**Study of optical, mechanical and permeability properties of sustainable packaging solutions for cured meat products**

Anna Mengozzi (anna.mengozzi@unipr.it)

Food and Drug Department, University of Parma, Parma, Italy

Tutor: Prof. Emma Chiavaro

This Ph.D. project aims to study the functional properties of sustainable packaging solutions specifically designed for cured meat products. In this work, optical, mechanical, and permeability properties of sustainable tray systems were investigated and compared with multilayer plastic materials suitable for cured meat products.

**Studio di proprietà ottiche, meccaniche e di permeabilità di packaging sostenibili per prodotti carnei affettati**

Lo scopo di questo dottorato è quello di studiare materiali di imballaggio sostenibili per prodotti carnei affettati. Pertanto, in questo lavoro le proprietà ottiche, meccaniche e di permeabilità di materiali di confezionamento sostenibili sono state studiate e comparate con materiali plastici multistrato utilizzati per il confezionamento di prodotti carnei affettati.

**Key words**: Food packaging, cured meat, barrier properties, optical properties, sustainability.

# **1. Introduction**

Common packaging for cured meat products relies on plastic multi-material trays and lids. However, these solutions are not environmentally sustainable as they derive from non-renewable sources, moreover, they are not biodegradable or compostable and the recycling process is still an open issue due to challenges with layer division (Horodytska et al., 2018). In accordance with the Ph.D. project, this poster reports the main results of the following activity:

1. Study of the optical, mechanical and permeability properties of a PET mono-material, and bio-based packaging compared with conventional multilayer plastic solution for cured meat products.

# **2. Materials and Methods**

A standard multilayer structure, made of APET-PE/EVOH/PE (T-STD250), were compared with alternative solutions: a mono-PET (PET/r-PET/PET) (T-PET), and a compostable biopolymer (T-Bio). Standard PET-PE-EVOH lid (L-EVOH) was compared with SiOx-coated PET (L-PETSiOx) and a biopolymer film (L-Bio). Optical properties (transparency and haze) were evaluated through a UV-Vis spectrophotometer (Lambda 650, PerkinElmer, Waltham, MA, USA). Mechanical properties (Young’s modulus (YM), elongation-at-break (EAB), and tensile strength (TS)) were measured using a dynamometer (Zwick Roell, Ulm, Germany) in machine (MD) and transverse direction (TD). Permeability properties of carbon dioxide (*CO2TR)*, oxygen (*O2TR)*, and water vapor barrier (*WVTR)* were determined with a permeability analyser (Extrasolution Srl, Capannori, Italy). The statistical analyses (one-way ANOVA, Tukey’s post-hoc, Dunnett’s T3) were carried out using the SPSS 27 software (SAS, Cary, NC).

# **3. Results and Discussion**

## **3.1 Optical properties**

## Tray materials displayed a decrease in transmission within the range of 200 – 400 nm (Figure 1), thus indicating good protection against UV light (Domínguez et al., 2019).

## **Figure 1.** *UV-Vis transmission spectra from 200 nm to 800 nm of tray packaging films. Legend: T-STD250 (black solid line), T-PET (grey solid line), T-Bio (black dotted line).*

## T-STD250 and the T-PET films exhibited the highest transmittance values within the visible region (84% < T550 < 86%), which indicates good transparency. These results can be attributed to the presence of amorphous PET, the main component of these tray films, characterized by a high clarity (Nisticò, 2020). However, the T-Bio film exhibited very low transmittance values at 550 nm (29%), due to the intrinsic opacity of the films. Among lid films, the transparency which is more important since it allows consumers to view the food products, ranged between 87 to 89% (data not shown).

## **3.2 Mechanical properties**

The plastic standard multilayer film exhibited YM value of ~ 1900 MPa in both machine and transverse directions. Nevertheless, the T-PET film showed significantly (p < 0.05) higher values of YM (2289 and 2250 MPa for TD and MD, respectively) as compared to the standard multilayer film, caused by the absence of PE layers which display good toughness. As expected, the T-Bio was characterized by the greatest value of YM, as well as by the lowest EAB value, which is attributed to the high brittleness and low plasticity of biobased polyesters (De Beukelaer et al., 2022).

Regarding the lid films (Table 1), L-EVOH exhibited good mechanical properties, thus showing good ductility, with a percentage of EAB ranging between 39% and 47%. Interestingly, the L-PETSiOx film showed the highest value of YM, together with acceptable extensibility (29% and 39% in TD and MD, respectively). The high YM of L-PETSiOx is related to the presence of the rigid silicon oxide layer (YMmetal ≈ 80 GPa) (Howells et al., 2008). The L-Bio carried a higher YM and significantly lower EAB in MD (7 %) as compared to the standard material (p < 0.05), due to the PLA layer which provides brittleness and rigidity (Pietrosanto et al., 2020).

**Table 1.** *Values of mechanical parameters for the lid materials.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Lid sample** | **E (MPa)** | **EAB (%)** | **TS (MPa)** |
| TD | MD | TD | MD | TD | MD |
| L-EVOH | 1343 ± 152a | 1356 ± 43A | 39.9 ± 7.0b | 47.5 ± 7.2B | 37.8 ± 2.0a | 37.8 ± 1.1A |
| L-PETSiOx | 4575 ± 488c | 4698 ± 144C | 29.5 ± 7.6a | 40.0 ± 7.1B | 133.8 ± 17.9c | 135.3 ± 8.8C |
| L-Bio | 2817 ± 347b | 2998 ± 337B  | \*33.6 ± 5.6ab | \*7.2 ± 3.9A | 63.8 ± 2.3b | 65.5 ± 2.6B |

# Significant differences (p < 0.05) among materials when evaluated in TD (lowercase letters) or MD (uppercase letters), respectively. \* Indicates a significant difference (p < 0.05) between MD and TD for the same material

## **3.3 Barrier properties**

Regarding tray films, the CO2 barrier properties of T-Bio (0.53 cm3 m-2 day-1) exhibited a significantly higher value (p < 0.05) compared to the standard multilayer film (1.53 cm3 m-2 day-1). It is interesting to note that water vapour transmission rates were analogous (p > 0.05) between T-PET, and T-Bio.

Regarding lid films, L-EVOH and L-PETSiOx showed comparable CO2TR and O2TR values (p > 0.05), suggesting that both the applied barrier film, respectively EVOH and SiOx, were accountable for the limited transfer of carbon dioxide and oxygen through the lid films (Korte et al., 2023). L-Bio exhibited statistical differences (p < 0.05) in CO2TR compared to L-EVOH and L-PETSiOx. Finally, the comparison between samples concerning the WVTR parameters revealed that materials performed fine with similar values. In these results, the L-EVOH film lid was characterized by a significantly higher value (4.97 g m-2 day-1) compared to the other ones (p < 0.05).

The results obtained in this study showed the potential of alternative solutions to replace multilayer plastic materials designed for cured meat products, which can be exploited in future packaging development.

# **4. Acknowledgment**

This work was carried out in collaboration with the University of Milan together with Dr. Daniele Carullo and Prof. Stefano Farris.

# **5. References**

De Beukelaer, H., Hilhorst, M., Workala, Y., Maaskant, E., & Post, W. (2022). Overview of the mechanical, thermal and barrier properties of biobased and/or biodegradable thermoplastic materials. Polymer Testing, 116, 107803.

Domínguez, R., Pateiro, M., Gagaoua, M., Barba, F. J., Zhang, W., & Lorenzo, J. M. (2019). A comprehensive review on lipid oxidation in meat and meat products. Antioxidants, 8(10), 429.

Horodytska, O., Valdés, F. J., & Fullana, A. (2018). Plastic flexible films waste management–A state of art review. Waste management, 77, 413425.

Howells, D. G., Henry, B. M., Leterrier, Y., Månson, J. A., Madocks, J., & Assender, H. E. (2008). Mechanical properties of SiOx gas barrier coatings on polyester films. Surface and Coatings Technology, 202(15), 3529-3537.

Korte, I., Albrecht, A., Mittler, M., Waldhans, C., & Kreyenschmidt, J. (2023). Quality impact of sustainable ma-packaging options for emulsion-type sausage: A German case study. Future Foods, 7, 100218.

Nisticò, R. (2020). Polyethylene terephthalate (PET) in the packaging industry. Polymer Testing, 90, 106707.

Pietrosanto, A., Scarfato, P., Di Maio, L., Nobile, M. R., & Incarnato, L. (2020). Evaluation of the suitability of poly (lactide)/poly (butylene-adipate-co-terephthalate) blown films for chilled and frozen food packaging applications. Polymers, 12(4), 804.