



**New bio-based food packaging materials  
with enhanced barrier properties**

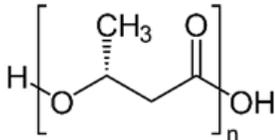
# **Mechanical and Barrier Properties of PHA**

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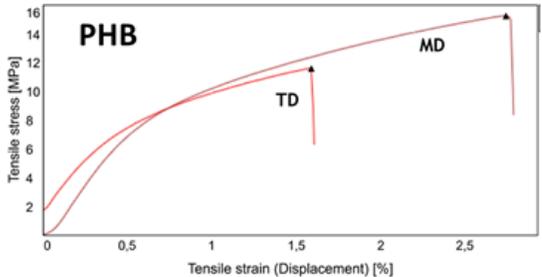
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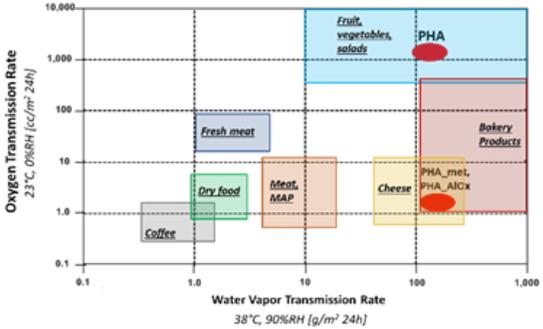
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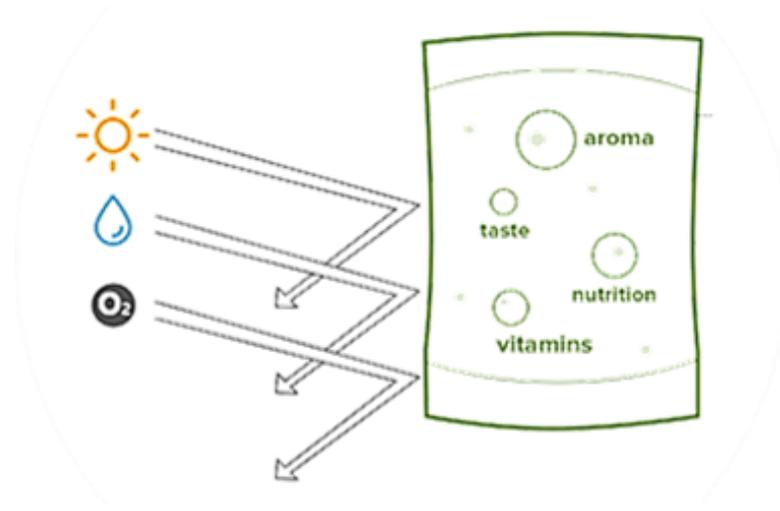
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# Introduction

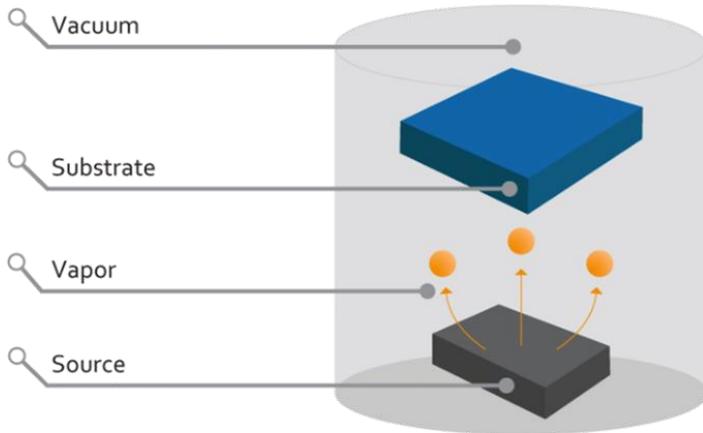
- ✓ Barrier properties of the flexible film, especially to water vapor and oxygen, establish the shelf life of the food packed, delaying its deterioration
- ✓ the mechanical properties of the flexible film are strictly related to the its runnability through all the steps of the converting and confectionary
- ✓ The use of bioplastics is limited in the food flexible packaging, due to their poor barrier and mechanical properties



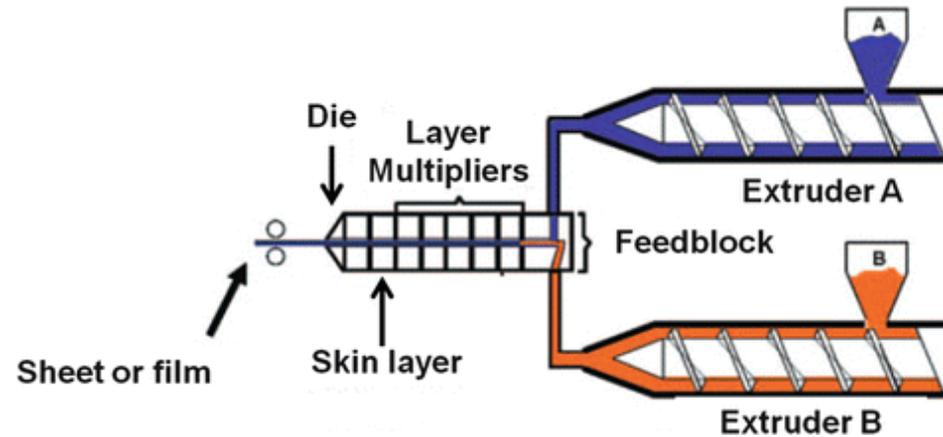
# Introduction

For conventional flexible plastics, to improve the barrier properties of a polymer, two main routes are used:

- ✓ **SURFACE TREATMENTS**  
(metallization, AlOx, SiOx)



- ✓ **COEXTRUSION WITH A BARRIER POLYMER**

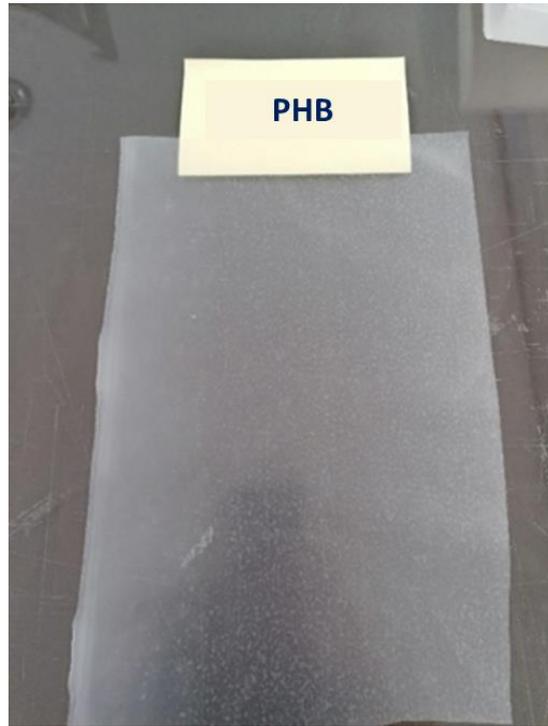


- ✓ **The coextrusion could also increase the mechanical properties of plastic films**

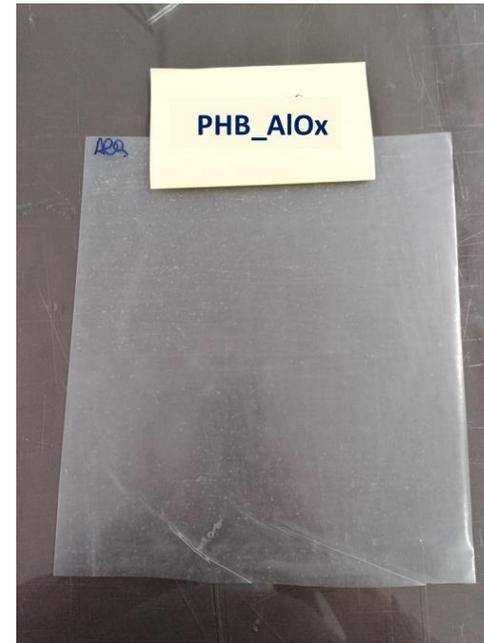
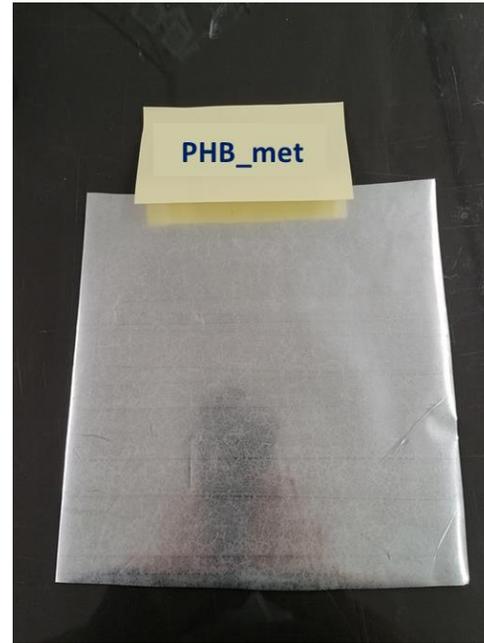
# Materials & Methods

Materials characterized for mechanical and barrier properties

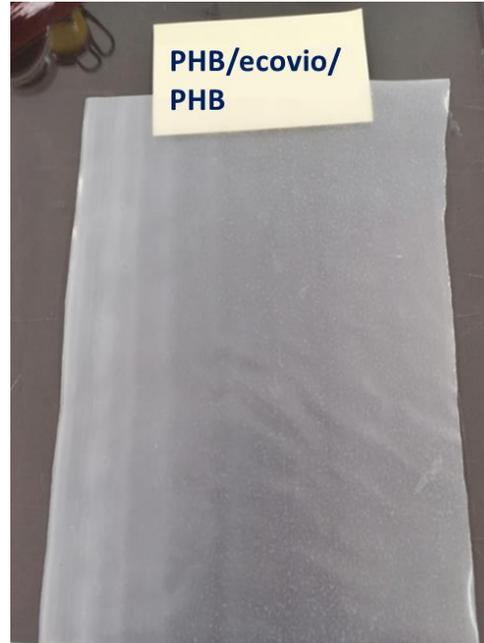
## ✓ Pristine PHB



## ✓ Surface treated PHB



## ✓ Coextruded PHB



# Materials & Methods

## Methods for the characterization of mechanical and barrier properties of flexible materials

### Tensile testing

**ASTM D882:** “Standard Test Method for Tensile Properties of Thin Plastic Sheeting”



- ✓ Stress-strain curve
- ✓ Tensile strength
- ✓ Elongation at break

### Permeability testing

**ASTM F1249:** “Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor”

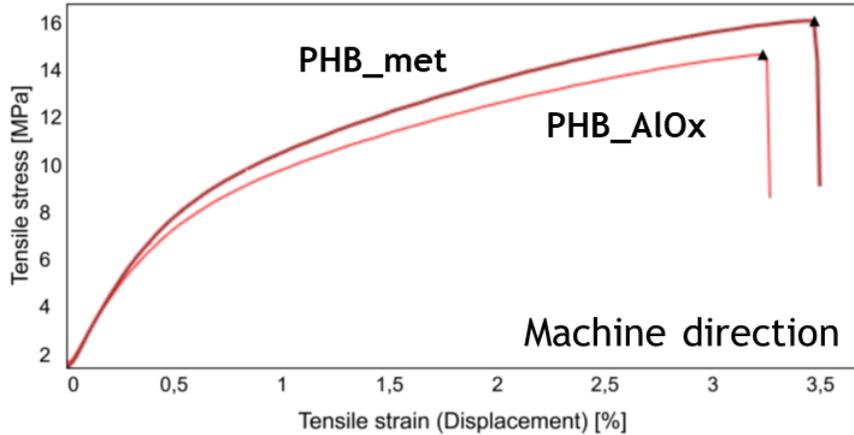
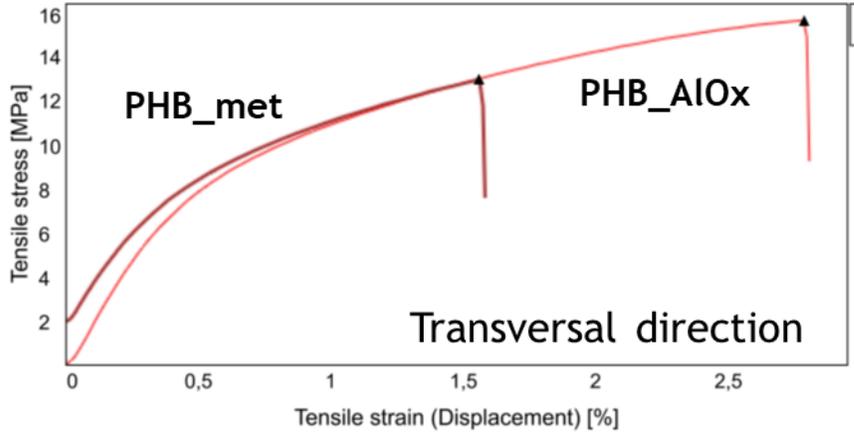
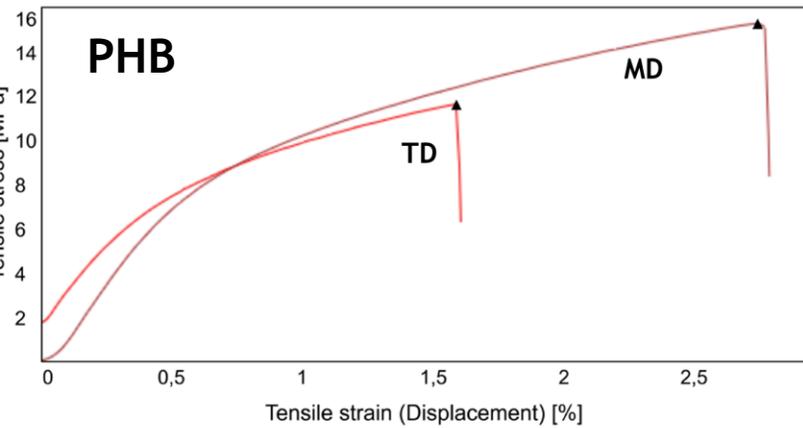
**ASTM D3985:** “Standard Test Method for Oxygen Gas Transmission Rate Through Plastic Film and Sheeting Using a Coulometric Sensor”



- ✓ WVTR
- ✓ OTR

# Results: Mechanical Properties

## Surface treated films



	$\epsilon_{\min} - \epsilon_{\max}$ (%)	$\sigma_{\max}$ (MPa)
PHB MD	2.7	15.3
PHB TD	1.6	11.7
PHB_Met MD	3.2	16.1
PHB_Met TD	1.6	14.3
PHB_AIOx MD	3.5	14.7
PHB_AIOx TD	2.8	15.5

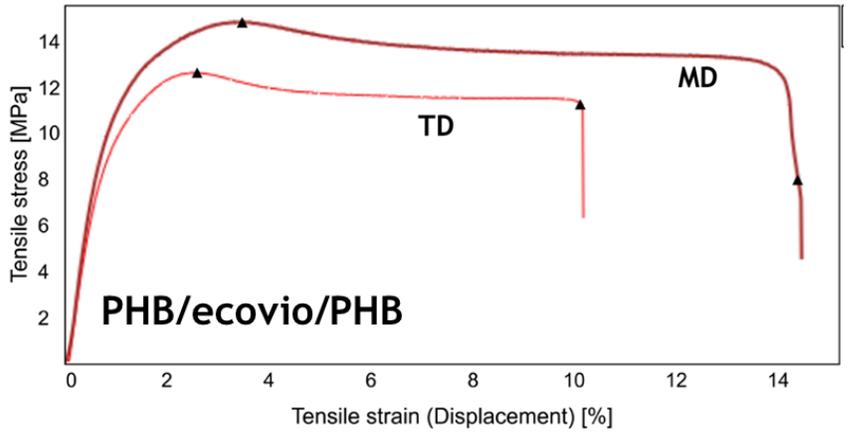
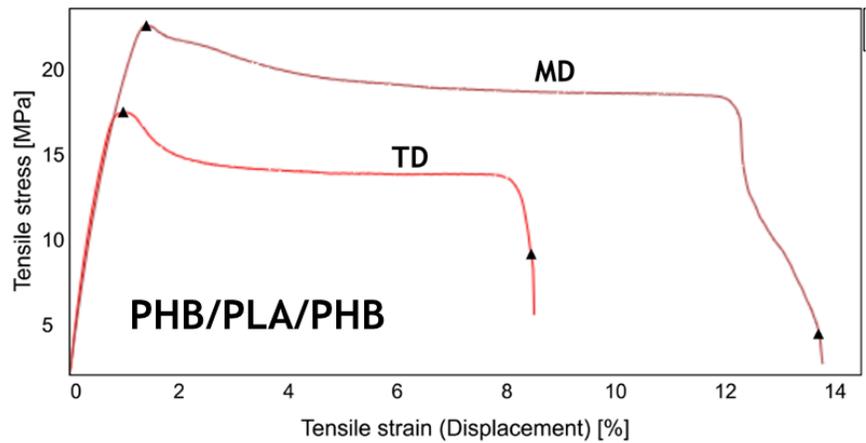
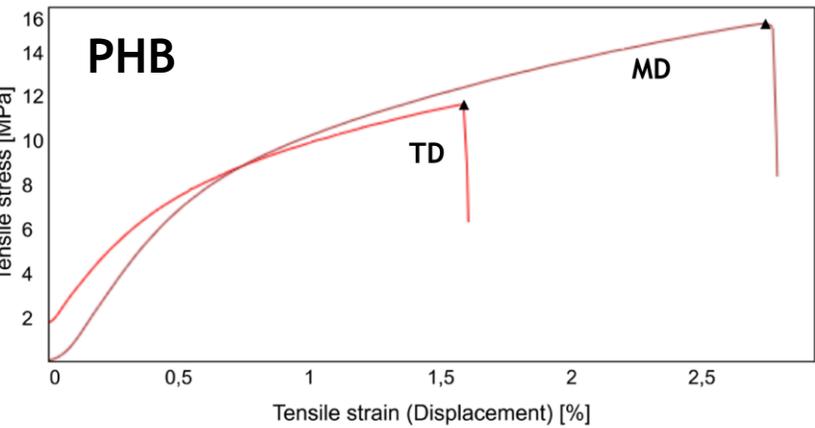
\*data represent an average several trials carried out

✓ Mechanical properties are not influenced by the presence of the thin layer of Al or AlOx



# Results: Mechanical Properties

## Coextruded films



	$\epsilon_{min} - \epsilon_{max}$ (%)	$\sigma_{max}$ (MPa)
PHB MD	2.7	15.3
PHB TD	1.6	11.7
PHB/PLA/PHB MD	12	22.6
PHB/PLA/PHB TD	8.4	17.5
PHB/ecovio/PHB MD	14	14.8
PHB/ecovio/PHB TD	10	12.6
PP coex MD	220	170
PP coex TD	80	280

\*data represent an average several trials carried out

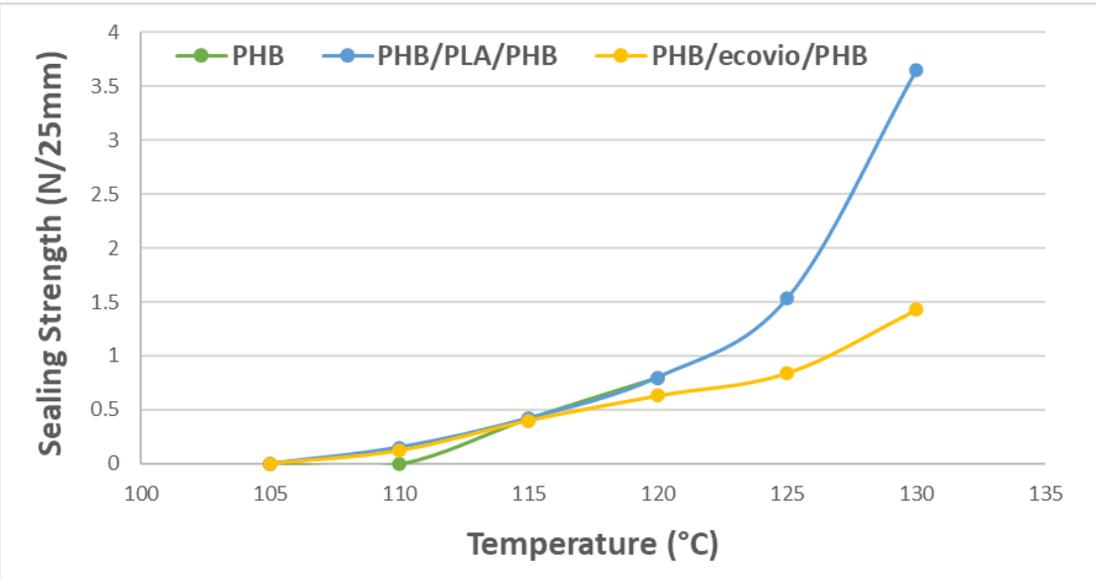
✓ The presence of a coextruded layer improves the mechanical properties of PHB and moves the behavior from fragile to plastic



# Results: Mechanical Properties

## Coextruded films

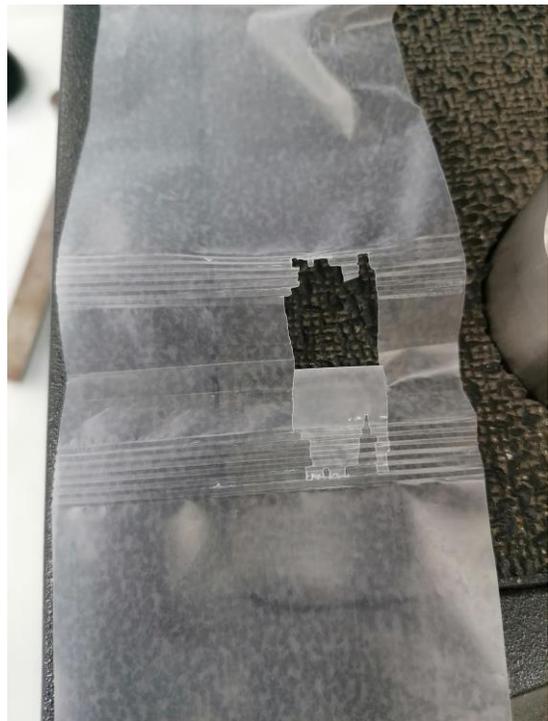
Seal Initiation temperature measurements



**ASTM F88:** Standard Test Method for Seal Strength of Flexible Barrier Materials

**Pressure 4bar; jaws time contact:0.5s**

- ✓ The improvement of mechanical properties for coextruded films also increase the stability of PHB under the sealing jaws



# Results: Barrier Properties

WVTR: measurements at 38°C, 90%RH

OTR: measurements at 23°C, 0%RH

## Coextruded films

	WVTR [g/m <sup>2</sup> 24h]	OTR [cc/m <sup>2</sup> 24h]
PHB	322	2597
PHB/PLA/PHB	295	1044
PHB/ecovio/PHB	251	1638

\*data represent an average several trials carried out

- ✓ Compared to PHB, coextruded films result to have similar barrier to water vapor. The OTR is slightly reduced.

## Surface treated films

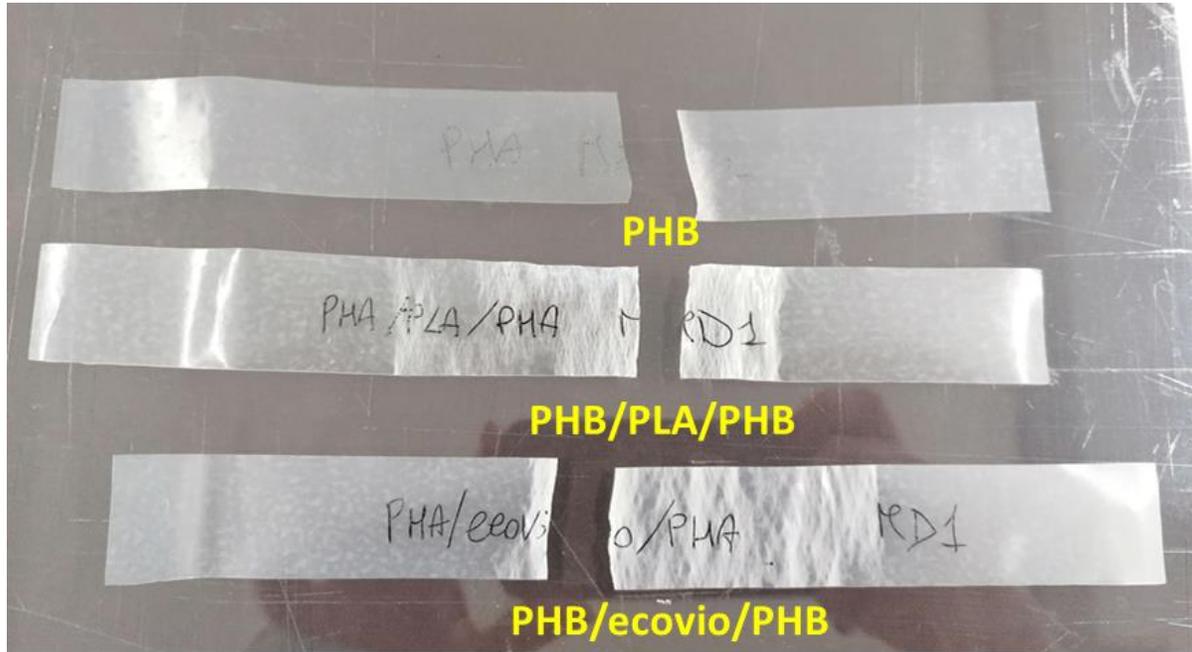
	WVTR [g/m <sup>2</sup> 24h]	OTR [cc/m <sup>2</sup> 24h]
PHB	322	2597
PHB_met	138	1,77
PHB_AlOx	142	2,66

\*data represent an average several trials carried out

- ✓ Both the surface treatments are able to improve water vapor and oxygen barrier performances of PHB: the decrease is more than 50% for WVTR and more than 99.8% for OTR.

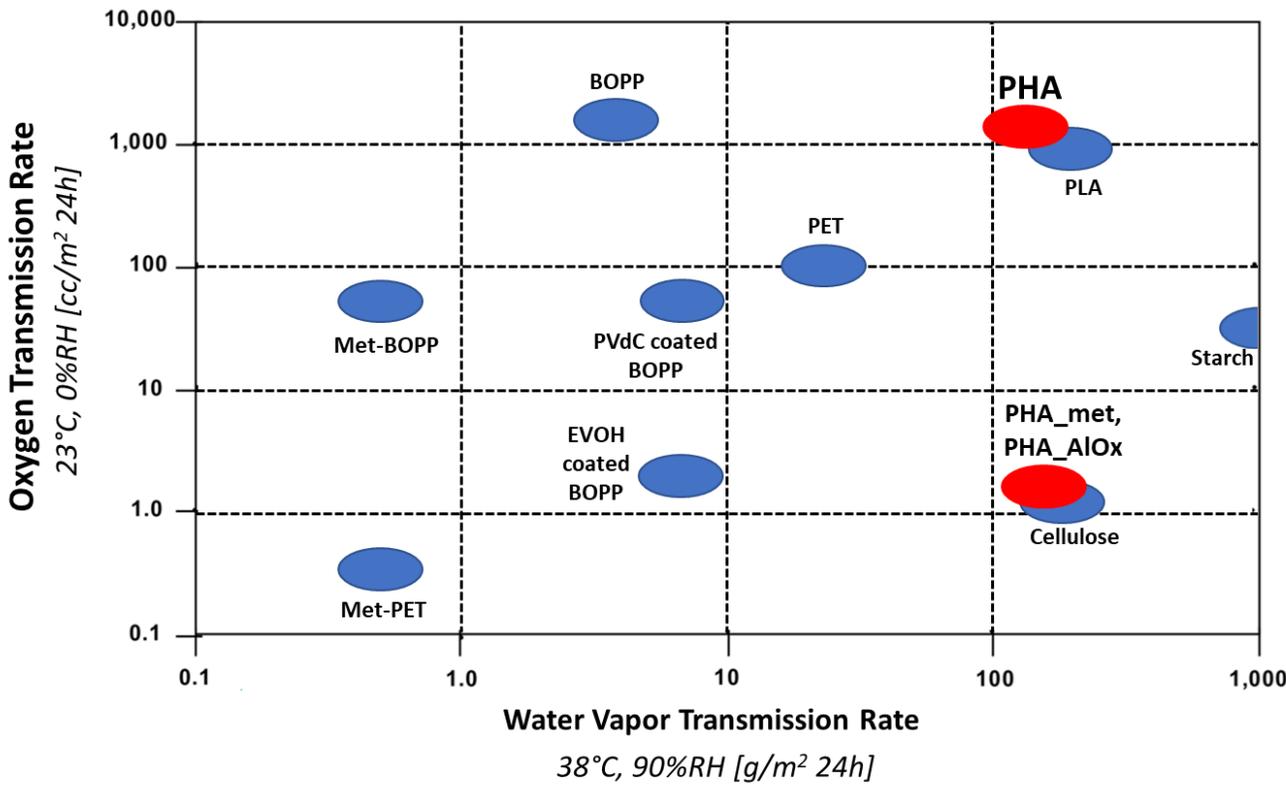


# Final Comments: Mechanical Properties

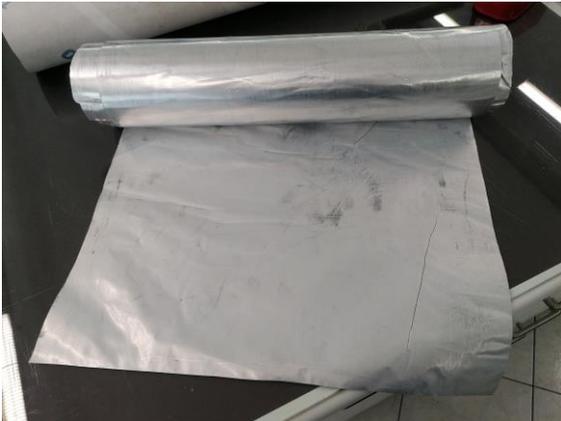


- ✓ Coextrusion with other compostable polymers seems to be the most promising route for the improvement of mechanical properties of PHB
- ✓ Coextruded films present a plastic deformation to break, while the PHB has a fragile behavior.
- ✓ Coextrusion could increase the mechanical stability of the PHB during the confectionary process

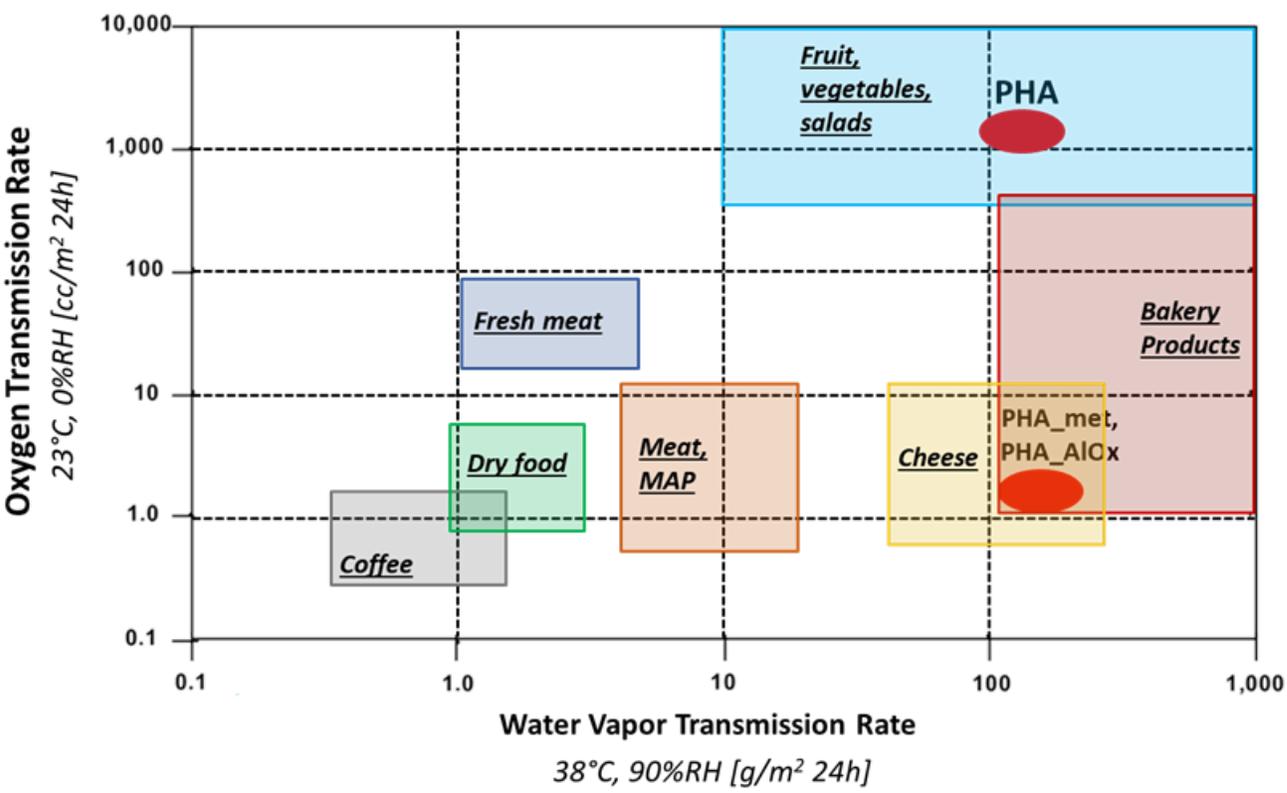
# Final Comments: Barrier Properties



- ✓ PHB barrier properties result to be similar to the other bioplastics used in flexible packaging
- ✓ Surface treatments improve (over 99%) the oxygen barrier properties of PHB



# Final Comments: Barrier Properties



- ✓ PHB results to be a potential packaging material for the confectionary of fresh food, such as fruit, vegetables and salads
- ✓ Surface treated PHB films result to be potentially suitable also for bakery products and cheese, as they guarantee a high barrier to oxygen



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