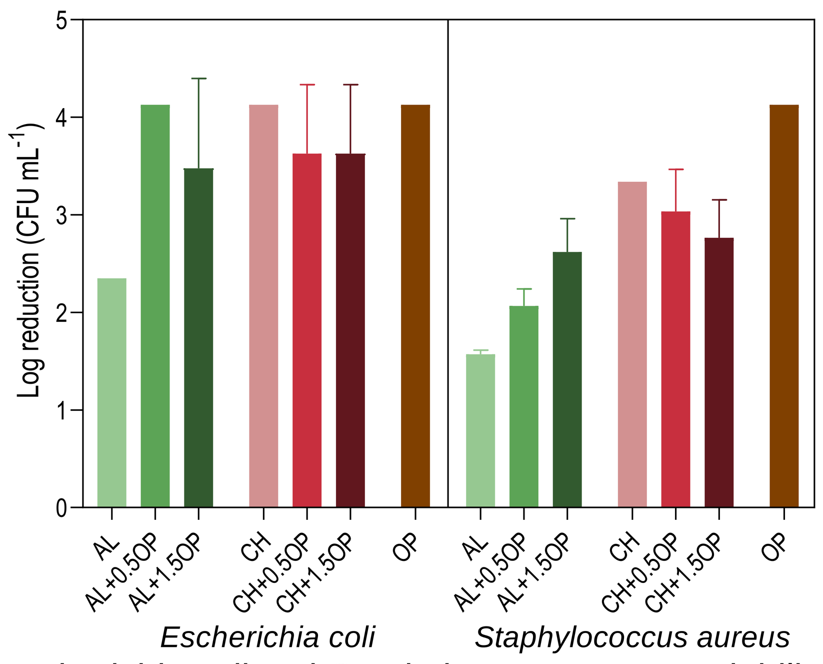

Figure 4 – *Escherichia coli* and *Staphylococcus aureus* viability reduction.

Conclusions

Incorporation of olive pomace into alginate or chitosan fibers:

- Modified the surface of the sample.
- Increased the linear density of the filament.
- Did not considerably affect the fiber degradation process.
- Impaired tensile strength, as well as the fiber extensibility.
- Demonstrated antibacterial activity against potentially pathogenic microorganisms.

Acknowledgments

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