



NewPack

New BioBased Film for Packaging

Cellulose and Natural Extracts: from Biomasses to Food Packaging

Workshop: Development of innovative bioplastics for the food sector

19th of November 2019, Piacenza, Italy

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Introduction



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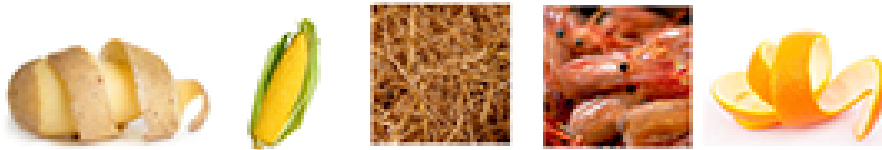
SusFoFlex

SMART and SUSTAINABLE FOOD PACKAGING
UTILIZING FLEXIBLE PRINTED INTELLIGENCE
and MATERIALS TECHNOLOGIES

Valorisation of
agricultural and food
residues

Material based on PLA
and PHB

Agro-food waste



NewPack

New BioBased Film for Packaging





Introduction: Cellulose



**Wheat Straw
(WS)**

*Antioxidant Compounds
(i.e. Phenols)*

Incorporation →
Active packaging

*Fiber Recovery (i.e
Cellulose)*

Incorporation as
nanocellulose →
improve the barrier
properties

**PLA-PHB
film**



WHY WS?

- WS production is about 594 million tons in 2017.
- Easy transport → high density form
- Low water content (i.e. about 5-8 %) → enables easy storage

WHY PLA-PHB?

- Wide range of applications
- Biodegradability
- Potentially low cost
- Good mechanical properties



- Brittleness
- Low barrier properties



Cellulose Recovery: Fractionation Processes



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Wheat
Straw
milled

Acid Hydrolysis *

Acid Liquor

Solid Recovered

Alkaline Hydrolysis *

Basic Liquor

Solid Recovered

Bleaching

Bleaching Liquor

Cellulose





Cellulose Recovery: Fractionation Processes



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Wheat
Straw
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Auto Hydrolysis *

Acid Liquor

Solid Recovered

Alkaline Hydrolysis

Basic Liquor

Solid Recovered

Bleaching

Bleaching Liquor

Cellulose





Results: Analysis of the outlet cellulose



Fractionation process was tested in 4 different cases:

- Acid Hydrolysis (i.e. traditional process)
- Autohydrolysis at 170 °C
- **Autohydrolysis at 195 °C**
- Autohydrolysis at 225 °C



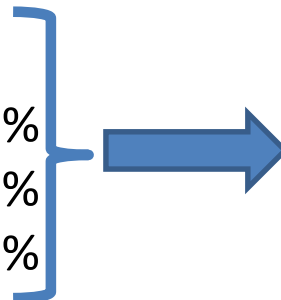
Main goal
Highest Micro Crystalline Cellulose (MCC) recovery



Crystallinity value for the 4 different cases:

Acknowledge to University of OULU (Partner of Newpack project)

- Acid Hydrolysis → 87 %
- Autohydrolysis at 170°C → 77 %
- Autohydrolysis at 195°C → 83 %
- Autohydrolysis at 225°C → 91 %



Main goal
No amorphous structure → cellulose is suitable for the production of nanocellulose

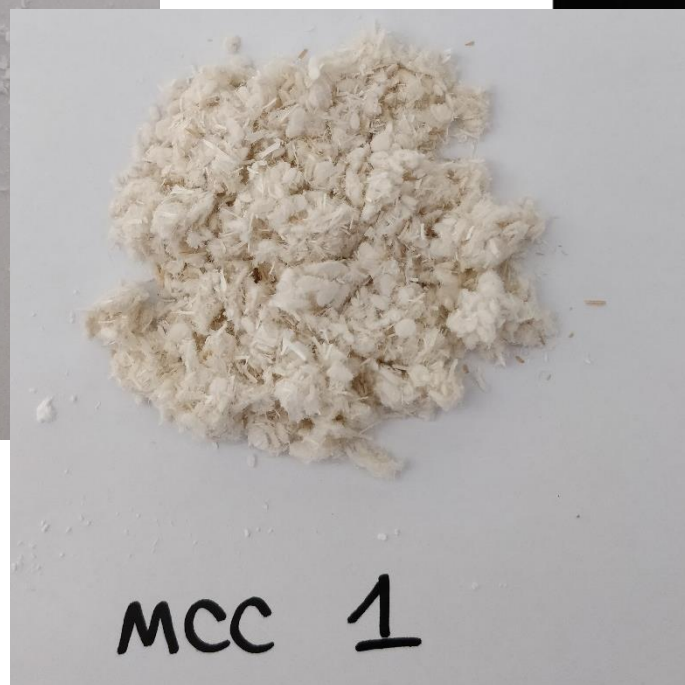
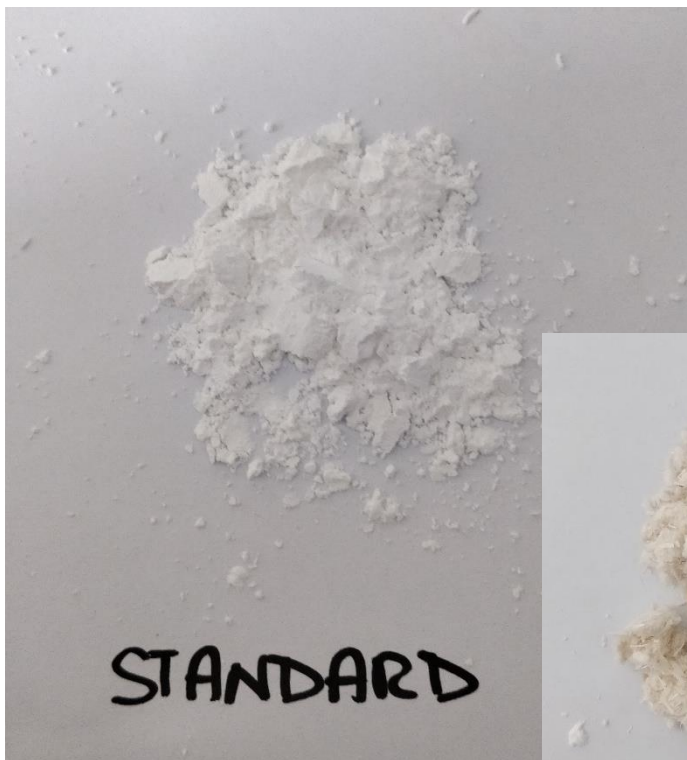




Results: Analysis of outlet cellulose



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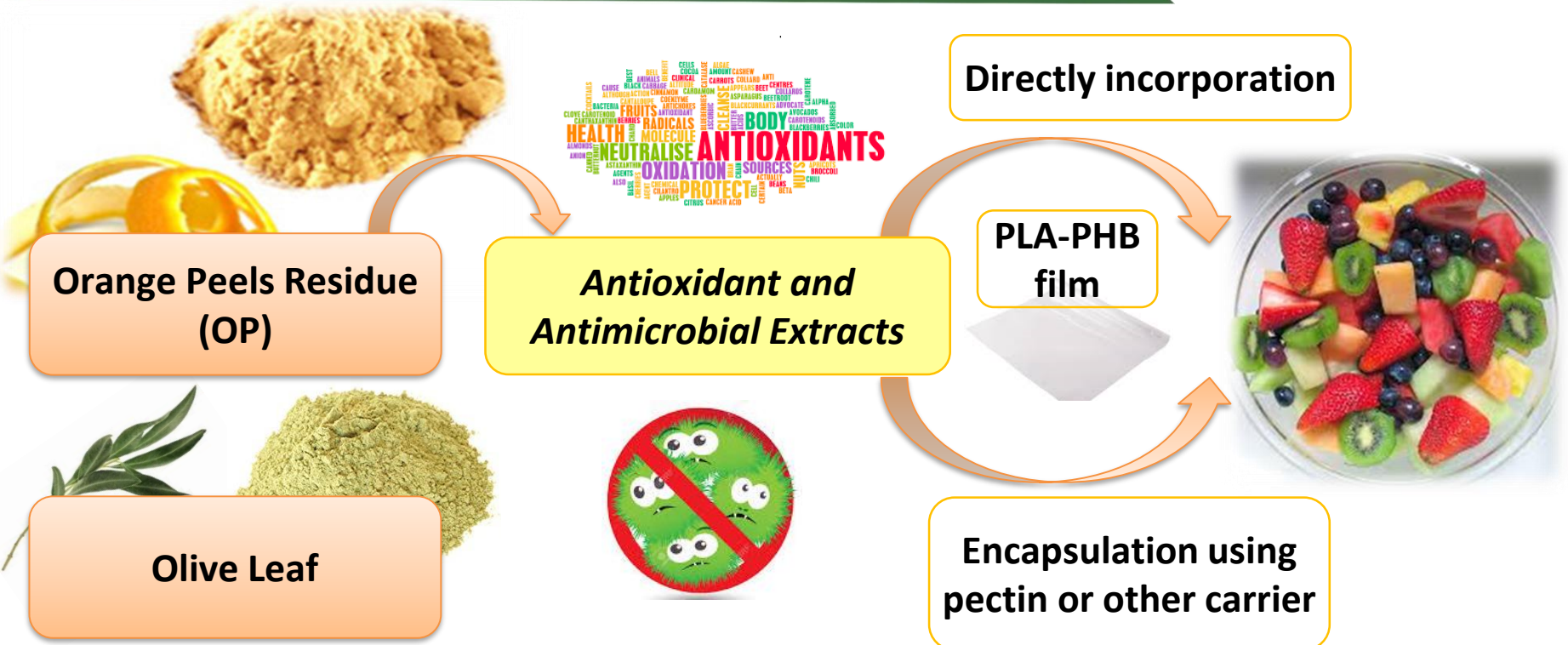




Introduction: Natural Extracts



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WHY OP?

- 73.33 Mtonnes of oranges produced in 2017.
- OP extracts incorporated into PLA films could be released to food products (Marinoni et al., 2018)

WHY OL?

- Well known for its high antioxidant activity



Experimental Design – Natural Extract



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ANALYSIS








- MOISTURE
- TOTAL PHENOLIC CONTENT (Folin-Ciocalteu assay)
- ANTIOXIDANT ACTIVITY (FRAP and ABTS)
- COLORING POWER (CIELab analysis)
- SOLUBILITY
- THERMAL STABILITY (DSC method)
- UV/VIS BARRIER
- ANTIMICROBIAL ACTIVITY (MIC)



Antimicrobial Activity



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RIBEREBRO products	ARGAL products	PATHOGENIC MICROORGANISMS
 <p>WHOLE MUSHROOM</p>	 <p>SLICED CURED HAM</p>	<ul style="list-style-type: none">• <i>Listeria monocytogenes</i> DSM 15675• <i>Escherichia coli</i> ATCC 25922• <i>Salmonella enterica</i> ser. Typhimurium DSM 17058• <i>Staphylococcus aureus</i> ATCC 33591• <i>Pseudomonas fluorescens</i>
 <p>MIX OF FRESH VEGETABLES</p>	 <p>READY TO EAT RUSSIAN SALAD</p>	<ul style="list-style-type: none">• <i>Aspergillus niger</i>• <i>Aspergillus pseudodeflectus</i>
 <p>MIX OF PASTEURISED GREEN BEANS</p>	 <p>SLICED VEGAN SAUSAGES</p>	<p style="text-align: center;"></p> <ul style="list-style-type: none">• Olive and some citrus extracts show high activity against the selected pathogen• Both citrus and olive extracts show fungal growth after incubation for 72h at room temperature.

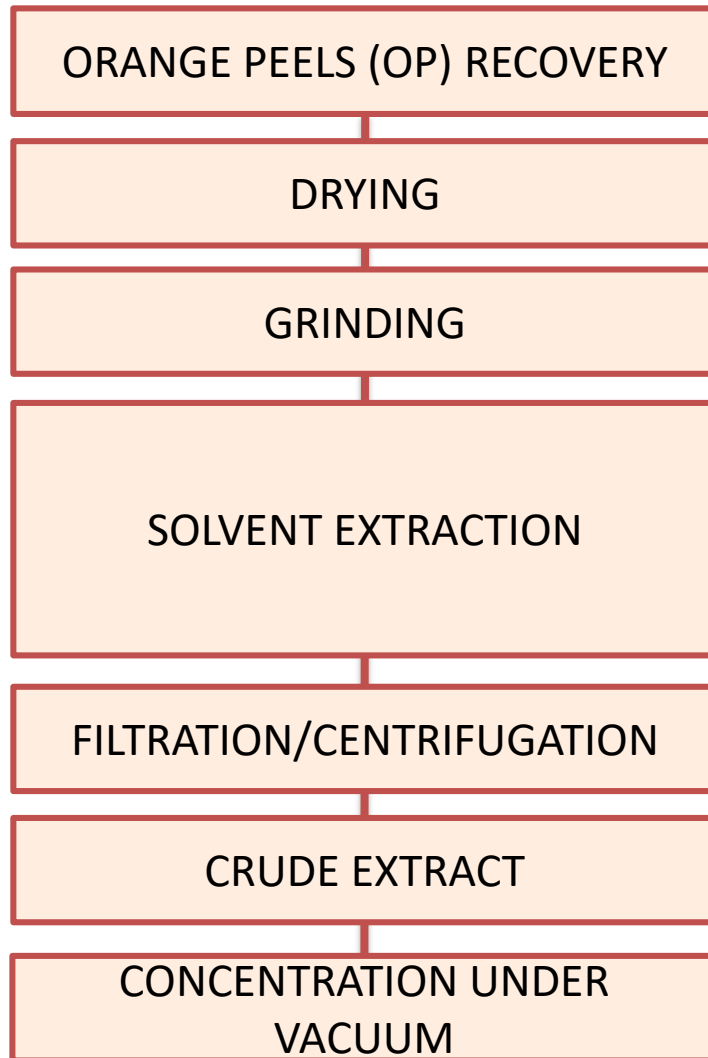


Critical point 1: Cost of Production Process



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CRUDE CONCENTRATED EXTRACT





Critical Point 2: inclusion of natural extract into bio-film



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Natural phenolic extracts are heat and oxygen sensitive



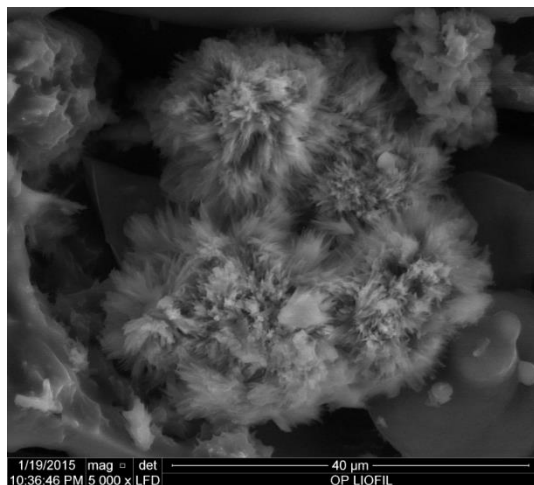
Solution

Encapsulation strategies

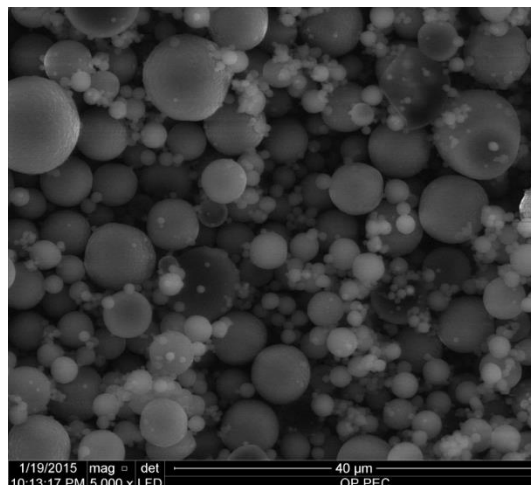
➤ increase thermal and oxidative stability of the compounds

Natural Extract Formulation

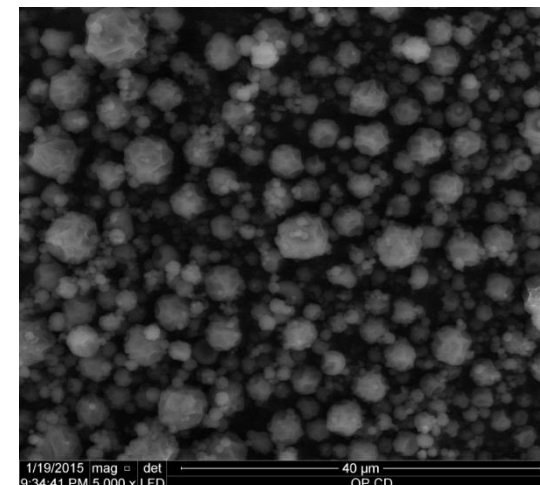
FREEZE-DRYING
extract



SPRAY-DRYING
Pectin as carrier



SPRAY-DRYING
Maltodextrin as carrier





Experimental Design – Encapsulated Natural Extract



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Critical Point 3: Film Colour with natural extract



	PLA (HYCAIL) + % purified orange extract (Freeze Dried)	PLA (HYCAIL) + % purified orange extract (Spray-Dried with PECTIN)	PLA (HYCAIL) + % purified orange extract (Spray-Dried with CYCLODEXTRINS)
0.25% OE			
0.50% OE			
1.00% OE			
2.00% OE			

- Addition of OPE, independently on the formulation, conferred to PLA film an orange colour and a 2 % concentration was unacceptable for material process (also from the point of view of the cost of the extract additive).



Conclusions



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Conclusions

- ✓ Autohydrolysis process for cellulose recovery from agriculture residue, with particular reference to wheat straw, was analyzed.
- ✓ Autohydrolysis process was compared with the traditional acid hydrolysis in terms of some key parameters like cellulose yield and recovery
- ✓ Natural extract shows a good antioxidant action and a promising antimicrobial activity.
- ✓ Spray drying encapsulation increased the thermal stability of the extract (especially with maltodextrins).



Future Developments



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Future Developments

- Application of natural extract on film as coating (e.g. by electro-spinning technique → cooperation with Proplast and other coating technique with Tecnalia)
- Model development of the whole fractionation process.
- Optimization of the whole process with the related test of the optimized conditions
- LCA Assessment of the process (Quantis)
- Optimization of the antioxidant recovery

