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EVALUATION OF FOOD QUALITY AND SAFETY FOR PACKAGED HAM USING BIODEGRADABLE PACKAGING

Morgan Guilbaud, Sandra Domenek

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Introduction

Inconvenience of PLA for Food Packaging

PLA is a bio-based and compostable commercial polymer already used widely in catering and processed-food packaging. Despite all the advantages of PLA, it misses satisfying properties for food packaging applications.^{1,2}

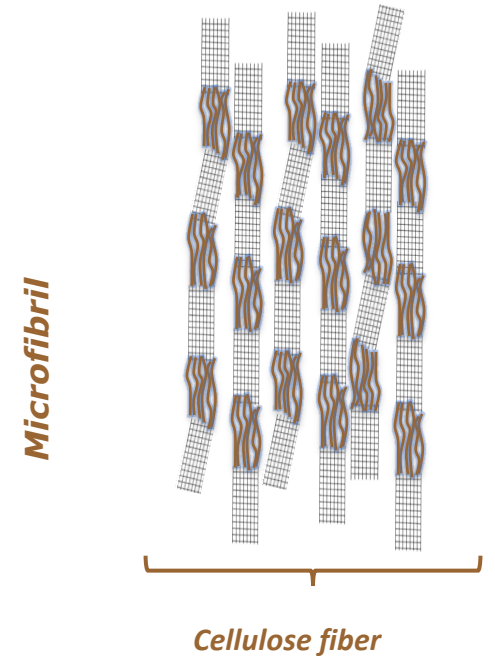
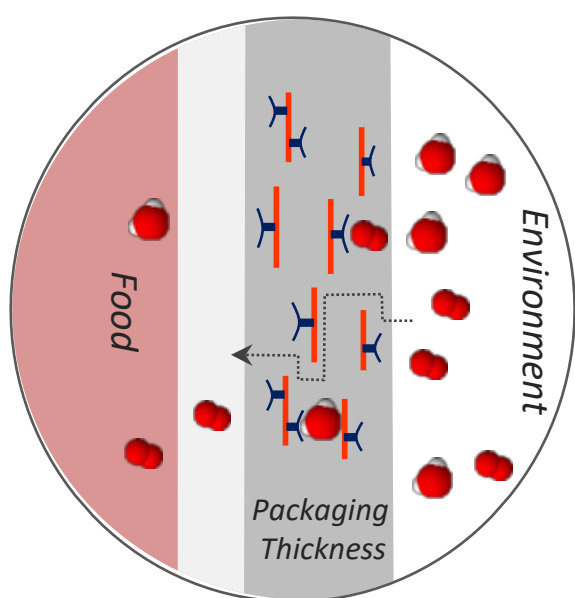


Defects
Bio-plastic PLA

- Inherent brittleness
- Low thermal stability
- Low gas barrier properties

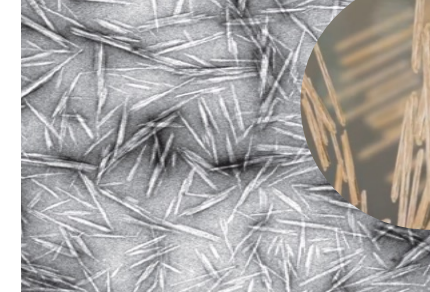
Objectives of the project “GASP”

- Develop innovative bio-based and bio-degradable packaging materials with high gas barrier properties
- Use nanocelluloses for property improvement



100% bio-based nanoparticles

Cellulose Nanocrystals (CNC)



D 2-20 nm
L 200-1000 nm

Specific Objectives:

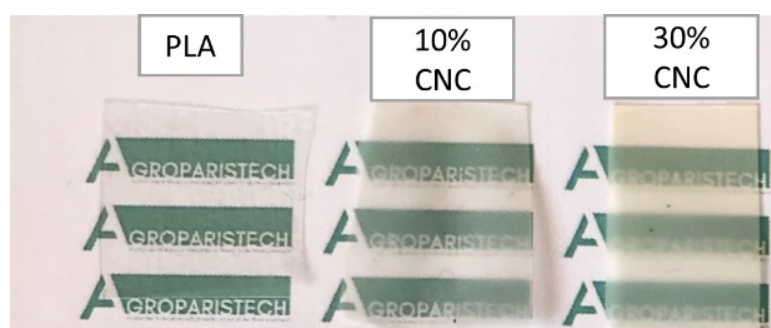
- Evaluate **hygienic properties** of the new PLA/CNC materials by adhesion and cross contamination tests with bacteria representative of common food pathogens and food spoilage
- Analyse the chemical and microbiological safety aspects of PLA packaging materials in a **real life conditioning experiment** of ham inside PLA trays compared to commonly used poly(ethylene terephthalate) (PET) trays under modified atmosphere

Materials and Methods

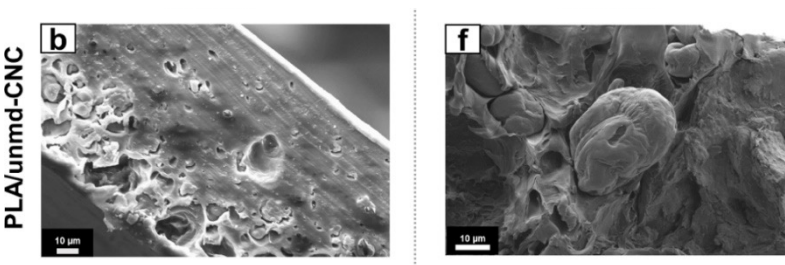
PLA/CNC materials



- Thermoformed trays of PLA 4060 D (NatureWorks)
- Lids:
 - PLA 4060 D (blank)
 - PLA/CNC 33 wt% obtained by twin-screw extrusion and thermoforming



PLA and PLA/CNC films



SEM images of PLA/CNC films

Benchmark:

- PET trays (PE seal layer)
- Lid: PET/PE/EVOH/PE

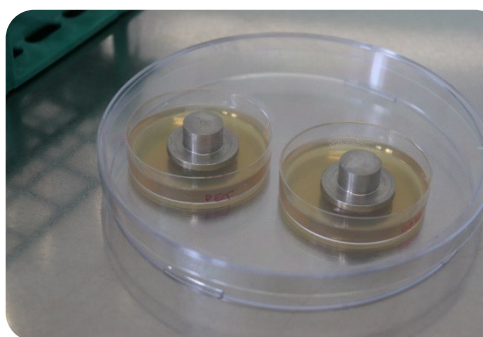
Hygienic evaluation

Bacterial Adhesion (in-house protocol):

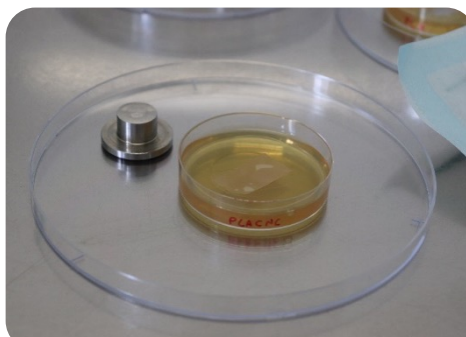
- Inoculation with bacterial suspension
- Adhesion: 2 hours at 8 °C (PLA, PET, LDPE), detachment with ultrasound bath for 2 min
- Counting of viable colonies after incubation on BHI agar for 24 h at 37 °C
- Analysis of total flora with epifluorescent coloration via optical microscopy

Cross Contamination test on food (ham), solid food model (TSA agar) and liquid food model (physiological water)

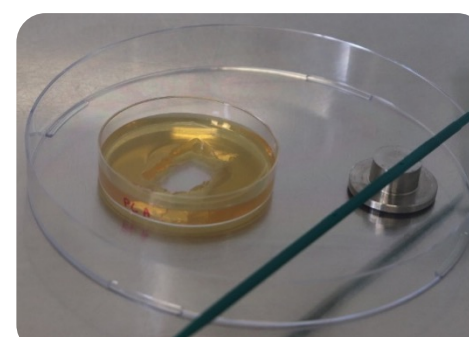
- Contamination of the material using the adhesion test
- Contact of the contaminated material with food model (see photos)
- Contact time: 24 h; contact pressure: 25 g
- Analysis of viable flora
 - Homogenization of solid food by a Stomacher (230 rev min⁻¹, 60 sec)
 - Serial dilution and incubation for 24 h at 37 °C for counting



Placement of polymers on food simulant (BHI agar) + 25 g weight



After 24 h of cross contamination



Polymer and food simulant taken for serial dilutions

Strain	Gram +/-	Microbial Risk
<i>Hafnia alvei</i>	-	Spoilage Bacteria
<i>Listeria monocytogenes</i>	+	Foodborne Pathogen

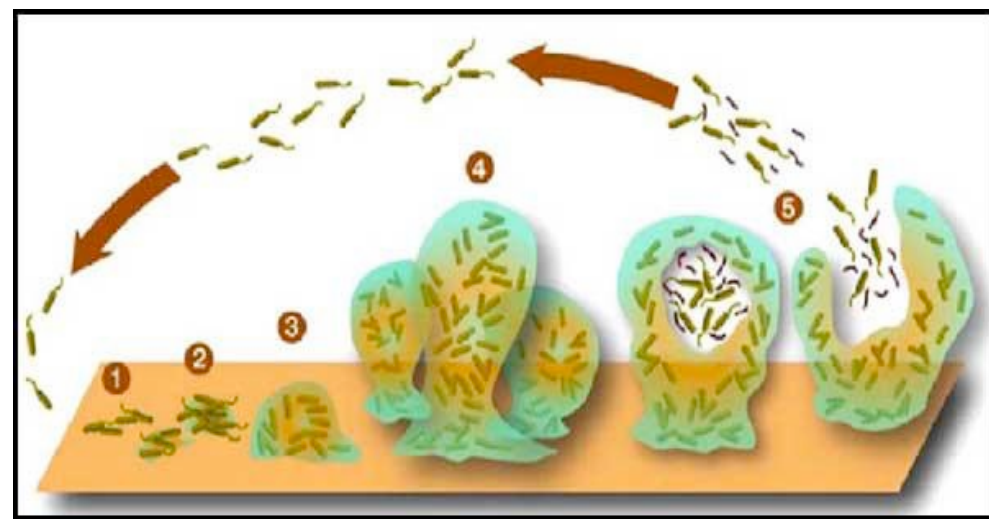
Conditioning under modified atmosphere



- Lidding machine Cryovac Multivac™ T 250
- Modified atmosphere: N₂/CO₂ 70/30
- Ham purchased from local supermarket
- Storage at 4 °C for 20 days
- Analysis of aspect, pH, total flora

Results

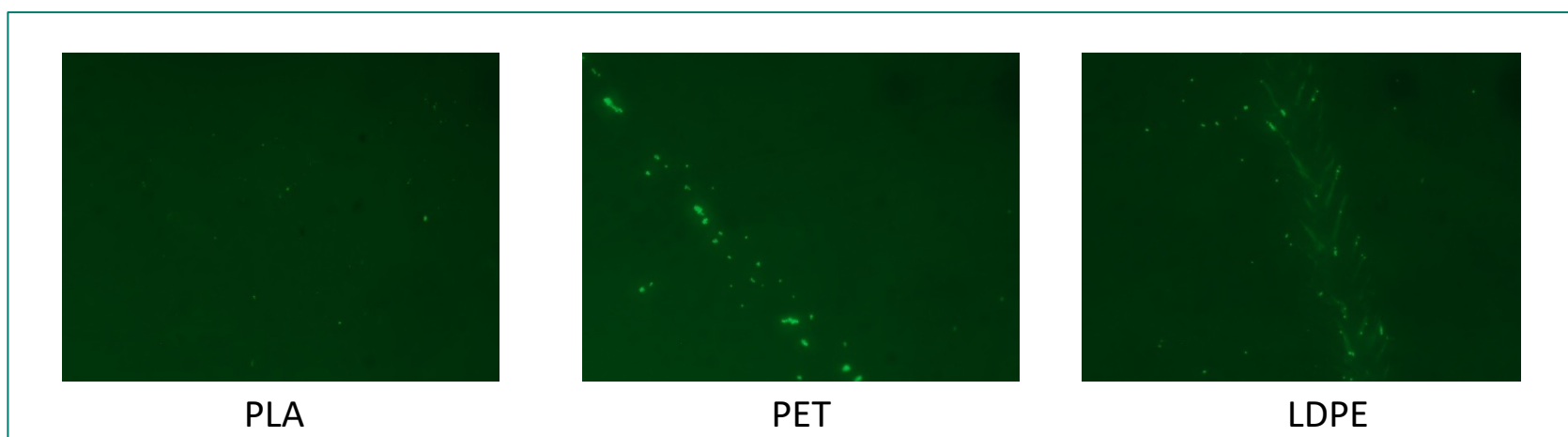
Microbial adhesion on polymers



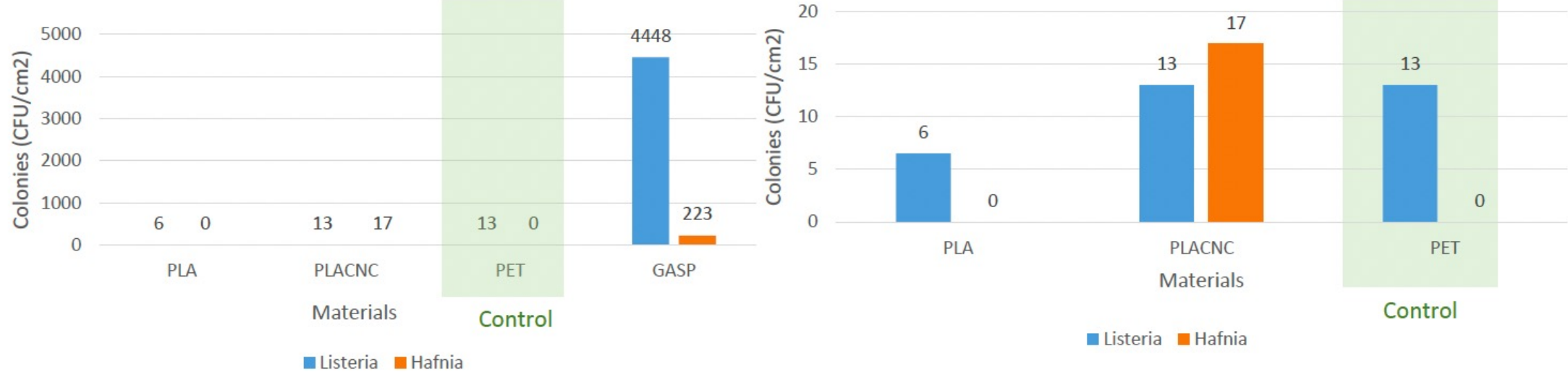
Bacterial adhesion and biofilm formation stages

The mechanism of adhering of bacteria to the surface is usually triggered by adhesion forces³

- Surface Charge, Surface Hydrophobicity
- Topological and mechanical surface characteristics
- Surface roughness, Surface hardness
- Environmental factors
 - Blooming of Additives
 - Presence of other substances (proteins, lipids ..)
 - pH and ionic force of the contact medium



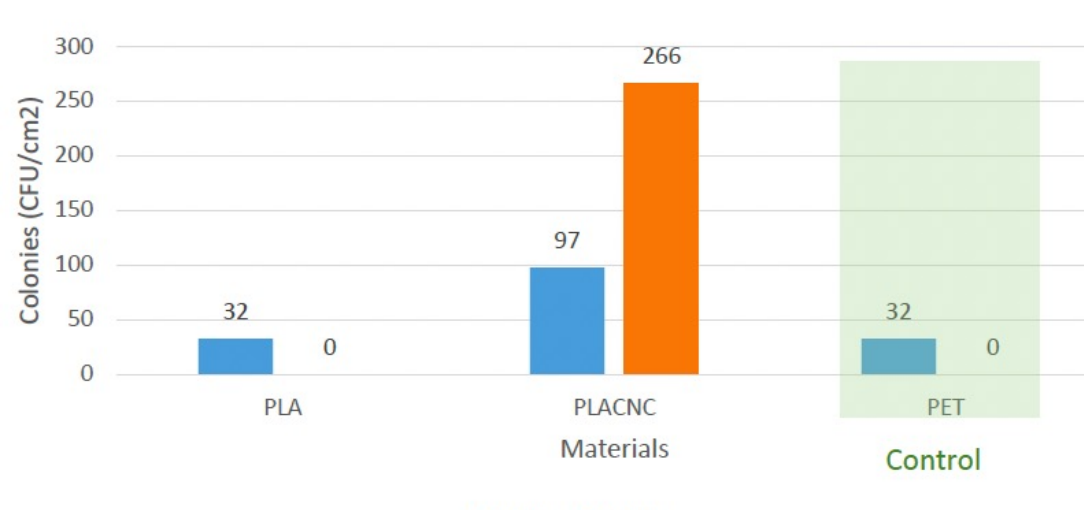
Bacterial adhesion on different materials



Count of bacterial adhesion on different materials

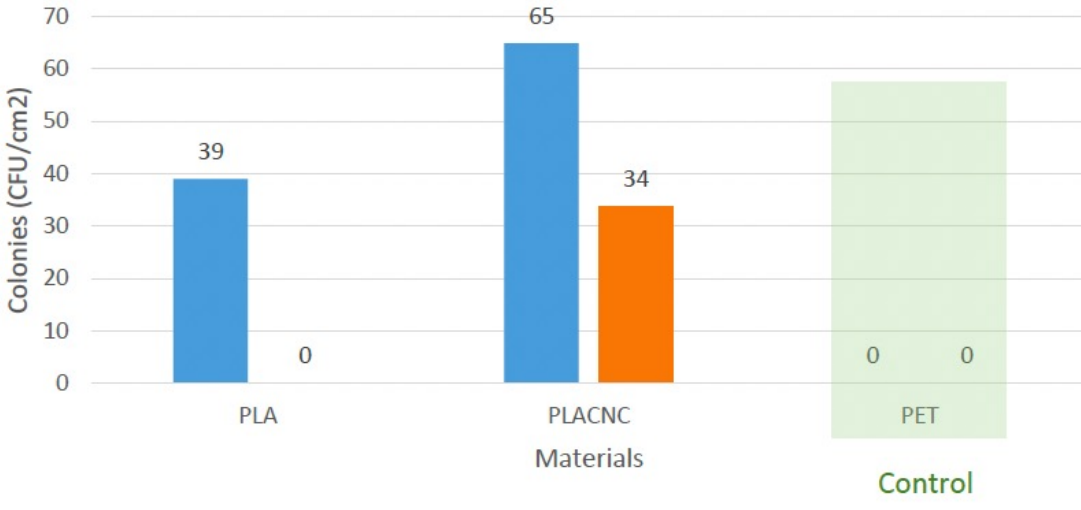
- High adhesion level for PLA/CNC (GASP) → delamination and roughness of cellulose particles
- Less contamination of PLA compared to PET

Cross-contamination of the food model by packaging



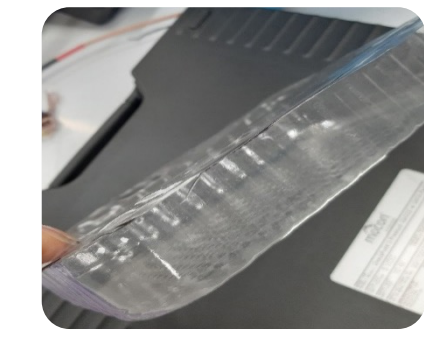
Bacteria remaining on the material after transfer

- Less contamination of PLA compared to PET but higher transfer to the food model



Bacteria transferred to the BHI agar

Shelf-life of ham in PLA versus PET trays

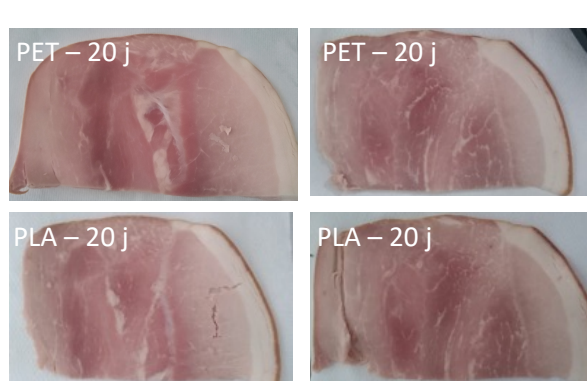
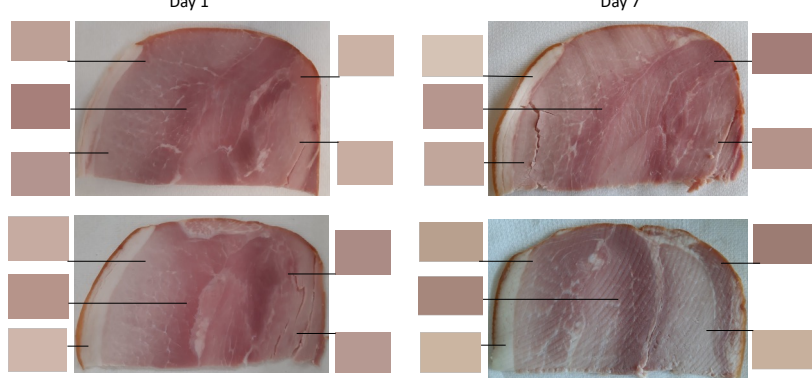
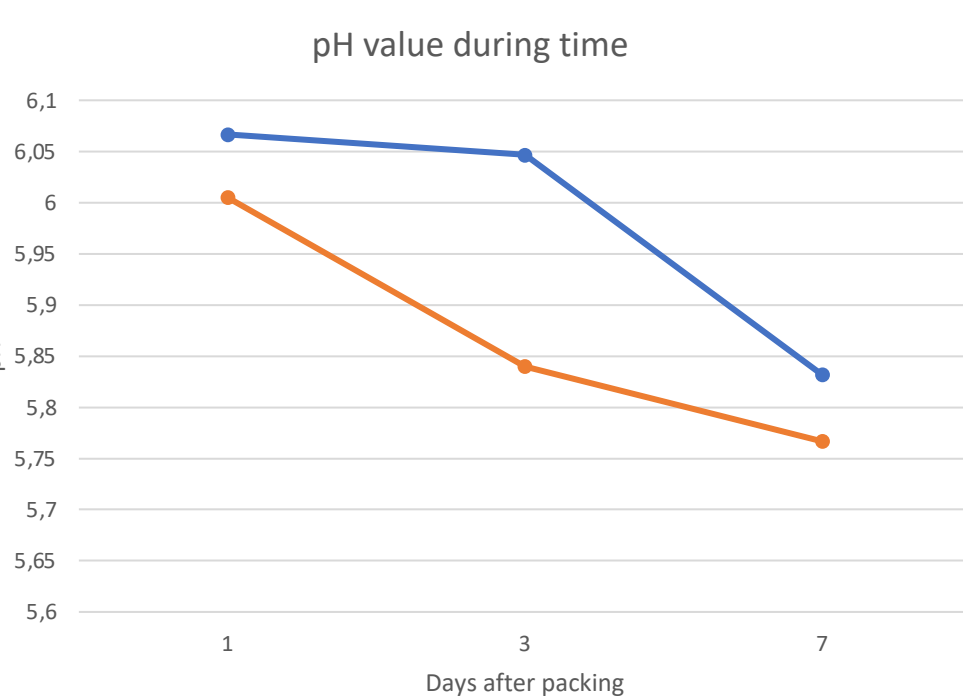
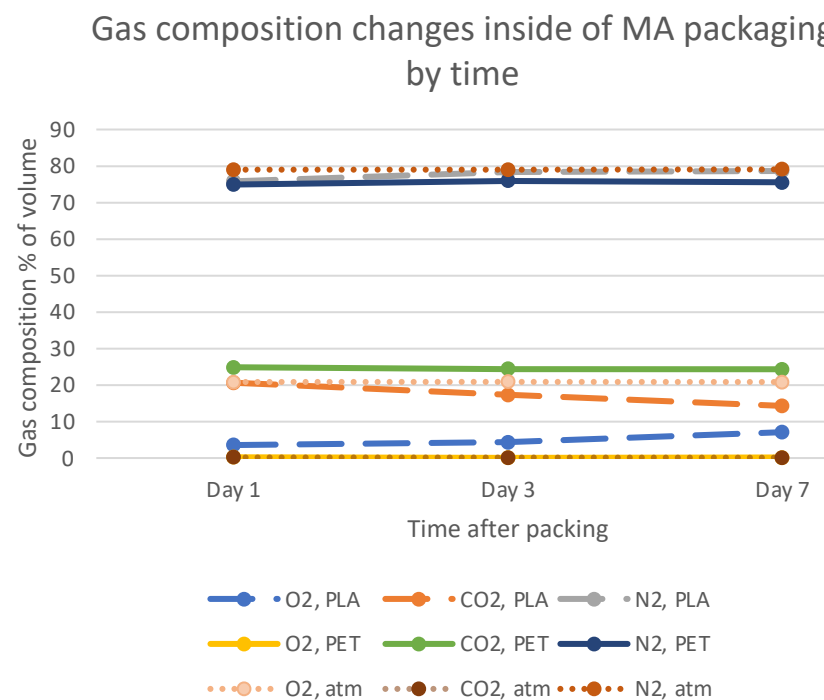


Heat sealing of PLA trays



Packaging under modified atmosphere

- Lower barrier properties of PLA cause lower shelf life
- PLA/CNC materials showed difficulties in heat sealing properties → optimization needed



Conclusions

- The biodegradable character of PLA does not induce a higher microbiological risk with respect to adhesion.
- The cross-contamination of the model food was higher for PLA than for PET.
- PLA trays could be heat-sealed and used in modified atmosphere packaging.
- The lower gas barrier properties of PLA with respect to PET diminished the shelf-life of ham.

→ This shows that the materials need to be optimized for equal performance.

ACKNOWLEDGEMENTS

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