ActInPak

COST Action FP1405

Active and intelligent fibre-based packaging – innovation and market introduction

Development of a novel oxygen scavenger film and its potential application in food packaging

Prof. Dr. Selcuk Yildirim

cost
EUROPEAN COOPERATION
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COST is supported by
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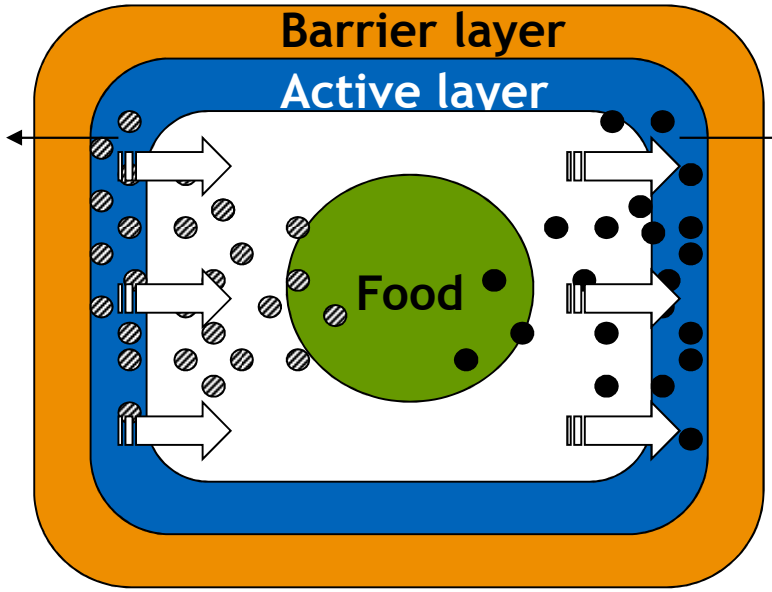
Active Packaging

- Active Packaging: „..designed to deliberately incorporate components that would release or absorb substances into or from the packaged food or the environment surrounding the food“ Regulation (EC) No 1935/2004

*** Active Releasing Systems**
- Antimicrobial agent
- CO_2
- Antioxidant
- Flavours
- Ethylene



Active Scavenging Systems
- Oxygen
- CO_2
- Moisture
- Ethylene
- Odour

* Yildirim S. *Active Packaging for Food Biopreservation*, in *Protective Cultures, Antimicrobial Metabolites and Bacteriophages for Food and Beverage Biopreservation*, Lacroix C (ed). Woodhead Publishing: Cambridge, 2011; 460-489.

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Food Trends

- Increase in consumer demand* for
  - natural high-quality foods less additives and without any preservatives
  - No harsh preservation process (non-processed or minimally processed)
  - fresh and convenient food products

- Acceptable shelf life and safe products
- Barrier properties reached their limits
- New packaging technologies
  - Active packaging

* Innova Market Insights: Top Ten Trends for 2016

Oxygen Scavengers

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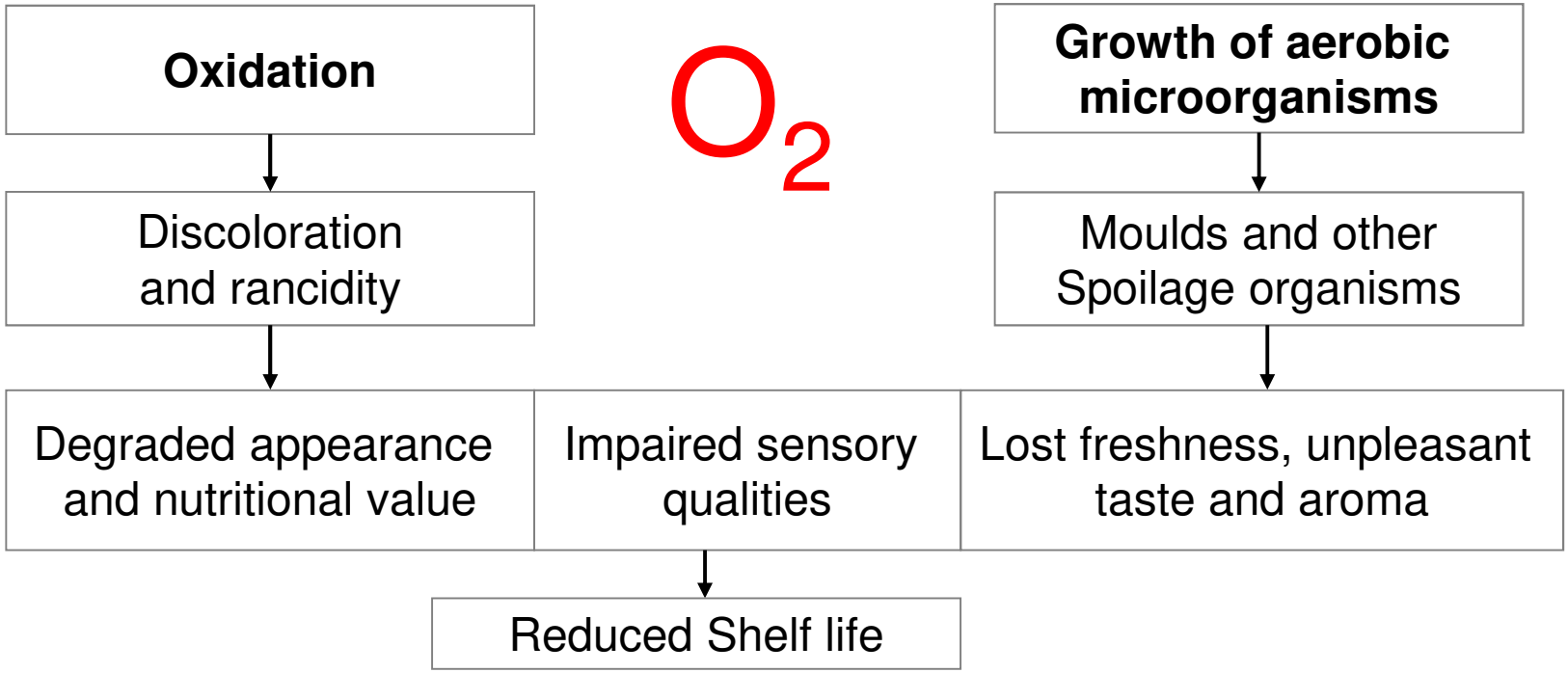

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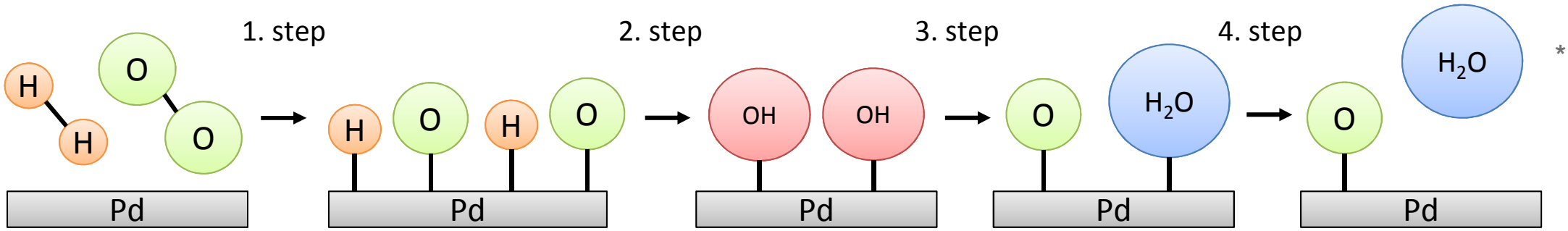
Palladium Based Oxygen Scavenger

$$H_2 + \tfrac{1}{2} O_2 \xrightarrow{Pd} H_2O$$



*

*Sängerlaub, S., Witzgall, S., & Müller, K. (2012). Palladium Based Oxygen Scavengers (Poster). In *5th international Symposium on Food Packaging*. Berlin.

Palladium Based Oxygen Scavenger

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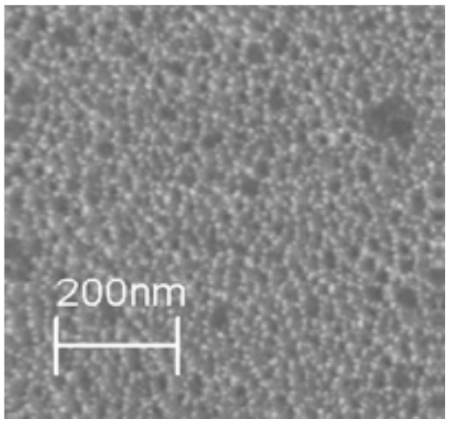

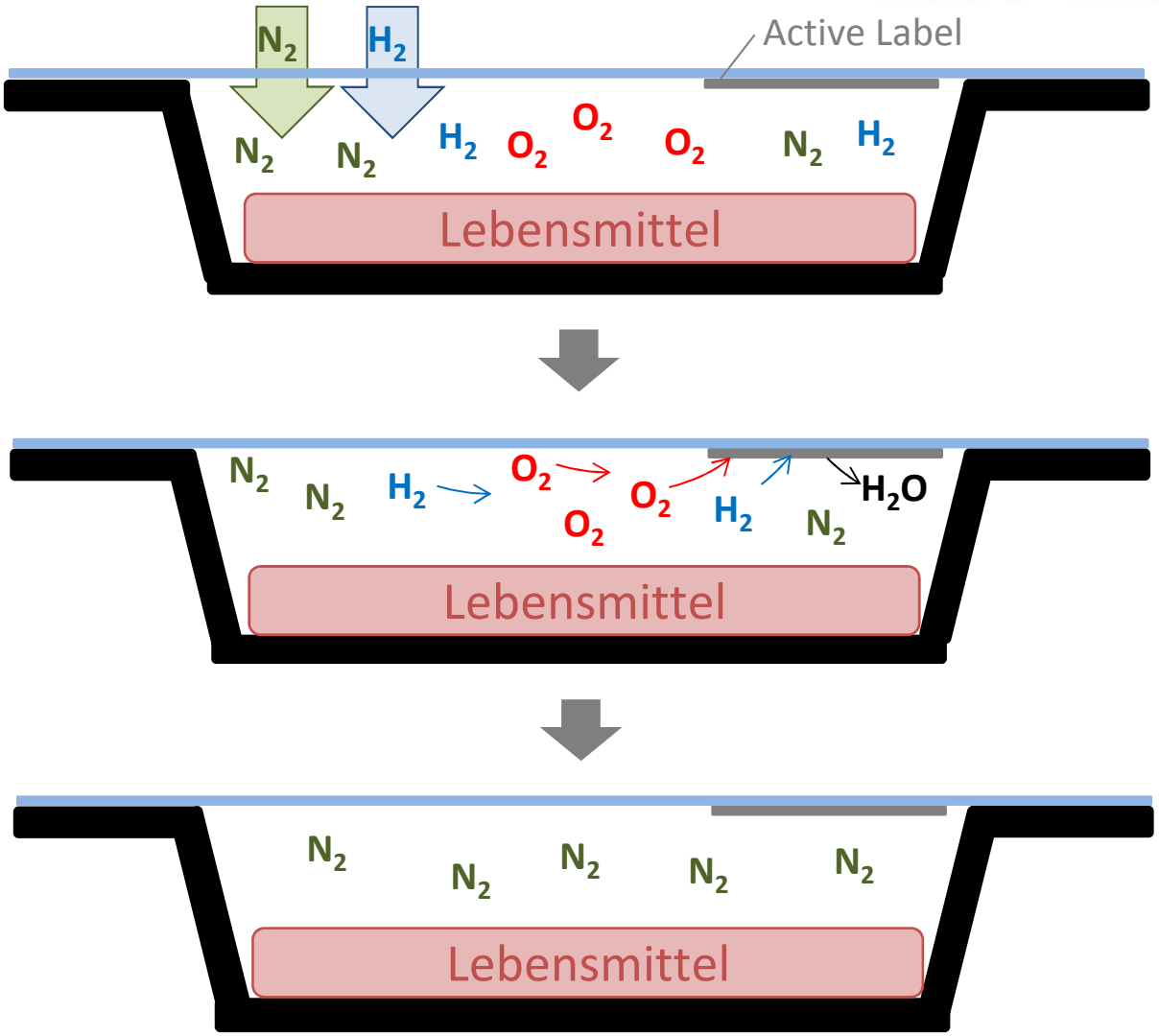

Lohwasser W, Wanner T. *Composite system, used as packaging foil, bag foil or partially applied single foil, comprises substrate foil thin film and catalyst for reduction of oxygen. European Patent, 1917139, 22/11/2005.*

Yildirim S, Jammet JC, Lohwasser W. Multi-layer film. European Patent, 2236284, 6/10/2010.

Effect of Coating Substrate on the Oxygen Scavenging Activity

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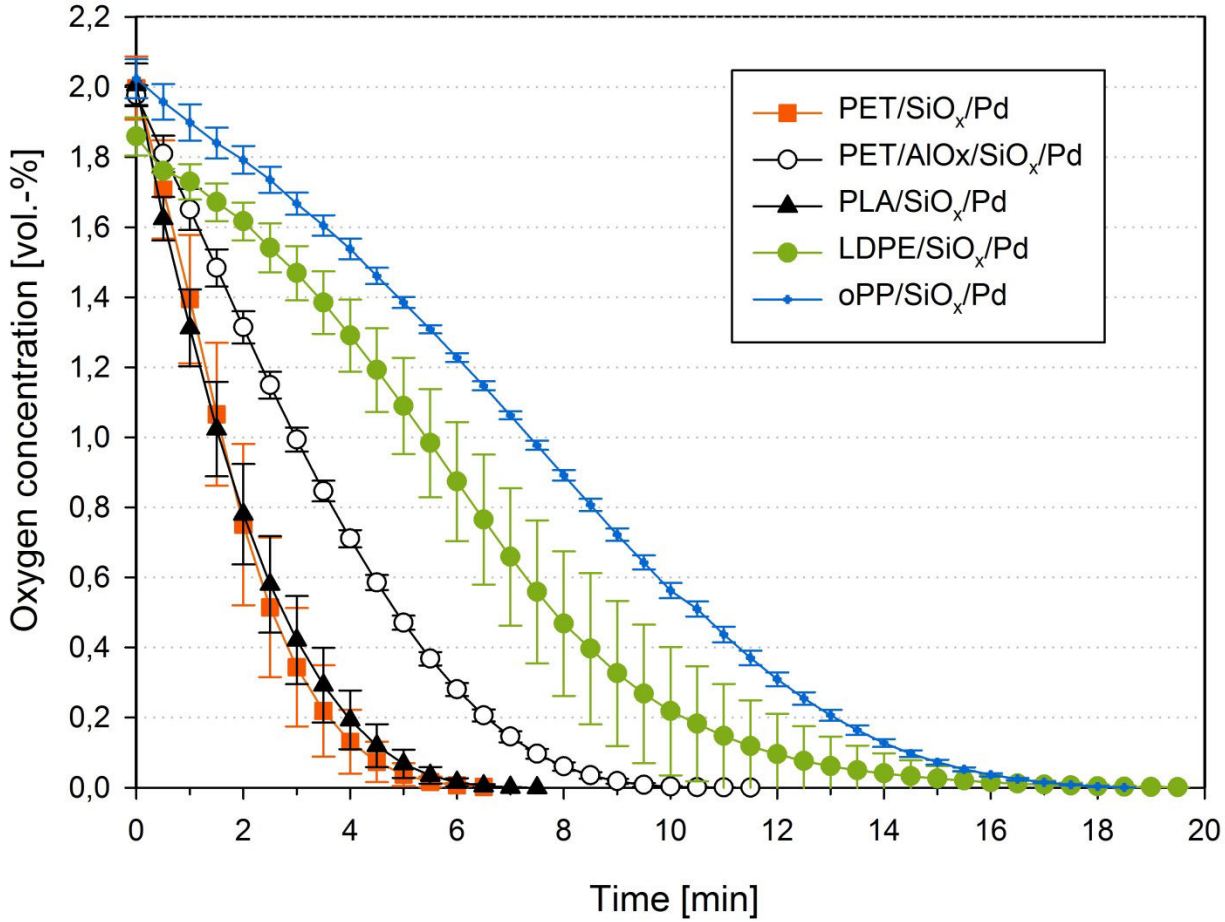
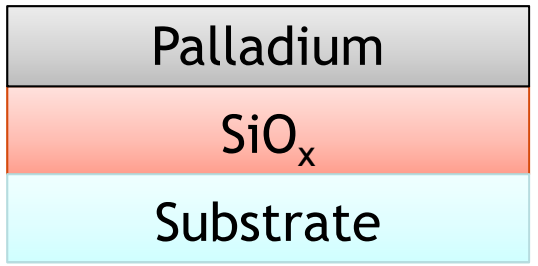


Oxygen Scavenger



Best Substrates:

- PET
- PET/AlOx
- PLA
- LDPE
- oPP

Reduction in oxygen concentration in the measurement cell with PET/SiO_x/Pd, PET/AlOx/SiO_x/Pd, PLA/SiOx/Pd, LDPE/SiO_x/Pd and oPP/SiO_x/Pd films using a palladium deposition thickness of 1.1 nm and SiO_x pre-coating. Mean values ± standard deviation (n=3).

Yildirim S, Röcker B, Rüegg N, Lohwasser W. Development of Palladium-based Oxygen Scavenger: Optimization of Substrate and Palladium Layer Thickness. *Packaging Technology and Science* 2015. 28(8): pp. 710-718, DOI: 10.1002/pts.2134.

Effect of Palladium Deposition Thickness on the Oxygen Scavenging Activity

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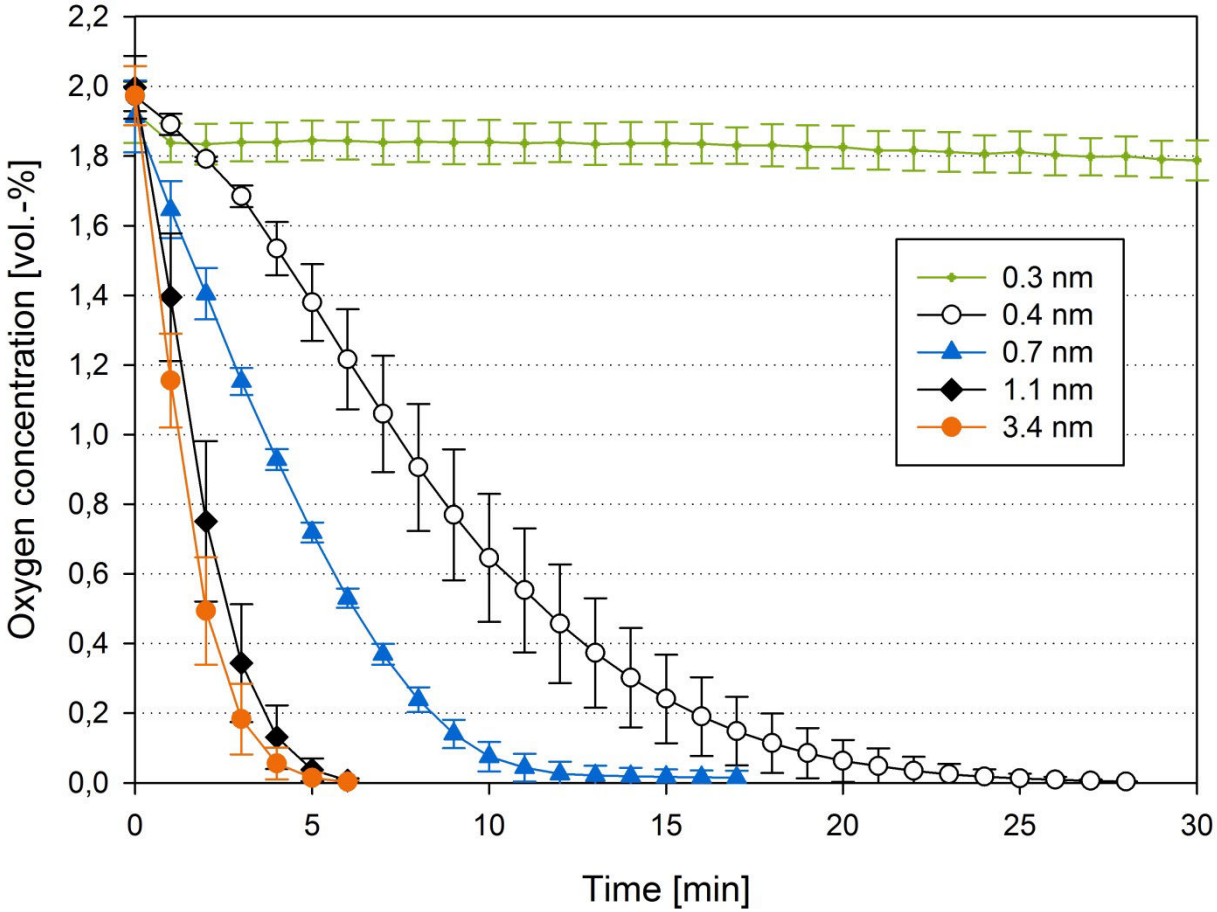
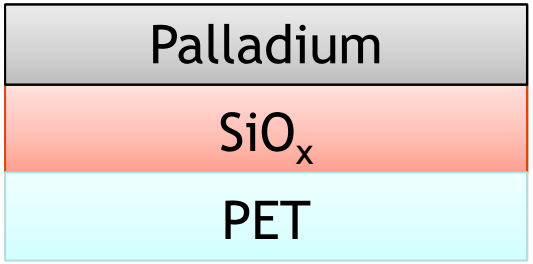


Oxygen Scavenger



Reduction in oxygen concentration in the measurement cell with PET/SiOx/Pd films using Pd-deposition thicknesses of 0.3, 0.4, 0.7, 1.1 and 3.4 nm. Mean values ± standard deviation (n=3).

Yildirim S, Röcker B, Rüegg N, Lohwasser W. Development of Palladium-based Oxygen Scavenger: Optimization of Substrate and Palladium Layer Thickness. *Packaging Technology and Science* 2015. 28(8): pp. 710-718, DOI: 10.1002/pts.2134.

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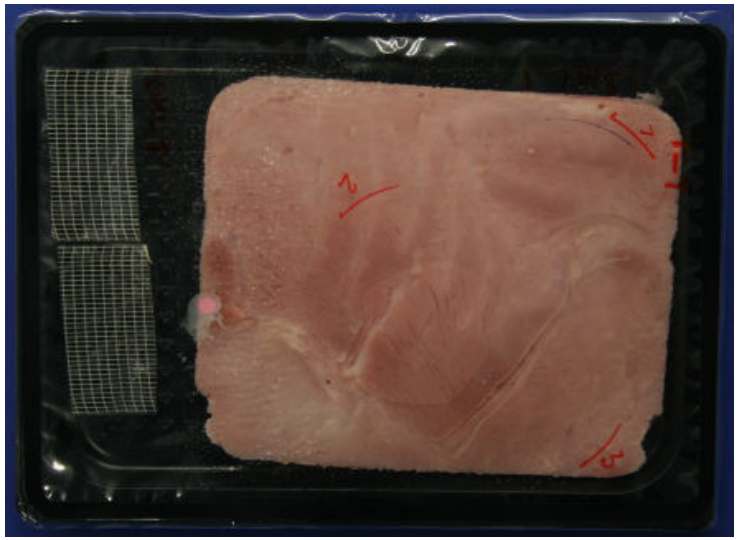
A case study:

Use of palladium based oxygen scavenger to prevent discoloration of ham



Hutter S, Rüegg N, Yildirim S. Use of palladium based oxygen scavenger to prevent discoloration of ham. *Food Packaging and Shelf Life* 2016. In Press.

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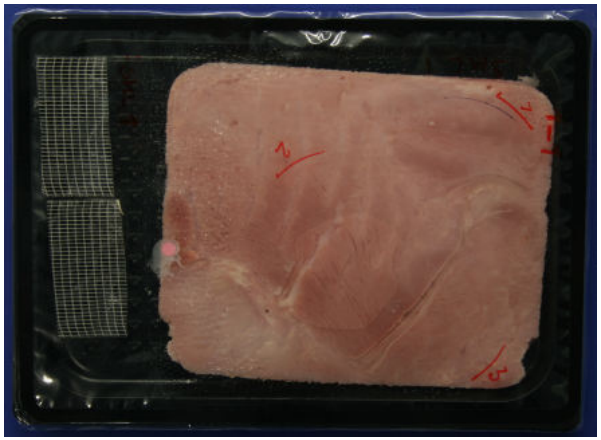
Material & Methods

Packaging:

- Commercial cooked cured ham
- High barrier EVOH tray and film
- Gas: Modified atmosphere (MA): 2% O_2, 5% H_2, 93% N_2, normal atmosphere (NA)
- With and without scavenger (25 cm2)



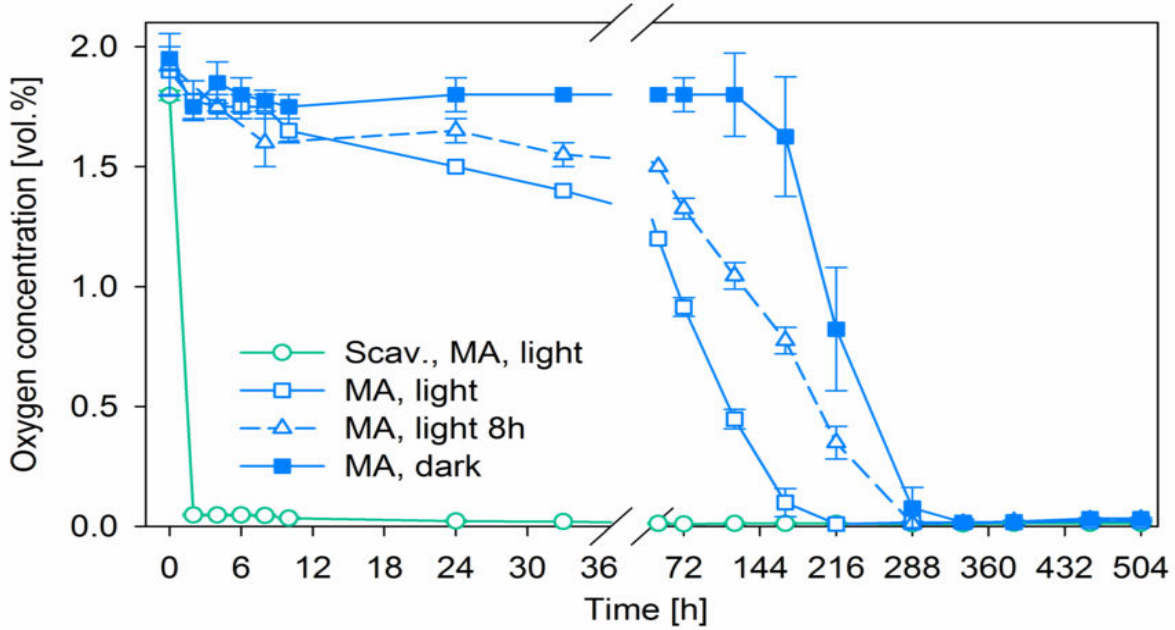
Storage:

- 4±1°C, 21 days
- Illumination (1'000 lx): 24 h/d, 8 h/d or dark

Analyses:

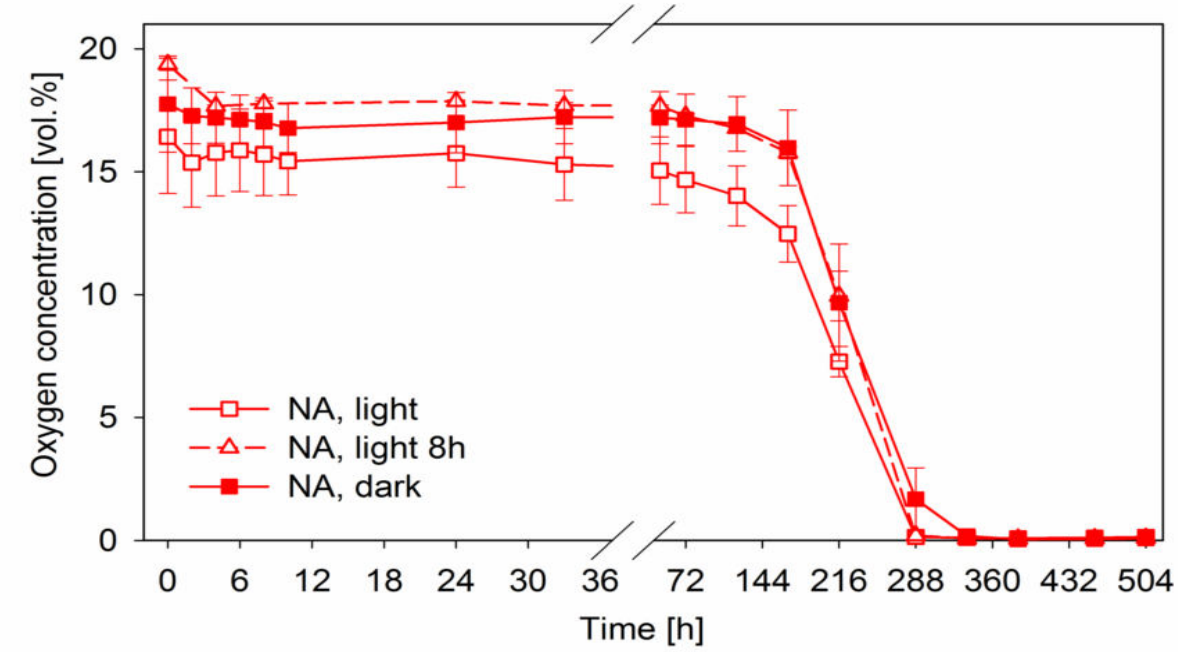
- Colour: *a (redness), *L (lightness) (CR-410, Minolta)
- Headspace oxygen concentration (Fibox 4 trace, PreSens)

Changes in headspace oxygen concentrations



Modified atmosphere:

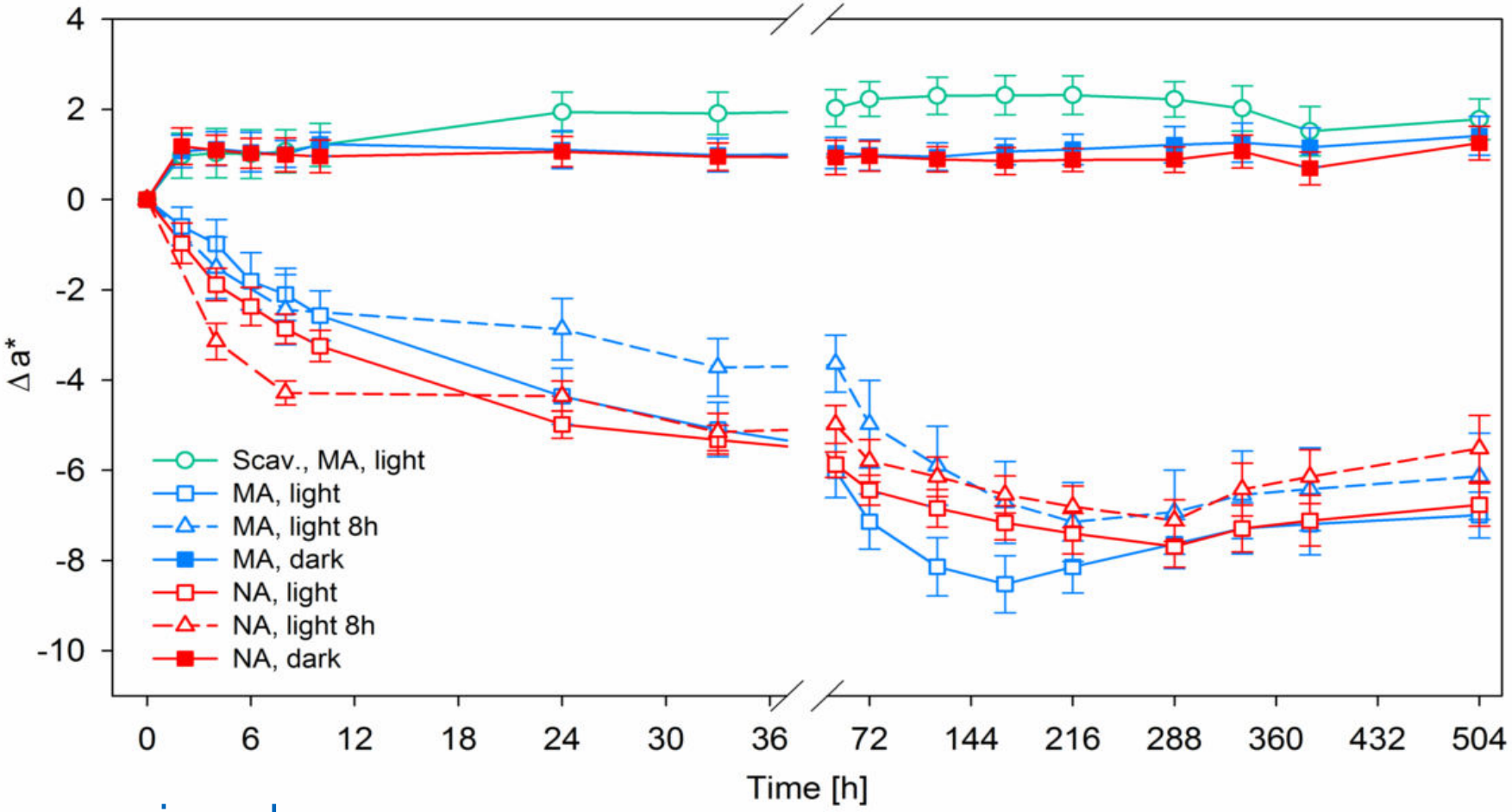
- Samples with scavenger stay <0.05 % O_2
- Illuminated, without scavenger: decrease beacause of discoloration reaction



Normal atmosphere:

- Decrease starting after ~5 days, probably due to microbial growth

Discoloration of Ham



Changes in redness:

- No loss in redness for sample with scavenger, even though it was illuminated 24 h/d
- Even slight increase in redness, compared to dark stored samples
- Illuminated samples show pronounced discoloration, significant after 2 h

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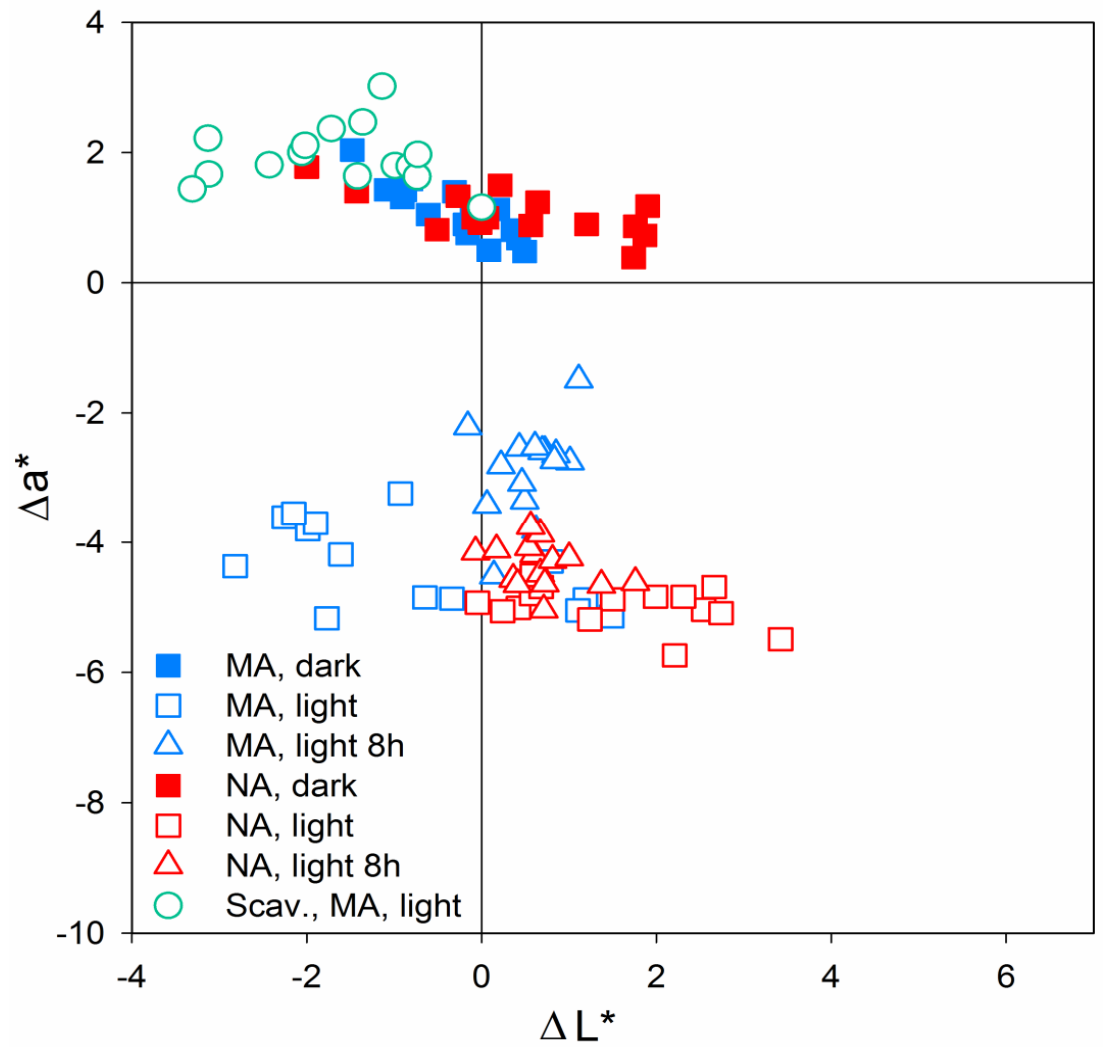
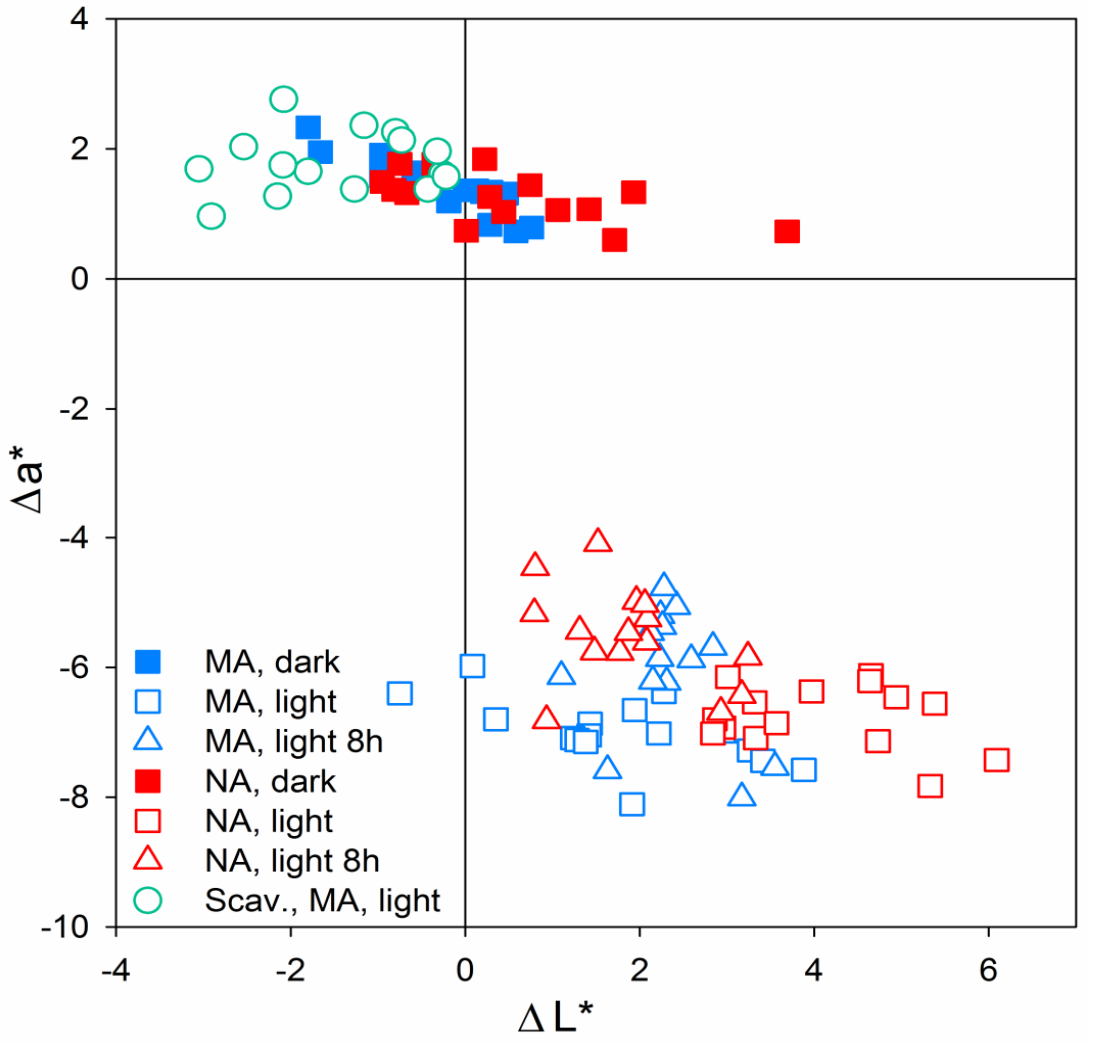
Discoloration of Ham

after 1 day of storage



after 21 days of storage



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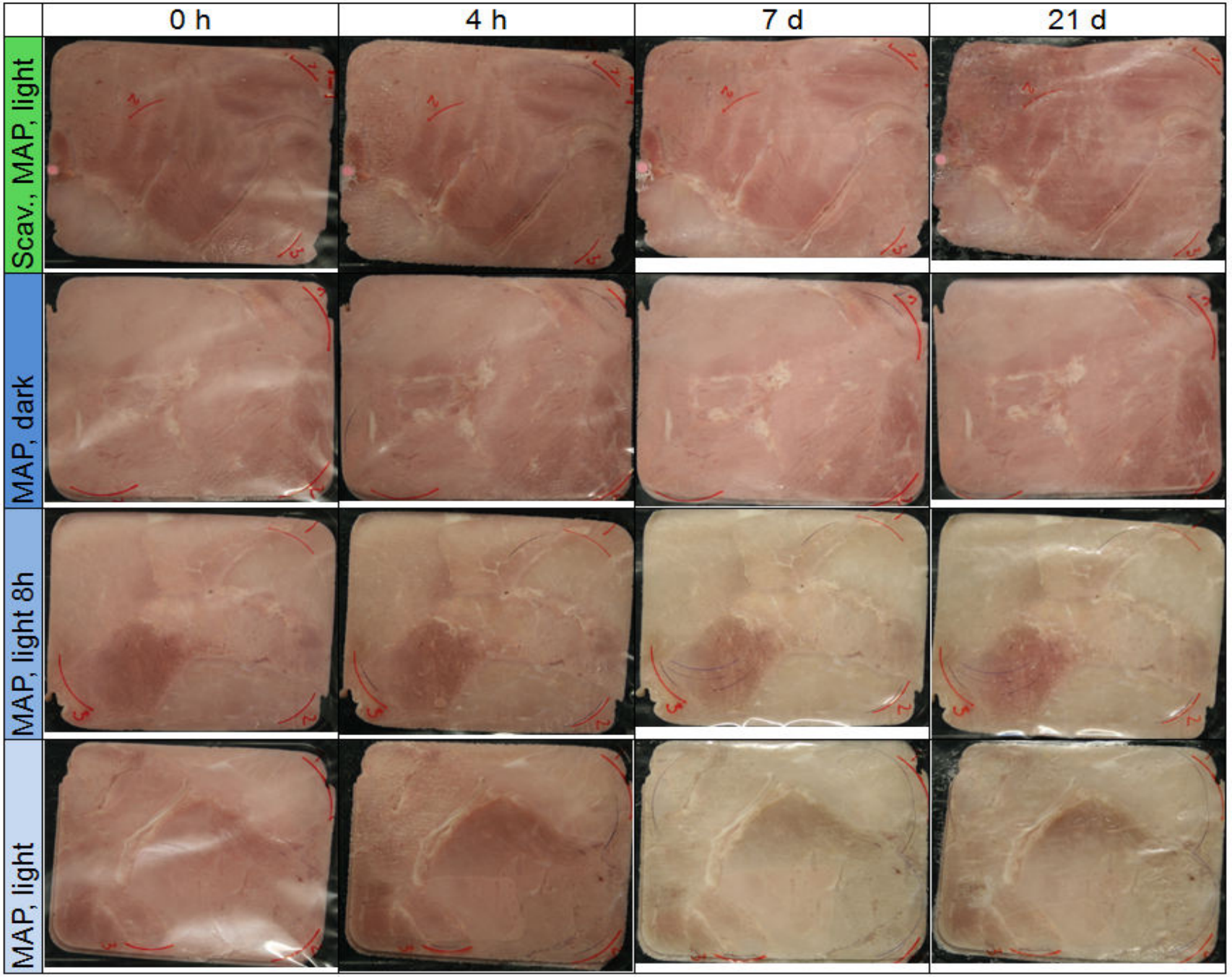
Discoloration of Ham



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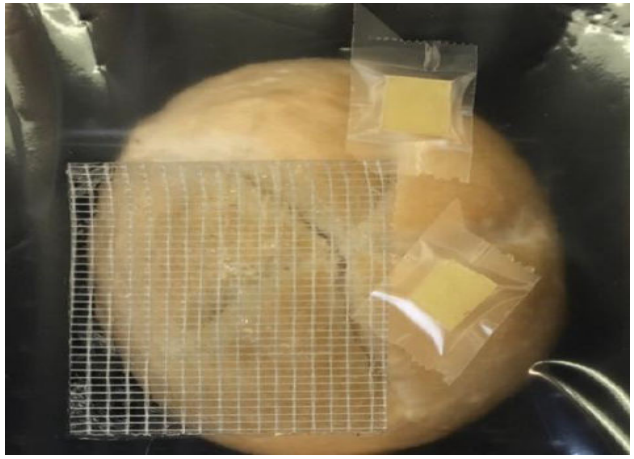
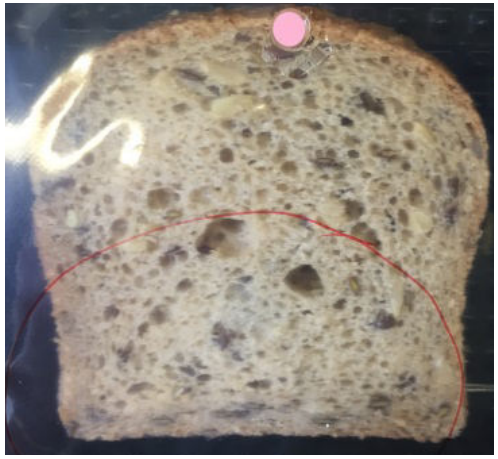
A case study: Use of palladium based oxygen scavenger to prevent mould growth of bakery product





Rüegg N, Blum T., Ebenreth M., Yildirim S. Use of palladium based oxygen scavenger to prevent mould growth of bakery product. *Manuscript in preperation*

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Experimental Set-up

Par-baked bread Toast bread Gluten free bread

⇩

Normalatmosphere **(NA)**

Modified atmosphere **(MAP)**

(93 vol. % N_2 ,2 vol. % O_2 ,5 vol. % H_2)

MAP

(93 vol. % N_2 ,2 vol. % O_2 ,5 vol. % H_2)

+ Scavenger

(**MAP +Active Label**)

⇩

No inoculation**,** Stress test

Aspergillus niger (9,7 x 10^3 KBE)

⇩

Storage

25 °C, 50 % RH

Experimental Set-up

Par-baked bread Toast bread Gluten free bread

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Normalatmosphere **(NA)**

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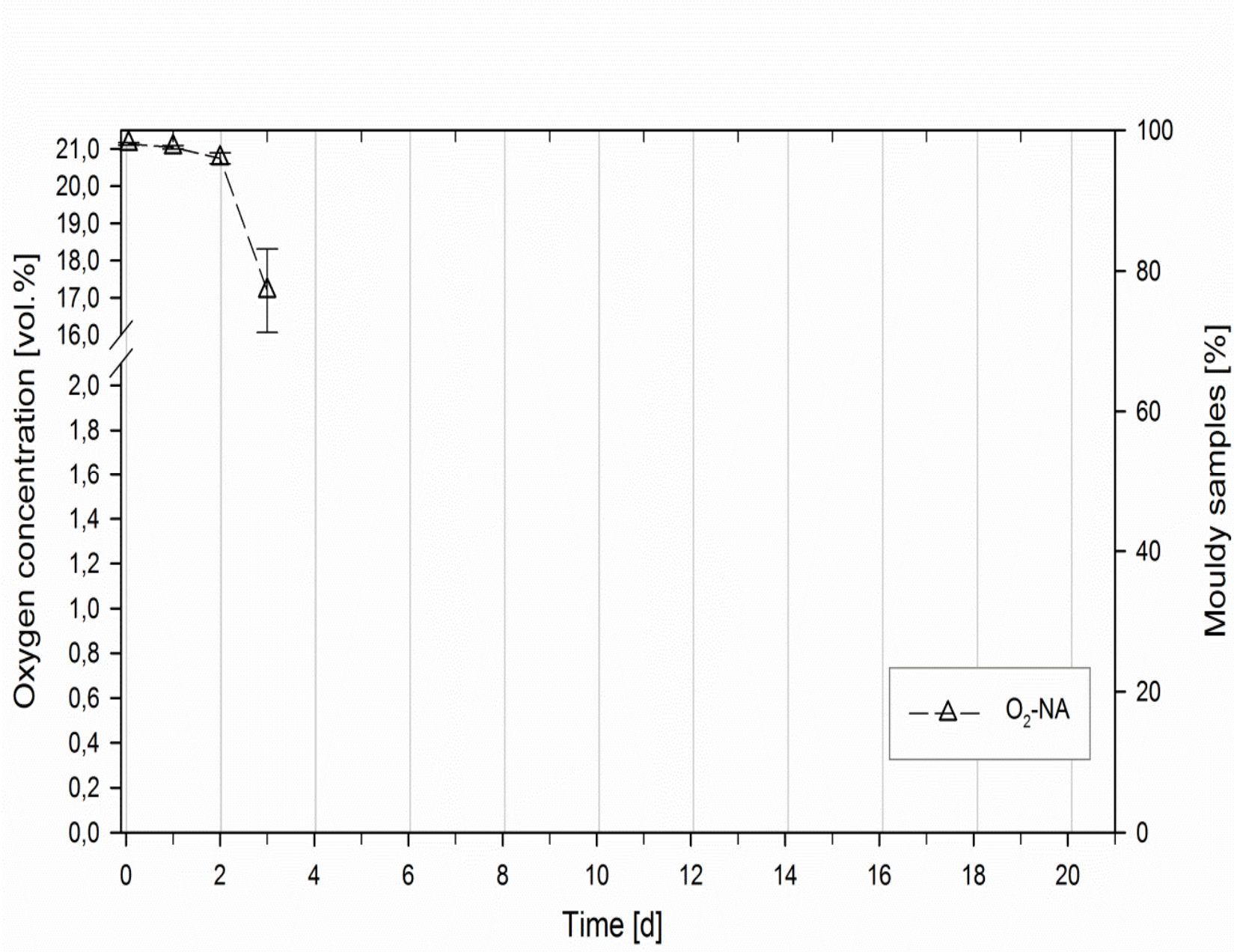
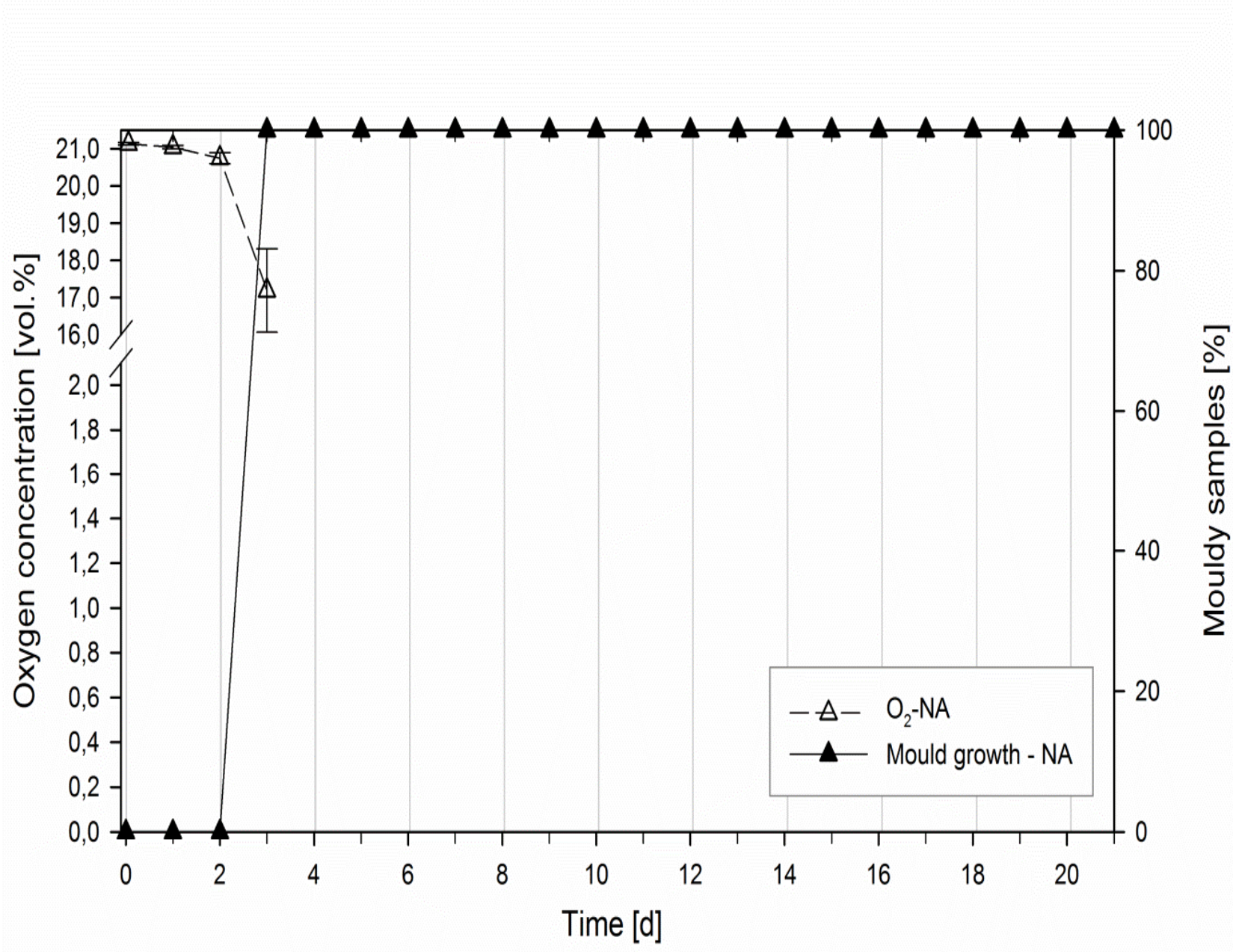
Storage

25 °C, 50 % RH

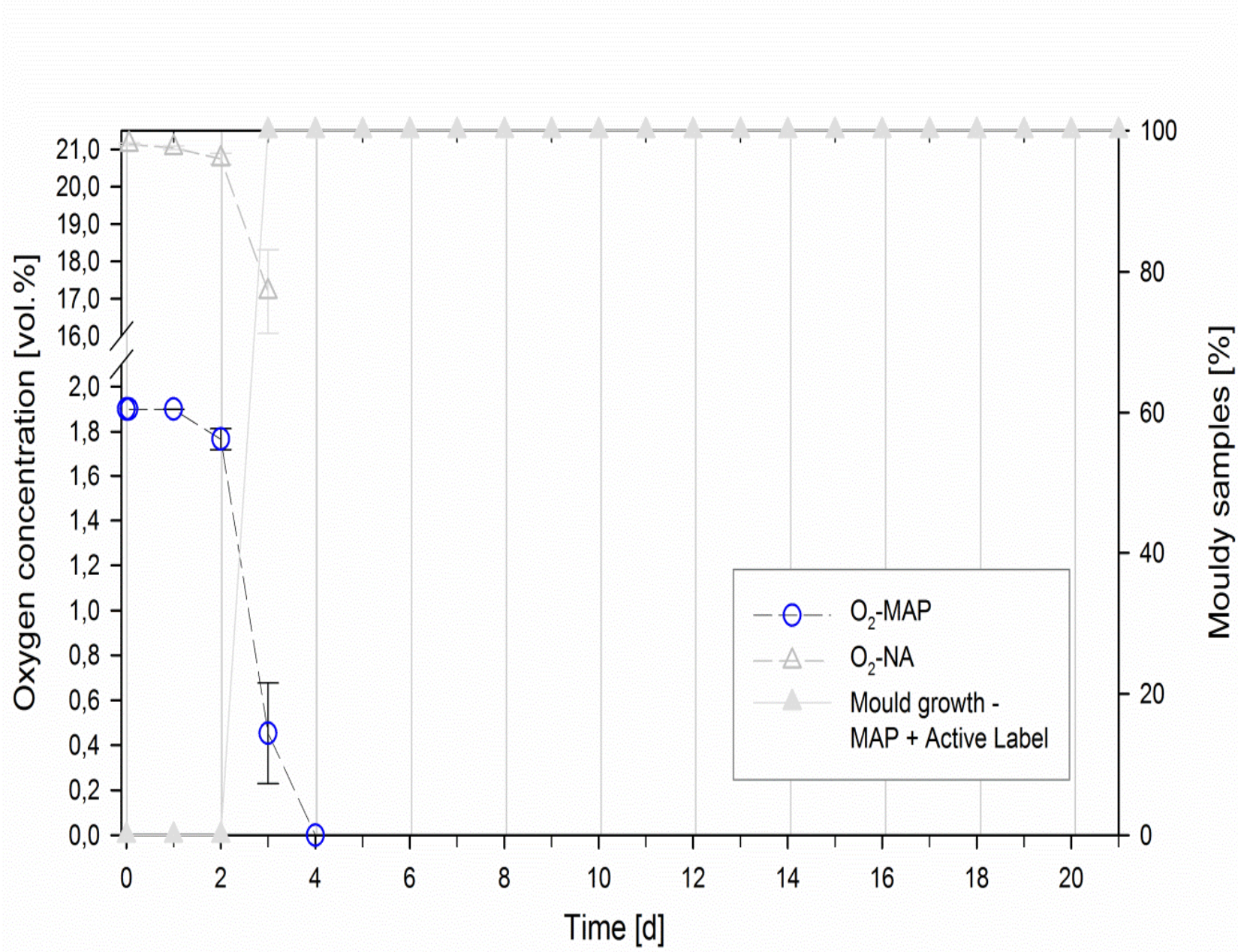
Par-backed bread, NA



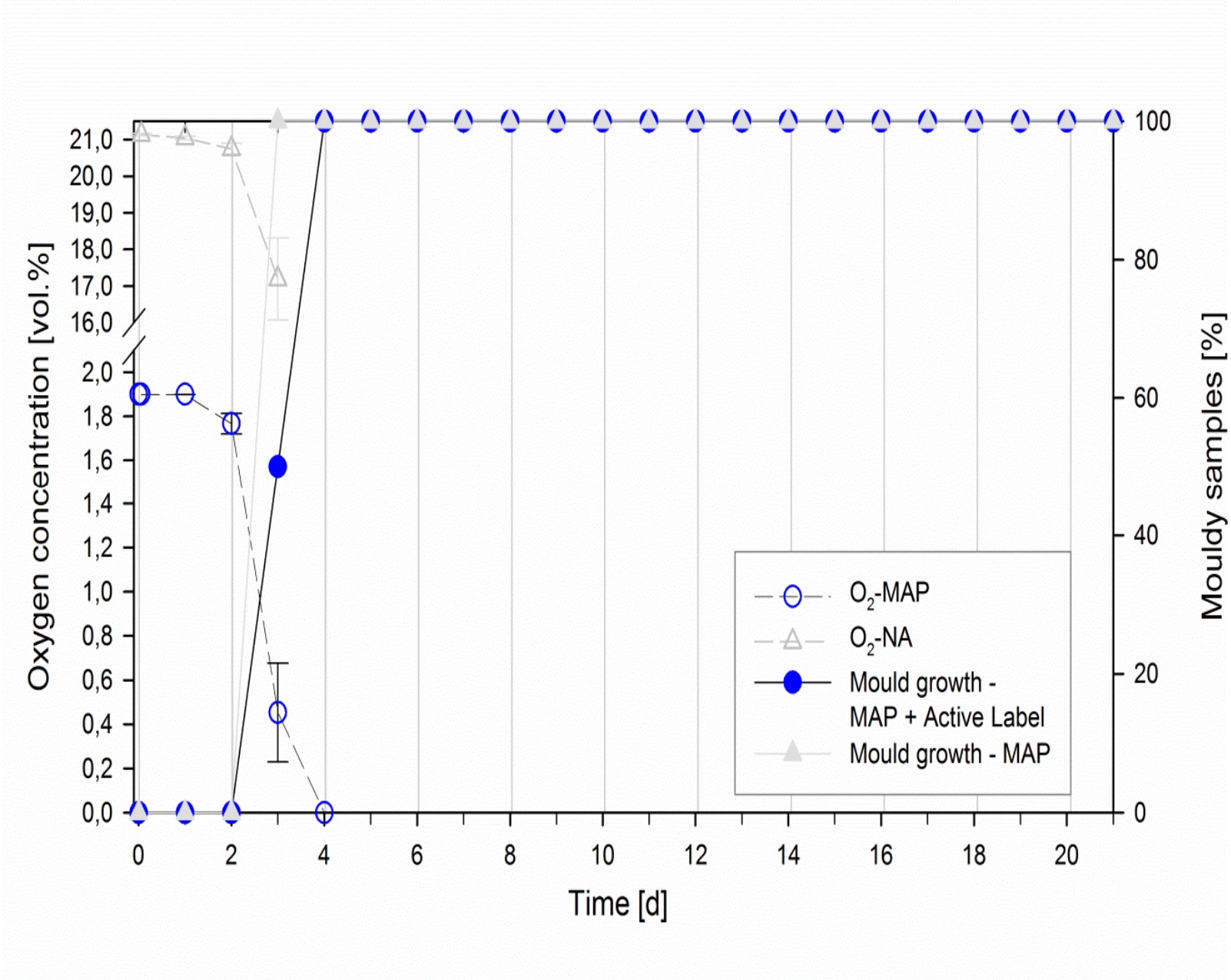
Par-backed bread, NA



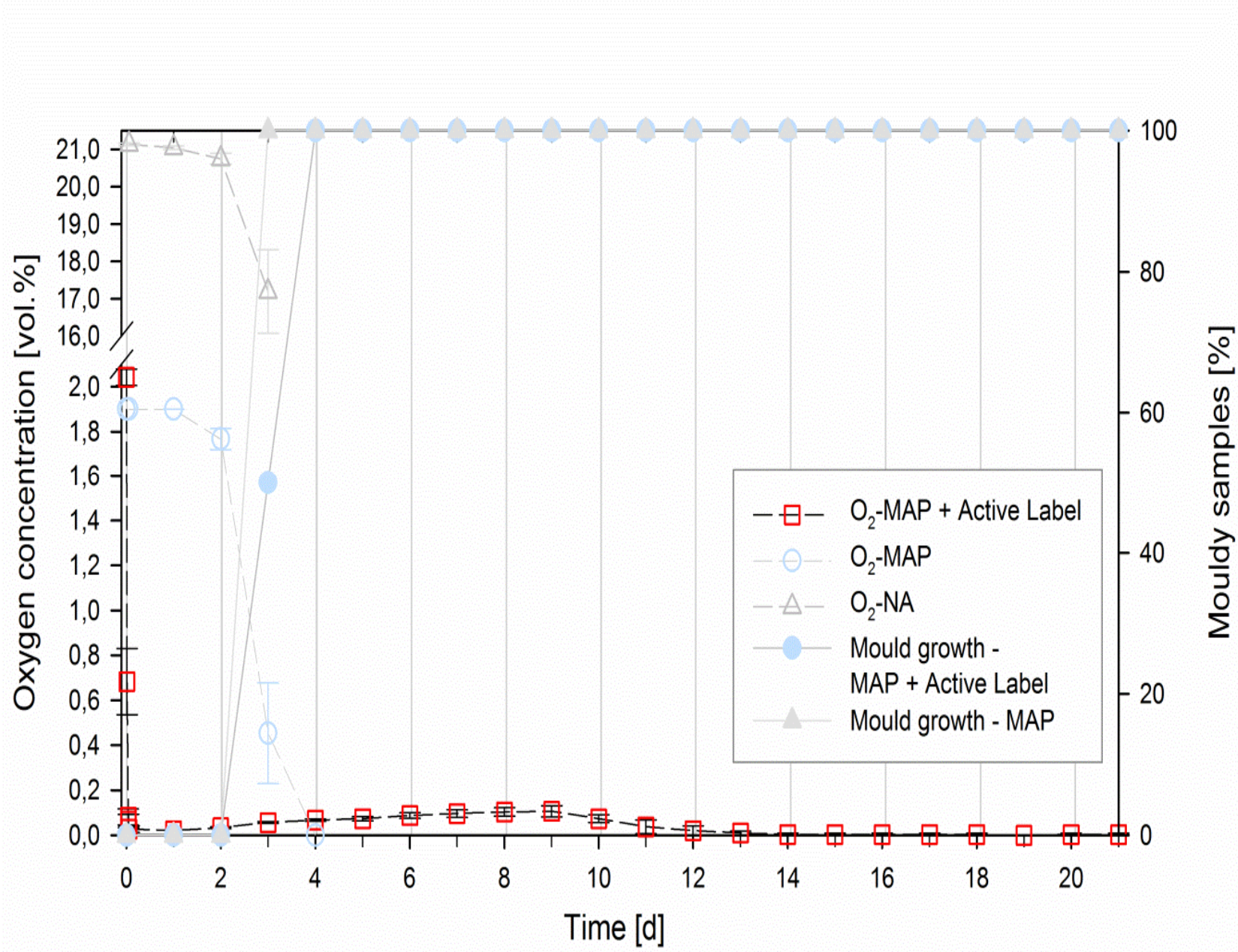
Par-backed bread, MAP



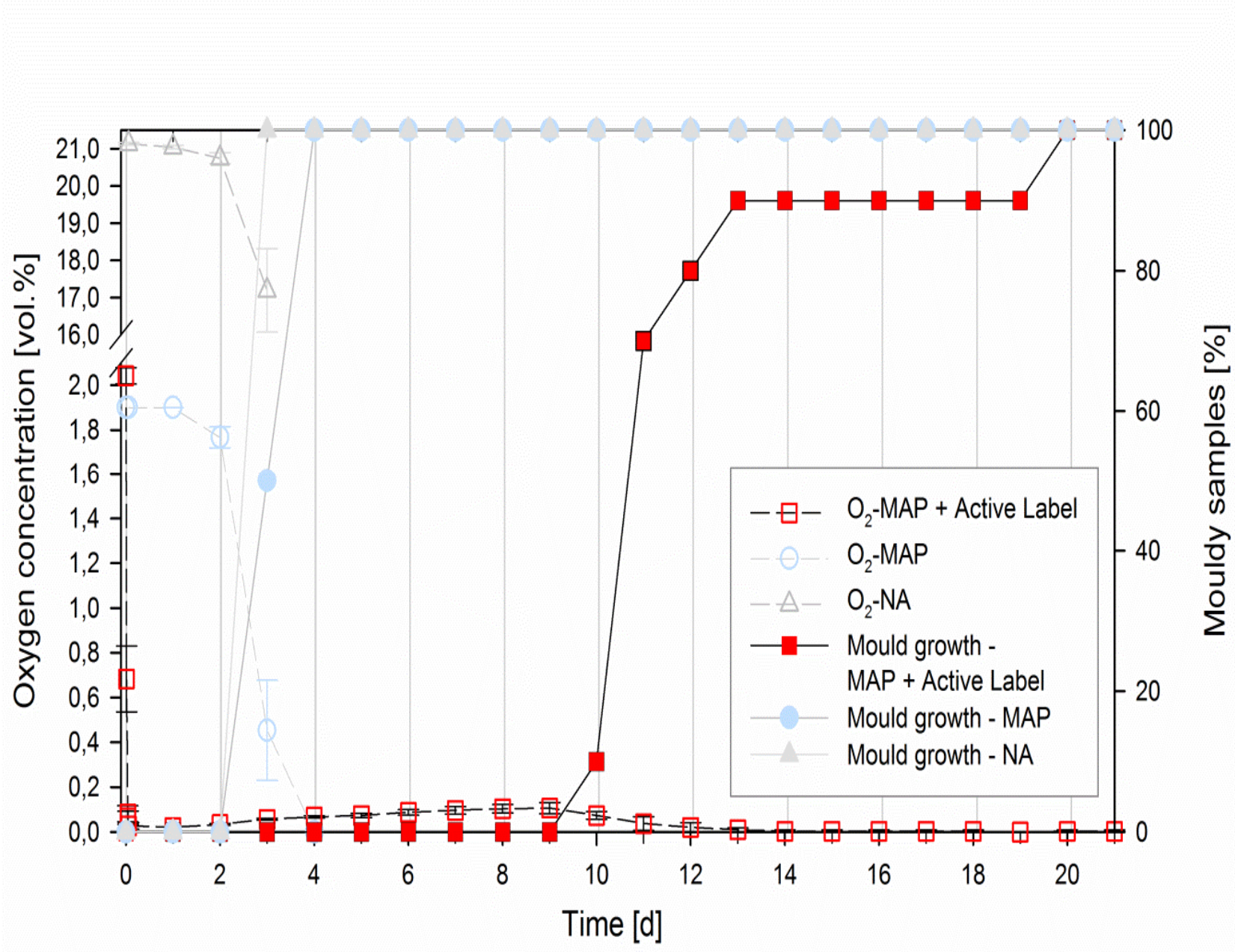
Par-backed bread, MAP



Par-backed bread, MAP + Active Label



Par-backed bread, MAP + Active Label



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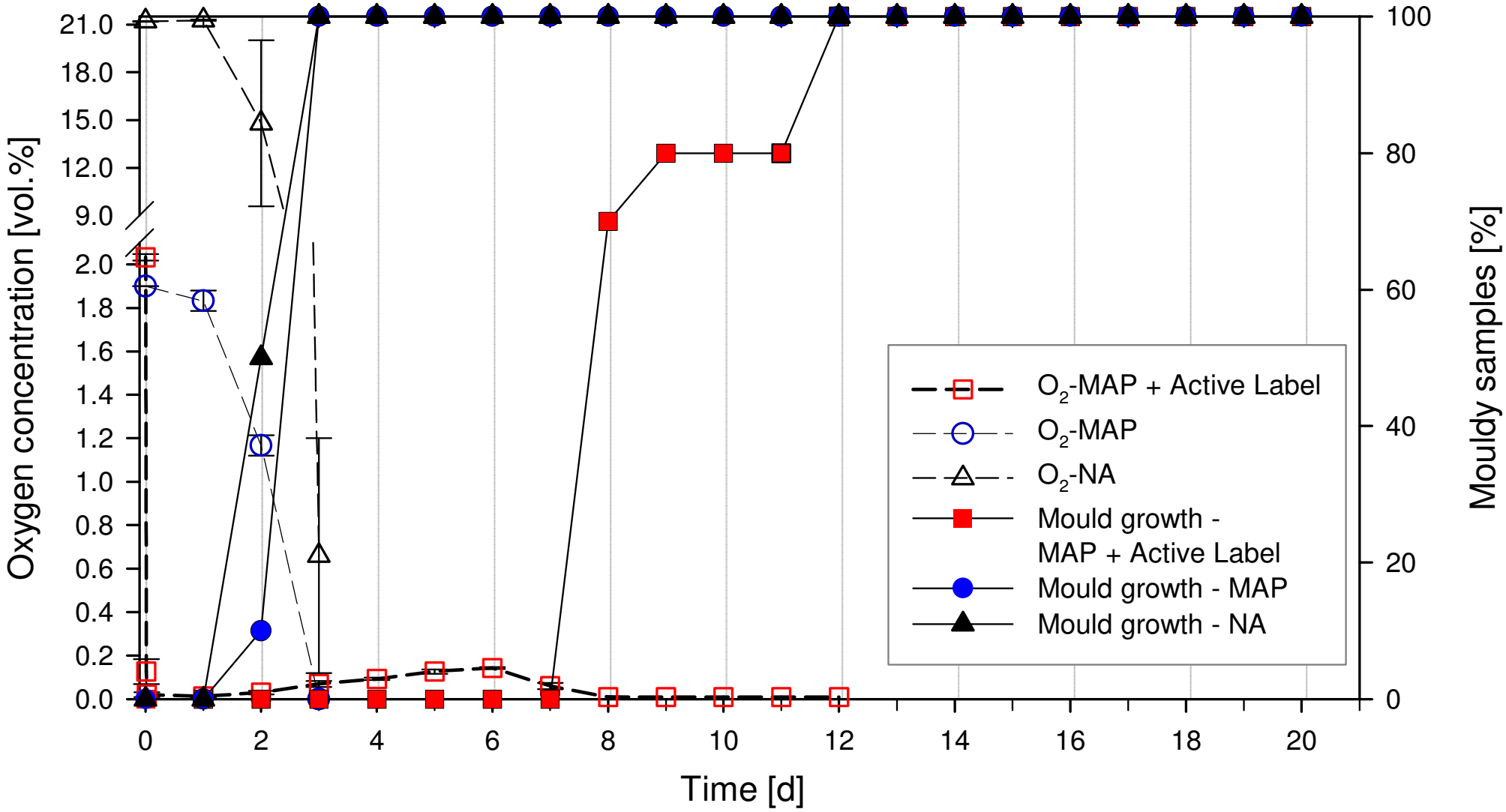
Toast Bread



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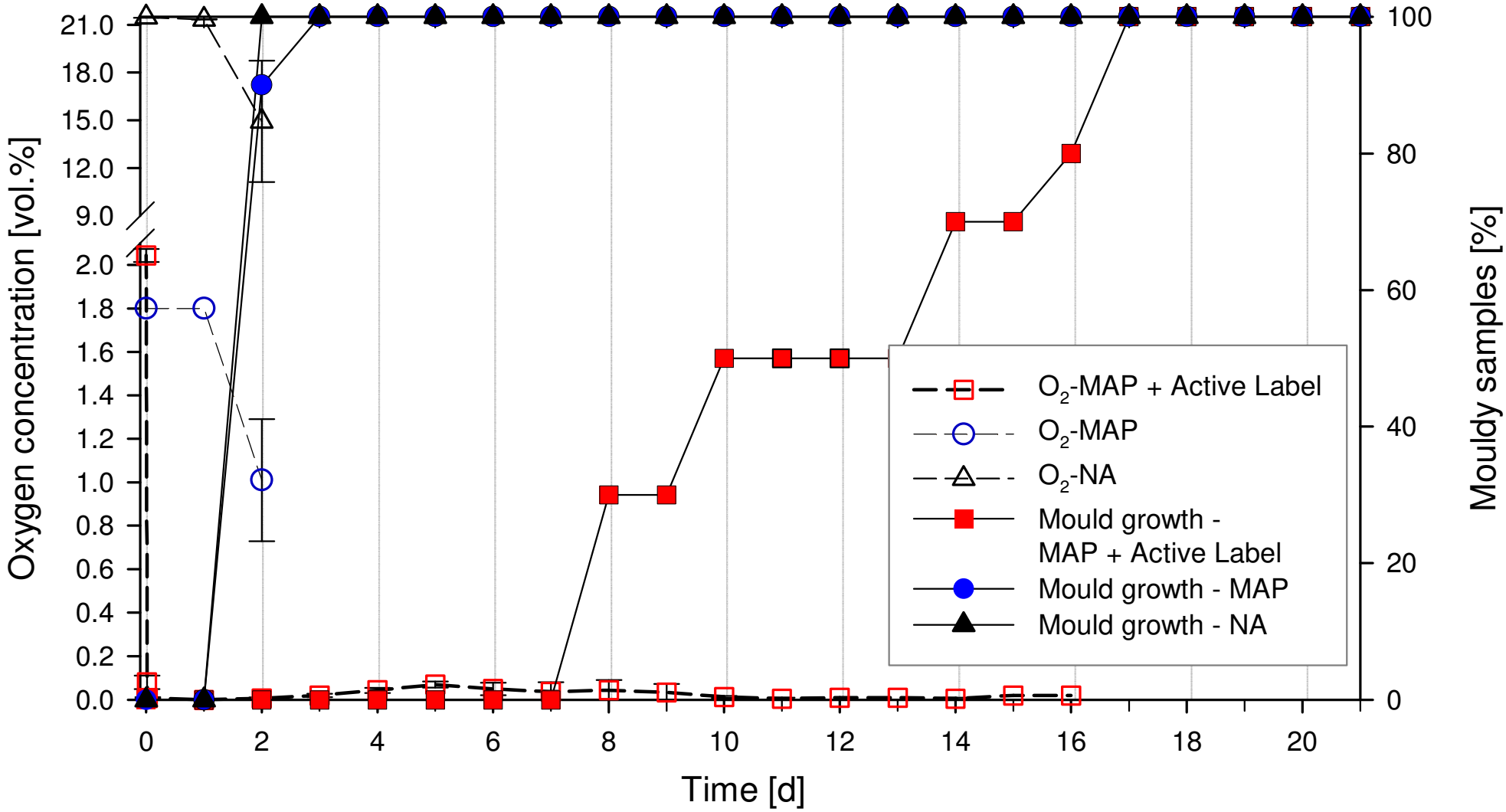
Gluten Free Bread



SCIENTIFIC OPINION

Scientific Opinion on the safety assessment of the active substances, palladium metal and hydrogen gas, for use in active food contact materials[1]

EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF)[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

This scientific opinion of EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids deals with the safety assessment of the active substances palladium metal (CAS No 7440-05-3, FCM No 993) and hydrogen gas (CAS No 1333-74-0, FCM No 1038), which are intended to be used as an oxygen scavenger in packages of foods and beverages at room temperature or below. The active article is designed as a gas permeable but liquid impermeable laminated pad, which is placed within a cap or closure or as an adhesive label on tray lids. The palladium metal is not in direct contact with the food being separated from it by different layers of passive materials. The specific migration of palladium metal into conventional food simulants was not detected at the limit of quantification of 0.6 µg/kg. Palladium was considered to be non genotoxic and of no toxicological concern under a low exposure level resulting from a concentration up to 50 µg/kg food in a previous evaluation (EFSA CEF Panel, 2012). Based on these previously drawn conclusions and given the intended conditions of use leading to non-detectable migration, the CEF Panel concluded that the active substances palladium and hydrogen do not raise a safety concern for the consumer when used as an oxygen scavenger in packages for foods and beverages at room temperatures or below. Palladium should not be in direct contact with food and should be incorporated in a passive structure impermeable to liquids which prevents the migration at detectable levels.

Acknowledgements

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Swiss Confederation

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Thank you for your attention

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