Effect of gas composition on quality attributes and microbial population dynamics of fresh-cut iceberg lettuce

14th August 2019, Maxence Paillart and Ernst Woltering

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Introduction:

- In North-Europa, shelf life of fresh-cut iceberg lettuce is limited to P+8
  - E-MAP: BOPP film → anaerobe condition reached within 3 days
  - Storage temperature: 7ºC
  - No chemicals used during sanitation process

- Overall visual quality (OVQ) mainly determines the shelf life of fresh-cut iceberg lettuce

Challenge: the right gas permeability

0_2 = 0%
CO_2 > 15%

0_2 ~ 0%
CO_2 < 15%

0_2 > 0.5%
CO_2 < 15%

Too low — *Increasing gas permeability* — *Too high*

Fermentation / Decay

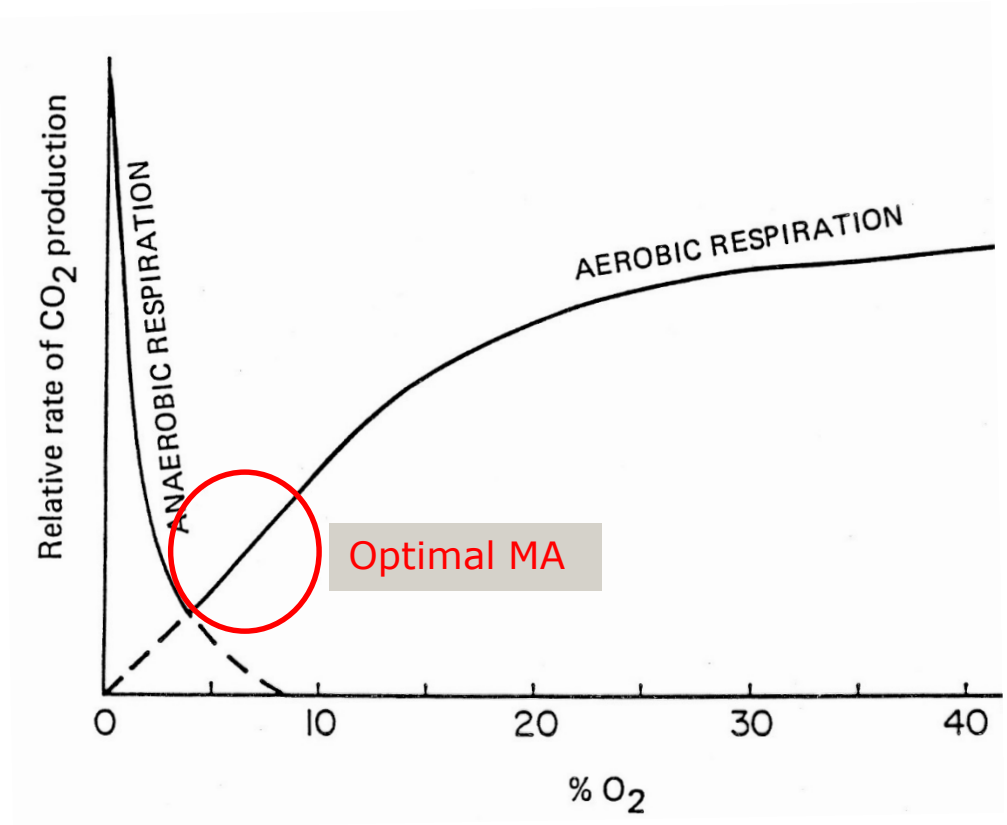
Red discoloration

Equilibrium-Modified Atmosphere Packaging (E-MAP)

- Suitable for product with respiration rate (fruit, vegetables, ornamentals)
- Use respiration rate of fresh product to create MAP

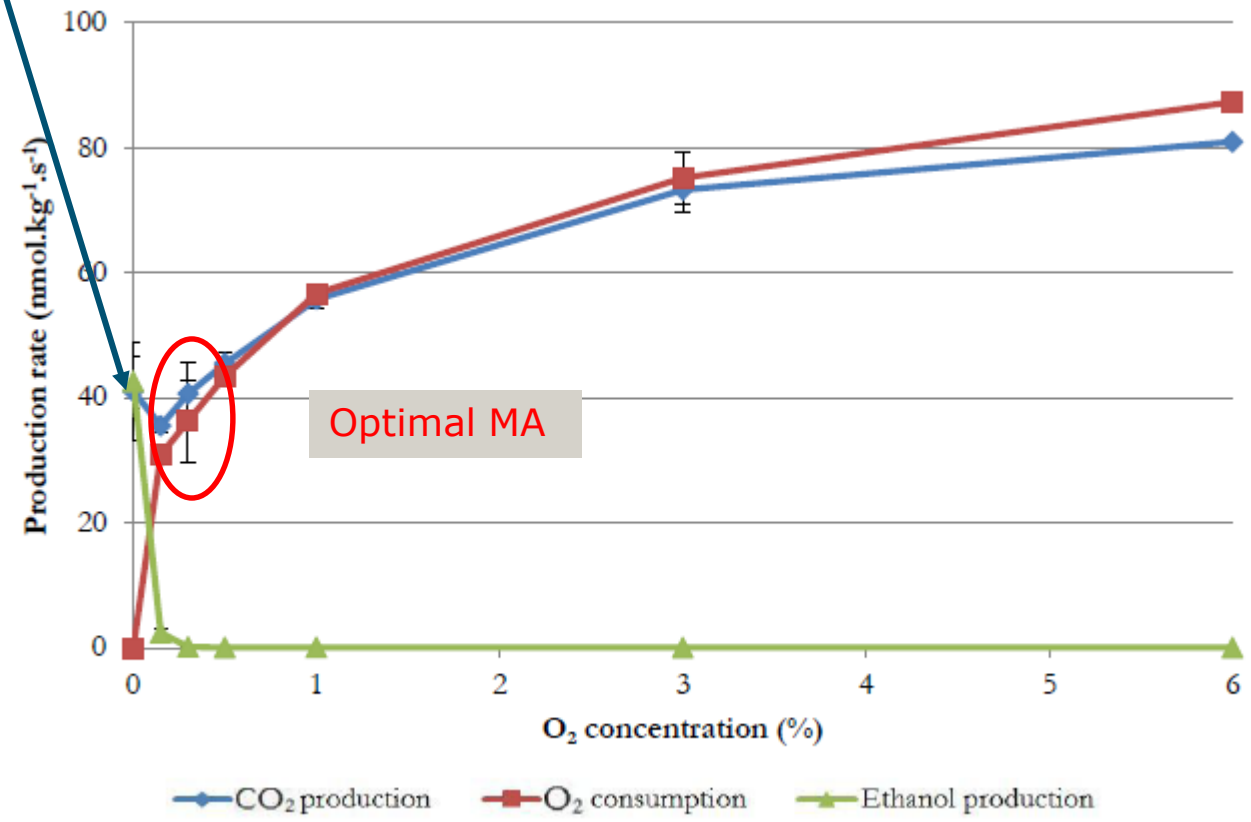
- Slow down activity of product

  → extend shelf life
- BUT avoid fermentation



Anaerobic E-MAP

- Anaerobic gas conditions are reached to avoid pink discoloration (oxidation process)
- Production of ethanol and acetaldehyde → toxicity?



Sensorial and microbial quality in MAP

- Shelf life of iceberg lettuce packed under E-MAP is limited by sourness off-odour and tissue collapsing.
- Acetic and lactic acid produced over the time by lactic acid bacteria population (*Lactococcus* and *Leuconostoc spp.*)

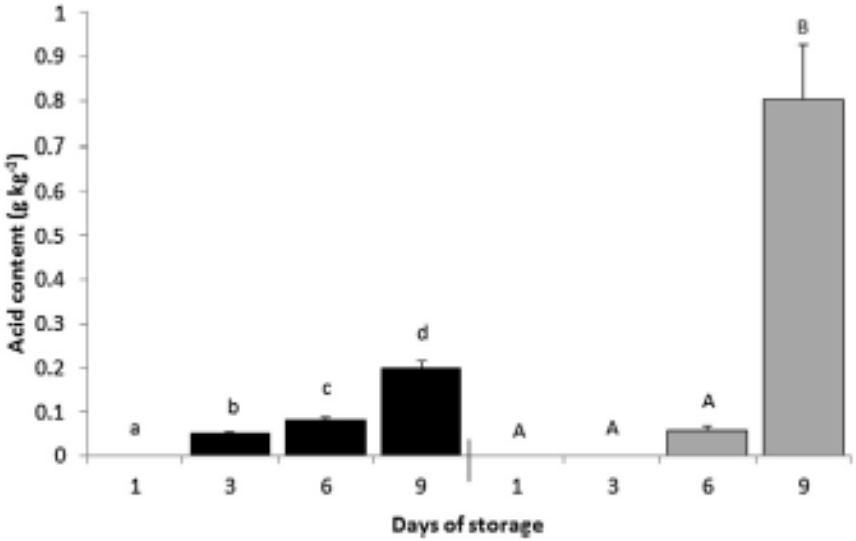


Fig. 4. Acetic acid (black bars) and lactic acid (grey bars) contents of fresh-cut iceberg lettuce stored at 7 °C. Bars are the mean of three replicates ± SD. Different small and caps letters indicate statistical differences between the evaluation days for acetic acid and lactic acid contents, respectively ($P < 0.05$).

Acta Hortic. 1141. ISHS 2016. DOI 10.17660/ActaHortic.2016.1141.36
Proc. III Int. Conf. on Fresh-Cut Produce: Maintaining Quality and Safety
Ed.: M.I. Cantwell

Postharvest Biology and Technology 124 (2017) 91–99

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Sensorial and microbial quality in MAP

- Microbial population dynamic follows the dynamic of the gas composition inside the packaging.

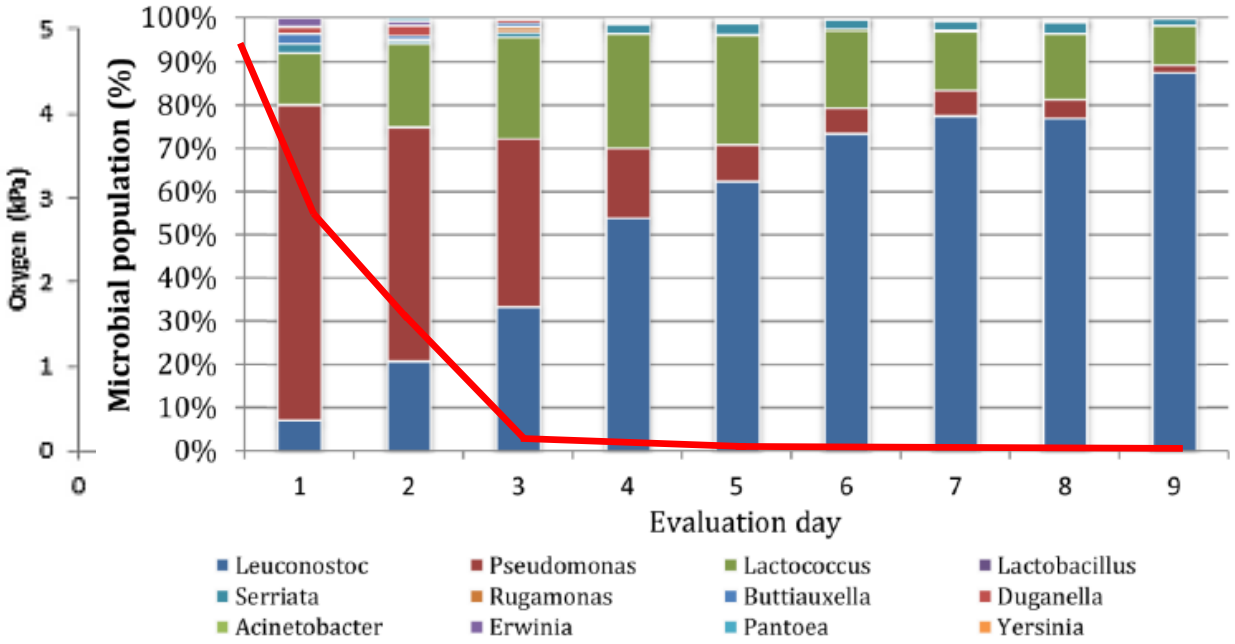


Figure 1. Microbial population dynamics of natural flora growing on fresh-cut iceberg lettuce packed under MA conditions and stored at 7°C. Microbial species are expressed as percentages of the total microbial load per evaluation day. Values are means (n=3).

Hypothesis:

- Can the microbial population dynamics be controlled by adjusting the headspace gas composition?
  - Lactic acid bacteria stays in lag phase when under pressure of *Pseudomonas spp.*
    - *Pseudomonas spp. a*re strictly aerobe microorganisms
  - *Pseudomonas spp.* stay predominant in the microbial population dynamics when oxygen is still available

➔ Hypothesis: Lactic acid bacteria population growth can be inhibited by applying a semi-anaerobe gas conditions

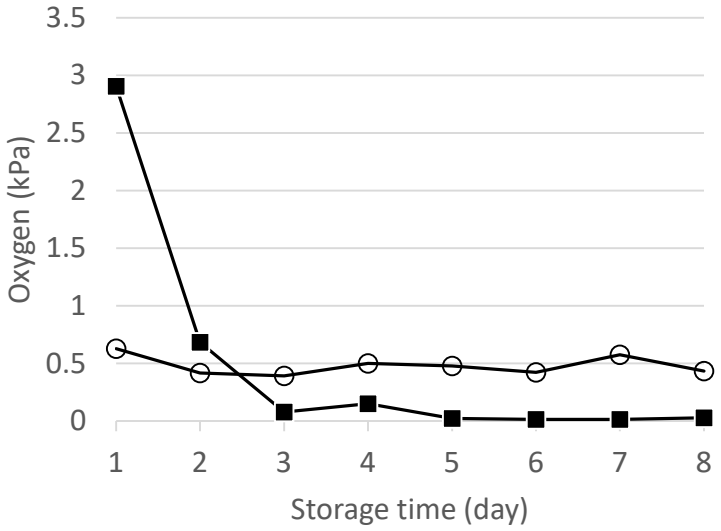
Material and method

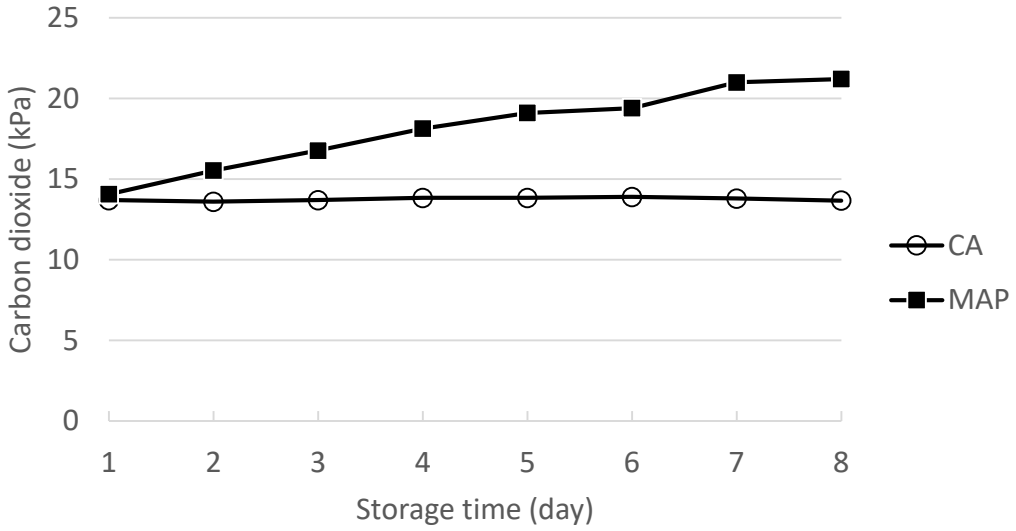
- Compare fresh-cut iceberg lettuce (sample of 200g) stored at 7°C for a total period of 8 days

- Two storage conditions:
  - E-MAP: commercial packaging → polypropylene bags (670 cm², 30µm thickness, initially flushed with 6kPa O_2 and 11kPa CO_2)
  - CA: fresh-cut lettuce stored in glass–jar, continuously flushed with humidified gas mix made of 0.3-0.5kPa O_2 and 12-14kPa CO_2

Gas content

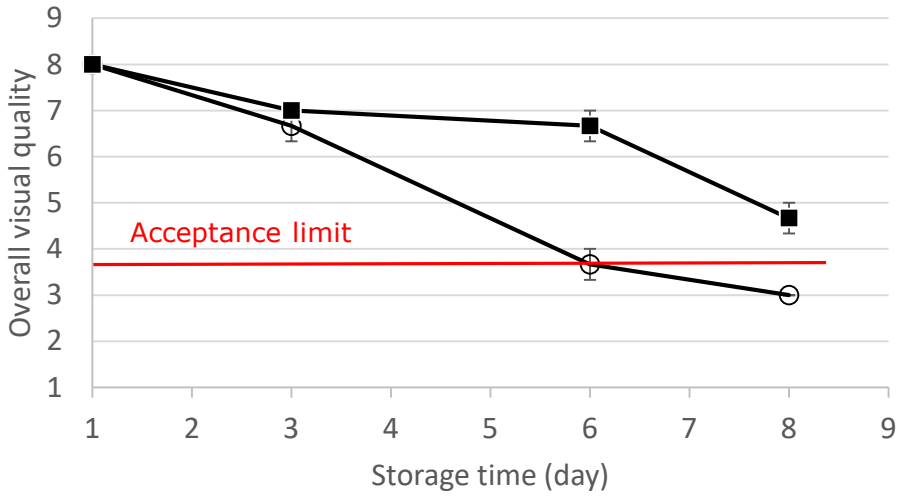
- Fresh-cut lettuce consumes the oxygen and produces CO_2 --> respiration rate
  - In MAP: Anaerobe condition reached after 3 days of storage and CO_2 content build up into packaging
  - In CA: O_2 and CO_2 content are controlled by the flushing set-up

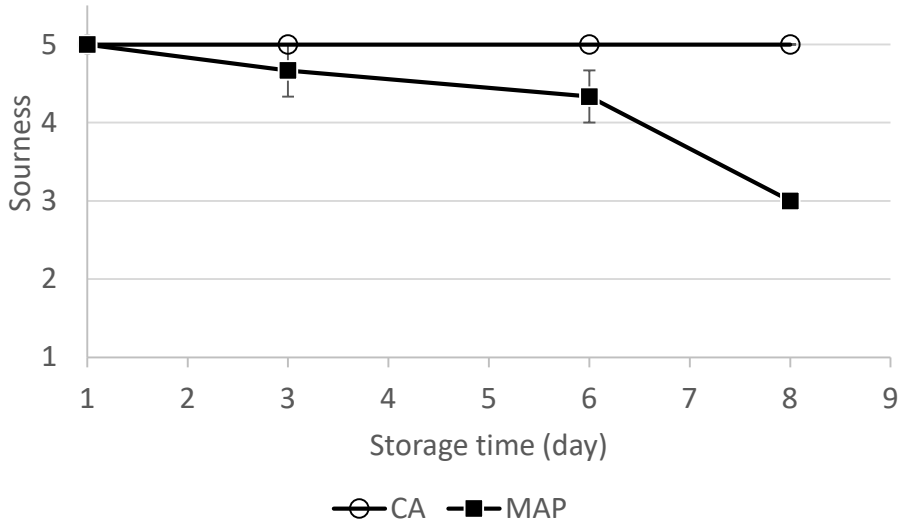




OVQ + sensorial quality

- Low quality score for CA storage due to discoloration (oxidation process)
- No sourness development when stored under semi-anaerobe condition.





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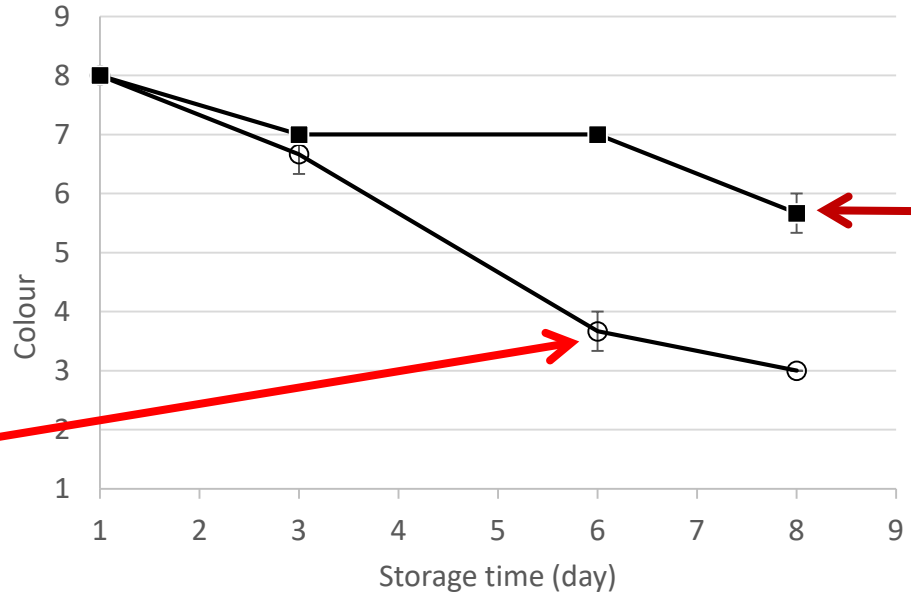
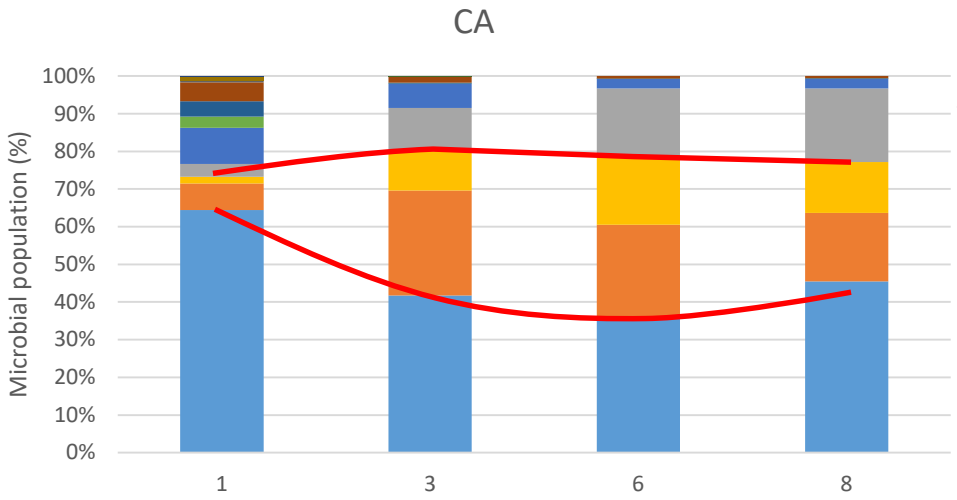
Discoloration

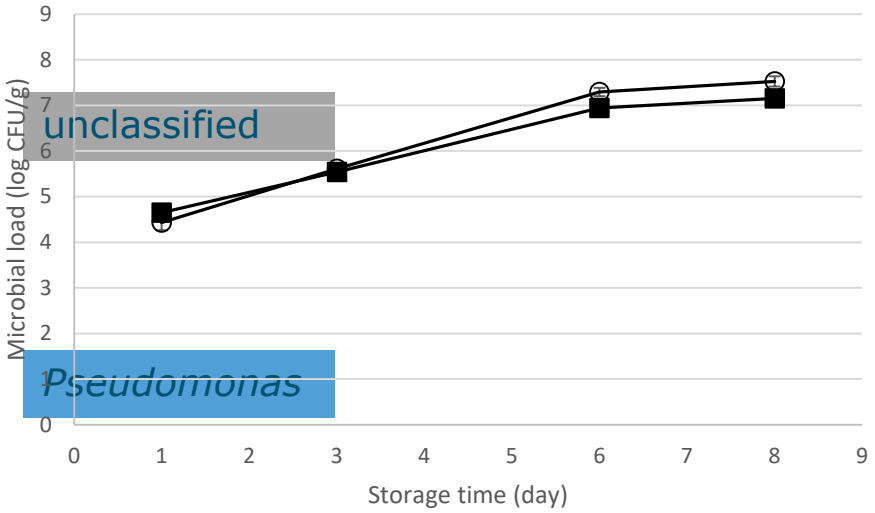
- Pink discoloration results of oxidation processes occurring under semi-anaerobe condition
- Brown discoloration is a result of tissue collapsing and anaerobe process

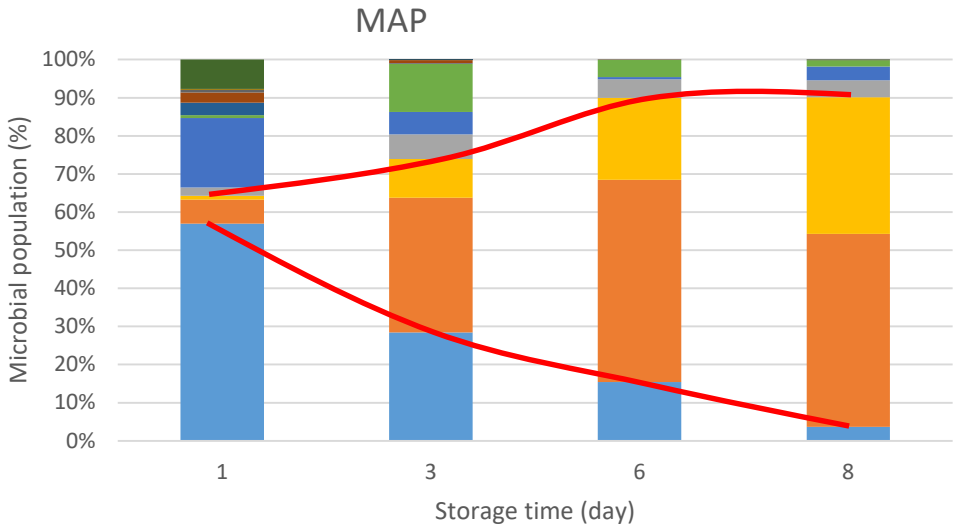


Microbial population dynamics

(16S rDNA amplicon mass sequencing)







Lactococcus

Leuconostoc

Lactic acid bacteria

- Both storage conditions showed similar microbial growth

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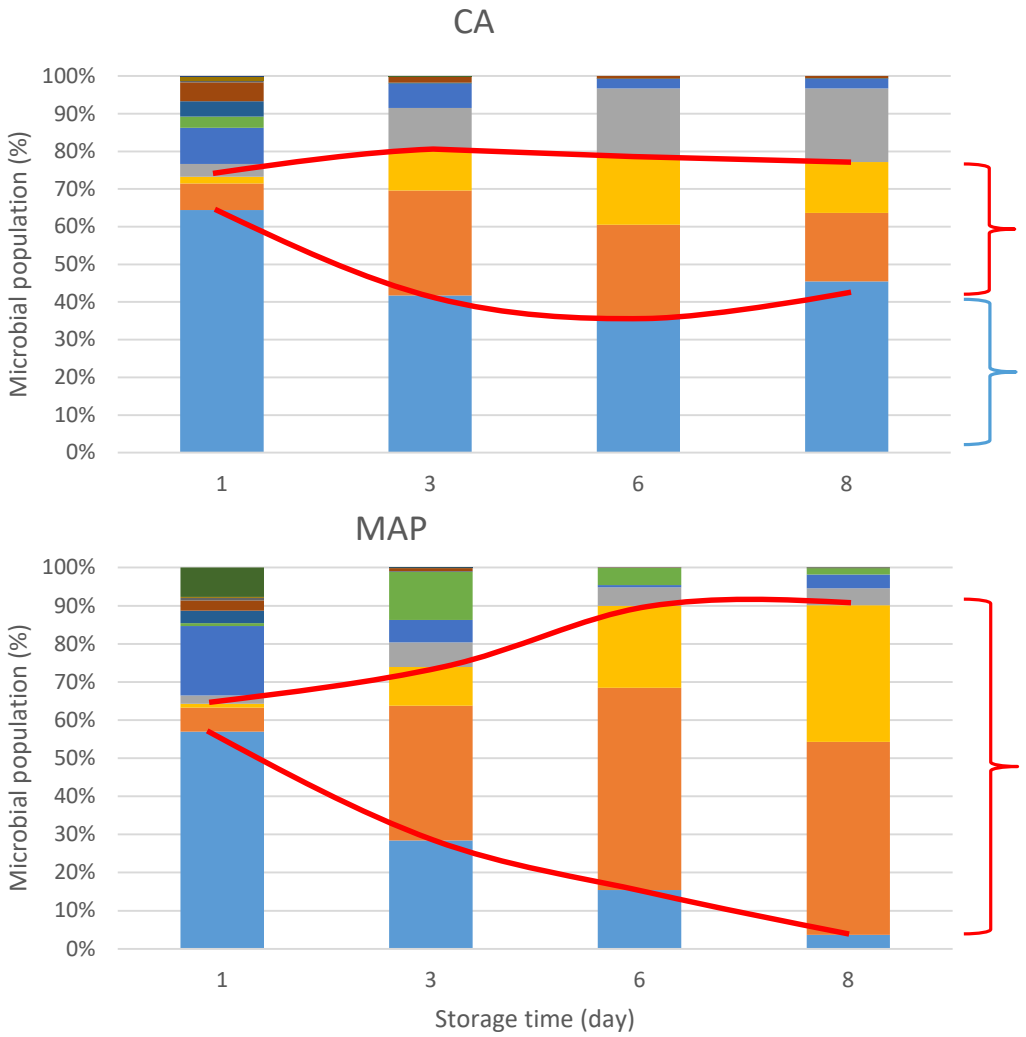
Pseudomonas | Lactococcus | Leuconostoc | unclassified
Pantoea | Yersinia | Duganella | Janthinobacterium
Xanthomonas | Alkanindiges | Acinetobacter | Stenotrophomonas

Microbial population dynamics

(16S rDNA amplicon mass sequencing)



- CA: Lactic acid bacteria remains under pressure by aerobe bacterial population (*Pseudomonas*)
- Higher proportion of lactic acid bacteria causes off-odour (sourness)

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Conclusion

- Storing fresh-cut iceberg lettuce under CA condition (semi-anaerobe gas conditions) limits the growth of lactic acid bacteria:

  --> No sourness odour development

  --> But did not avoid discoloration of lettuce tissue (oxidation process)

- MAP creates anaerobe gas condition within 3 days of storage:

  --> Correlation between the anaerobe condition, the growth of lactic acid bacteria and the sourness quality decay

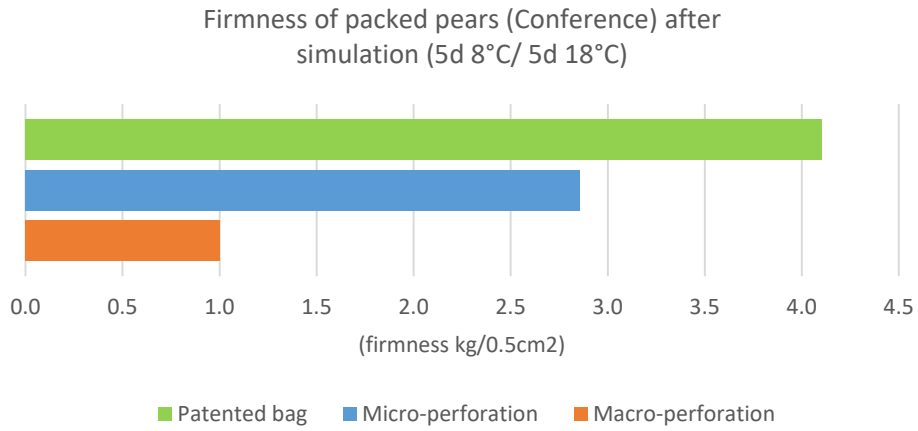
New insight & recommendations

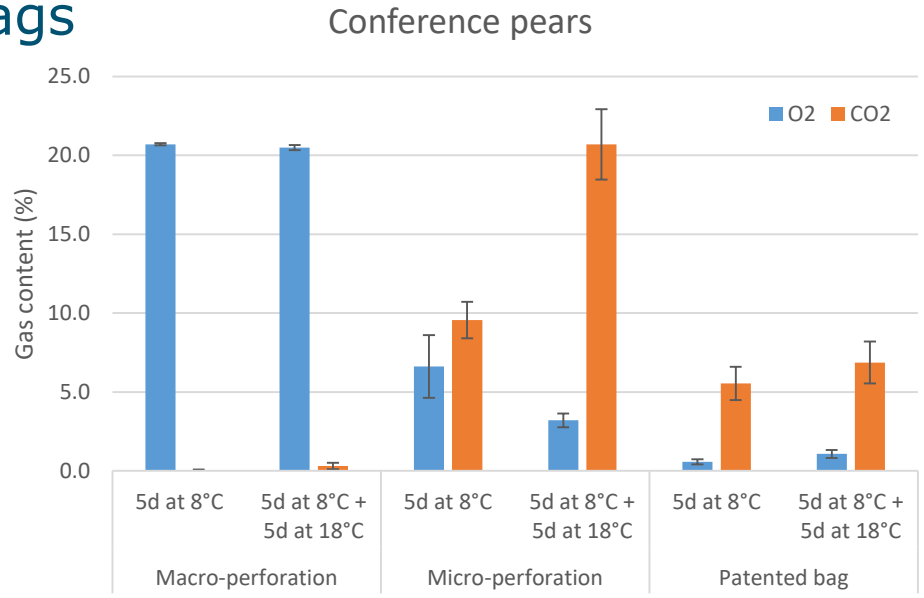
- Packaging concept affects:
  - Activity of fresh-cut product (respiration rate, physiological and enzymatic processes)
  - Microbial population dynamic

- Use of more permeable packaging may help to control the growth of lactic acid bacteria, but extra hurdles (ex: Heat shock, mutant lettuce variety, ...) should be combined to avoid discoloration (due to semi-anaerobe gas condition)

Dynamic packaging concept

- New packaging material allows to store fresh-product at several storage temperatures: gas transmission rate of packaging follow similar rate that product activity
  - Pears stay longer firm and green when packed into patented bags





Patent: PCT/EP2019/067393

Thank you for your attention

VII Postharvest Unlimited
ISHS International Conference
18-21 October 2021 - Wageningen

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