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Agroscope

Postharvest experiments with the Variety 'CH 201' at Agroscope

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08/06/2022

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Agenda

1/ Introduction

2/ Focus on CA-related disorders

3/ Methods to predict at harvest susceptibility to CA-related disorders during storage

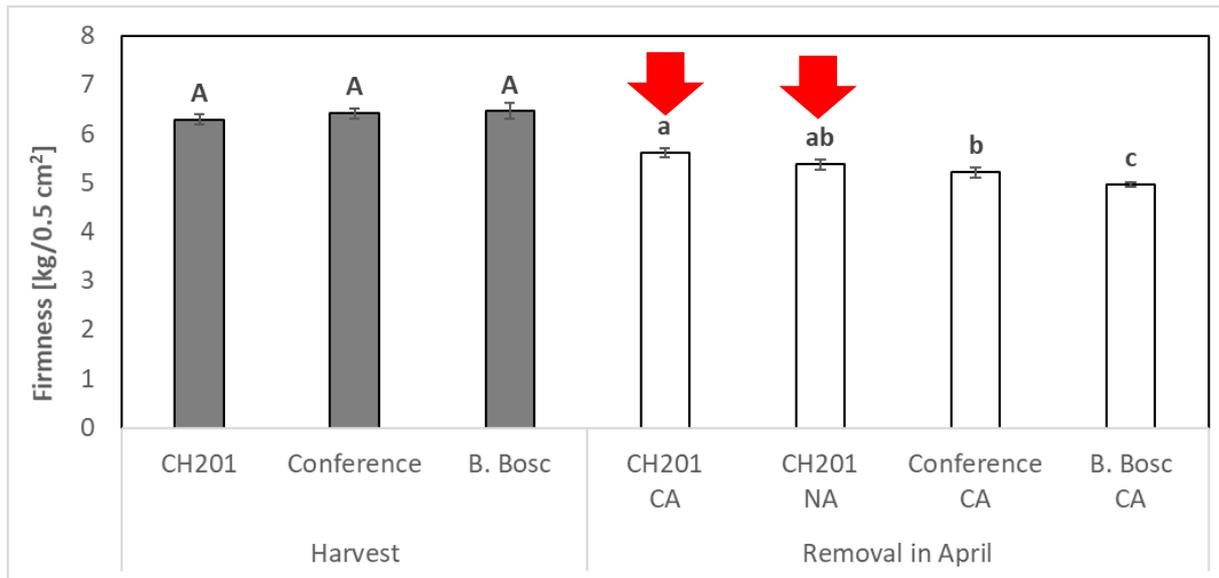


1/ Introduction



The variety 'CH 201'

- **Rapid entry** into production
- **High yield**
- Red blush → **bicolor**
- **Firm and crunchy flesh**, easy to grab-and-go
- **Long term storage potential**

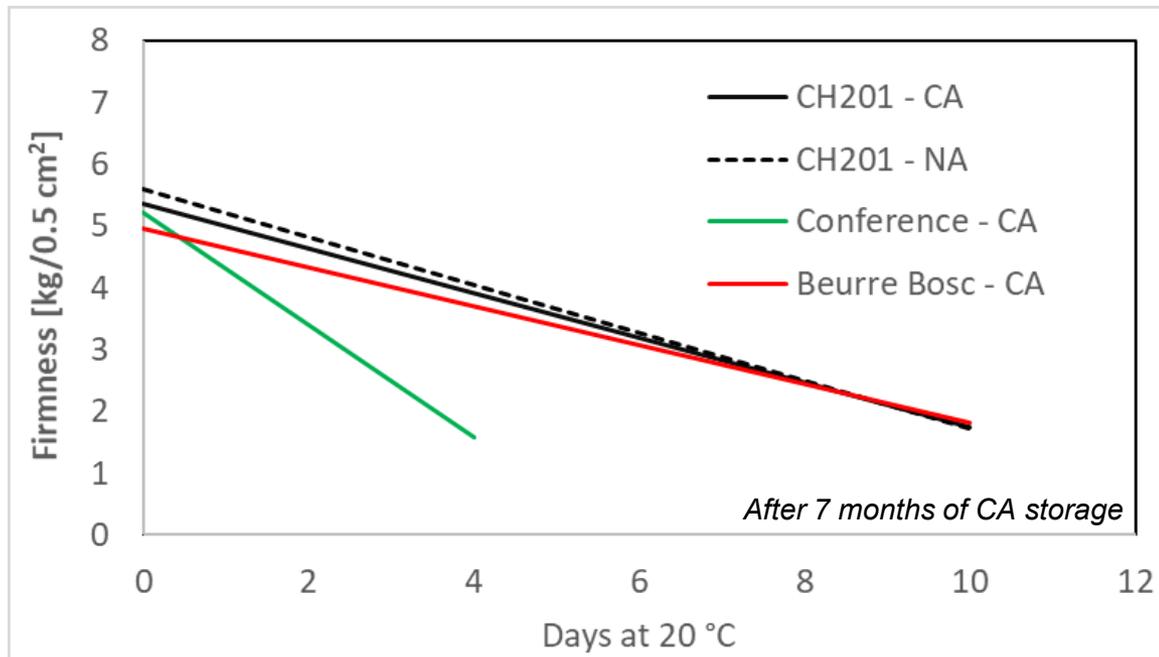


CA: controlled atmosphere
NA: normal atmosphere



'CH 201' has a slow softening rate during shelf life

- 7 to 10 days of shelf life
- Good resistance to postharvest handling



CA: controlled atmosphere
NA: normal atmosphere

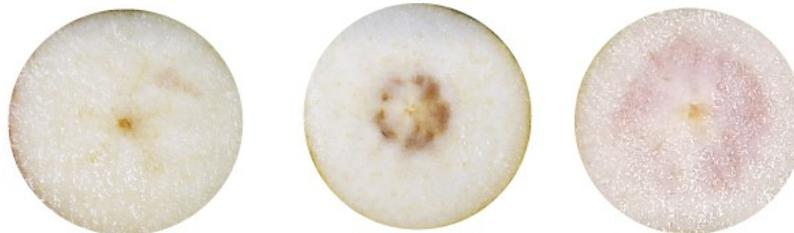


However, 'CH 201' is susceptible to CA-related disorders

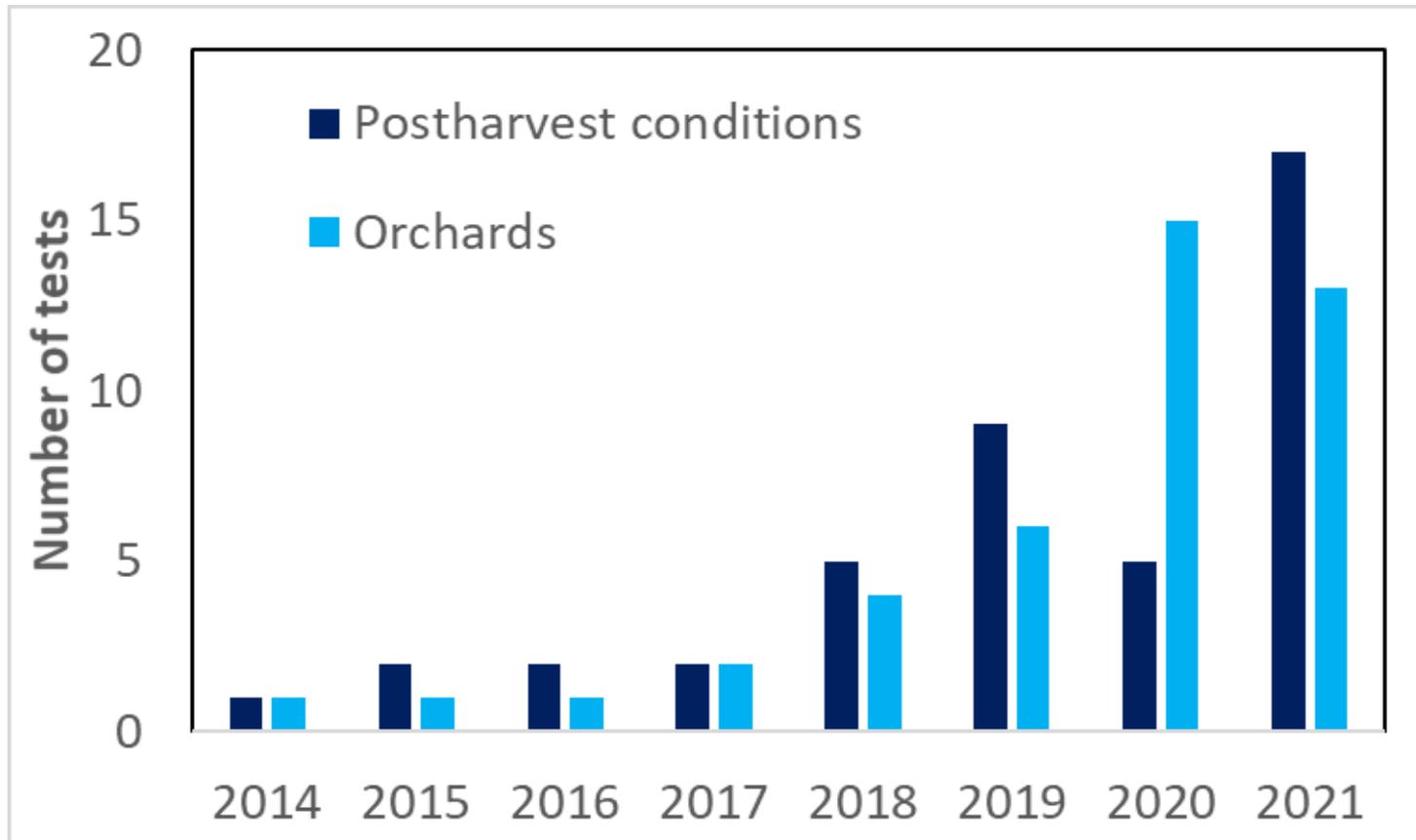
- Cavities



- Flesh browning



We intensified our activities since 2014 to determine the best pre- and postharvest conditions for 'CH 201' pears





2/ Focus on CA-related disorders

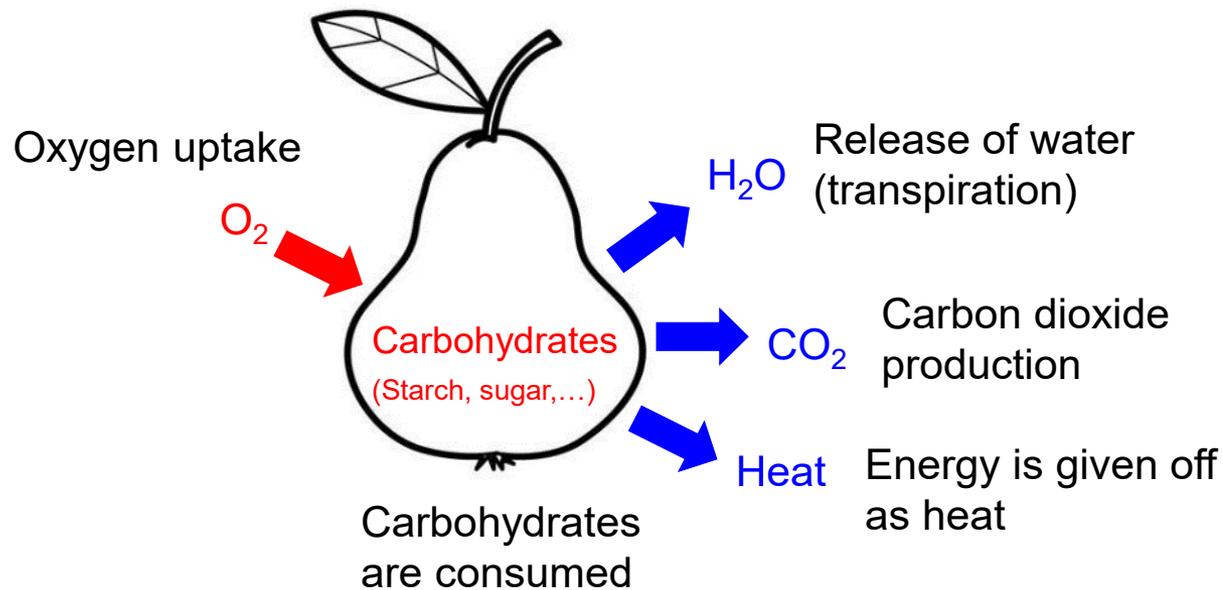
- Physiological background
- Post-harvest factors influencing CA-related disorders
- Pre-harvest factors influencing CA-related disorders



2/ Focus on CA-related disorders

- Physiological background**
- Post-harvest factors influencing CA-related disorders
- Pre-harvest factors influencing CA-related disorders

Fruit respiration after harvest is needed to keep the pears «alive»



- Fruit respiration leads to **aging, softening, degreening,...** of the pears and to the development of decay.

Storage aims at reducing fruit respiration to maintain quality as good and as long as possible

- **Firmness** is a key parameter whose loss is correlated to the intensity of fruit respiration.
- **Various methods** can be used to reduce respiration, and thereby extending fruit storage life:
 - **Temperature** management (cooling and cold storage)
 - **Atmosphere** management (O₂, CO₂ and ethylene)
 - Controlled atmosphere (CA, ULO, XULO, ...)
 - Modified atmosphere (MA)
 - Dynamic controlled atmosphere (DCA)
 - 1-MCP treatment
 - ...

If fruit respiration is reduced too much, CA-related disorders are likely to occur

Controlled atmosphere: **low O₂** and **high CO₂** levels



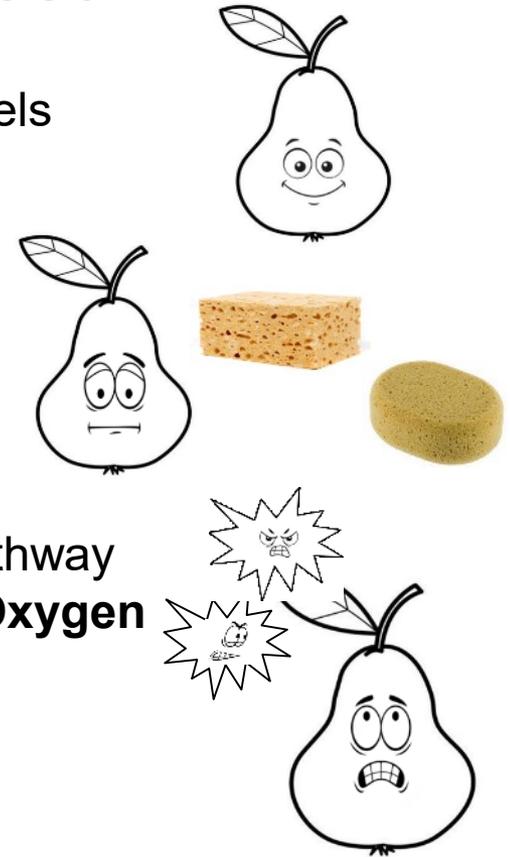
Anoxic conditions in the center of the pear
= **Oxidative stress**



Insufficient energy production via fermentative pathway
leading to accumulation of cell-damaging **Reactive Oxygen Species**



Cavities



Pre-harvest factors influencing CA-related damages have been identified on other pear cultivars

- **Weather** conditions (temperature, rainfall during fruit growth)
- **Orchard** characteristics (type of soil, irrigation, fertilization)
- **Position** of the fruit on the tree

- Main **pear attributes** affected by pre-harvest factors and known to affect browning susceptibility
 - Fruit size
 - Vitamin C
 - Phenolics contents
 - Gas transport properties

Post-harvest factors influencing CA-related damages have been identified on other pear cultivars

- **Maturity** at harvest
 - Duration of **cooling** period
 - **Oxygen** and **carbon dioxide** levels
 - **Temperature** of storage
 - **Duration** of storage
 - **CA-delay**
-
- In general, **late-harvested** and **oversized** fruit are more susceptible to develop CA-related disorders.
 - **Low O₂** and **high CO₂** levels and a **rapid storage under CA** after harvest have been shown to increase the susceptibility to disorders.

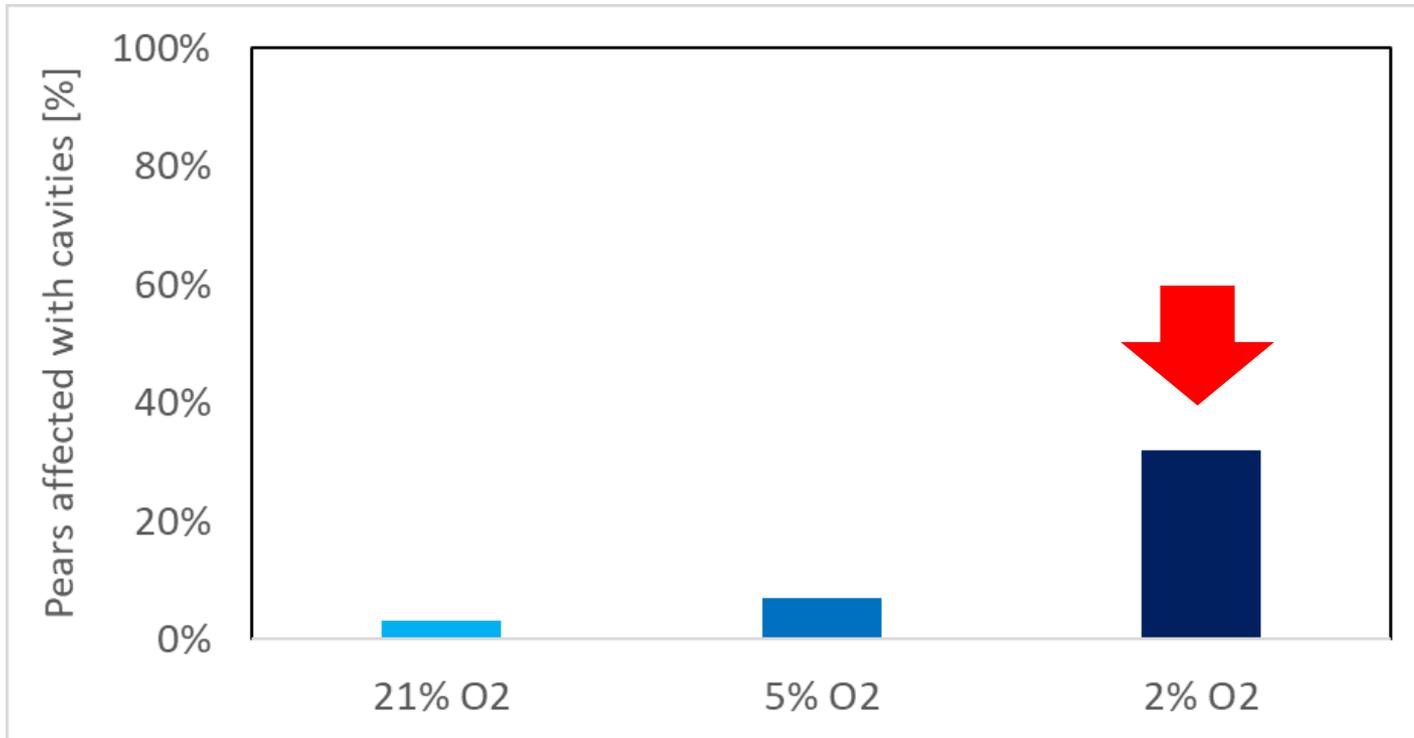


2/ Focus on CA-related disorders

- Physiological background
- Post-harvest factors influencing CA-related disorders**
- Pre-harvest factors influencing CA-related disorders

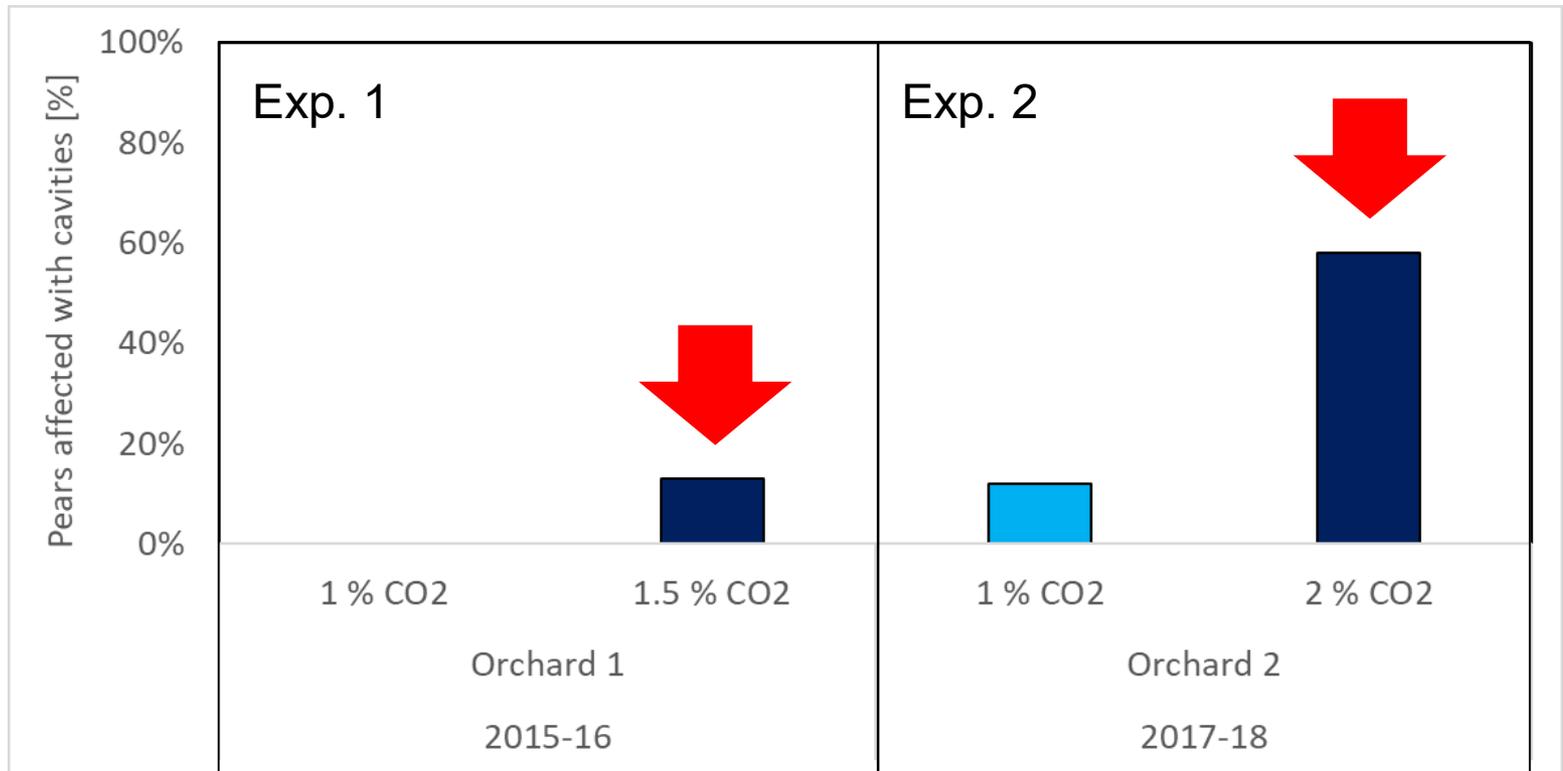


A low O₂ level increases incidence of cavities



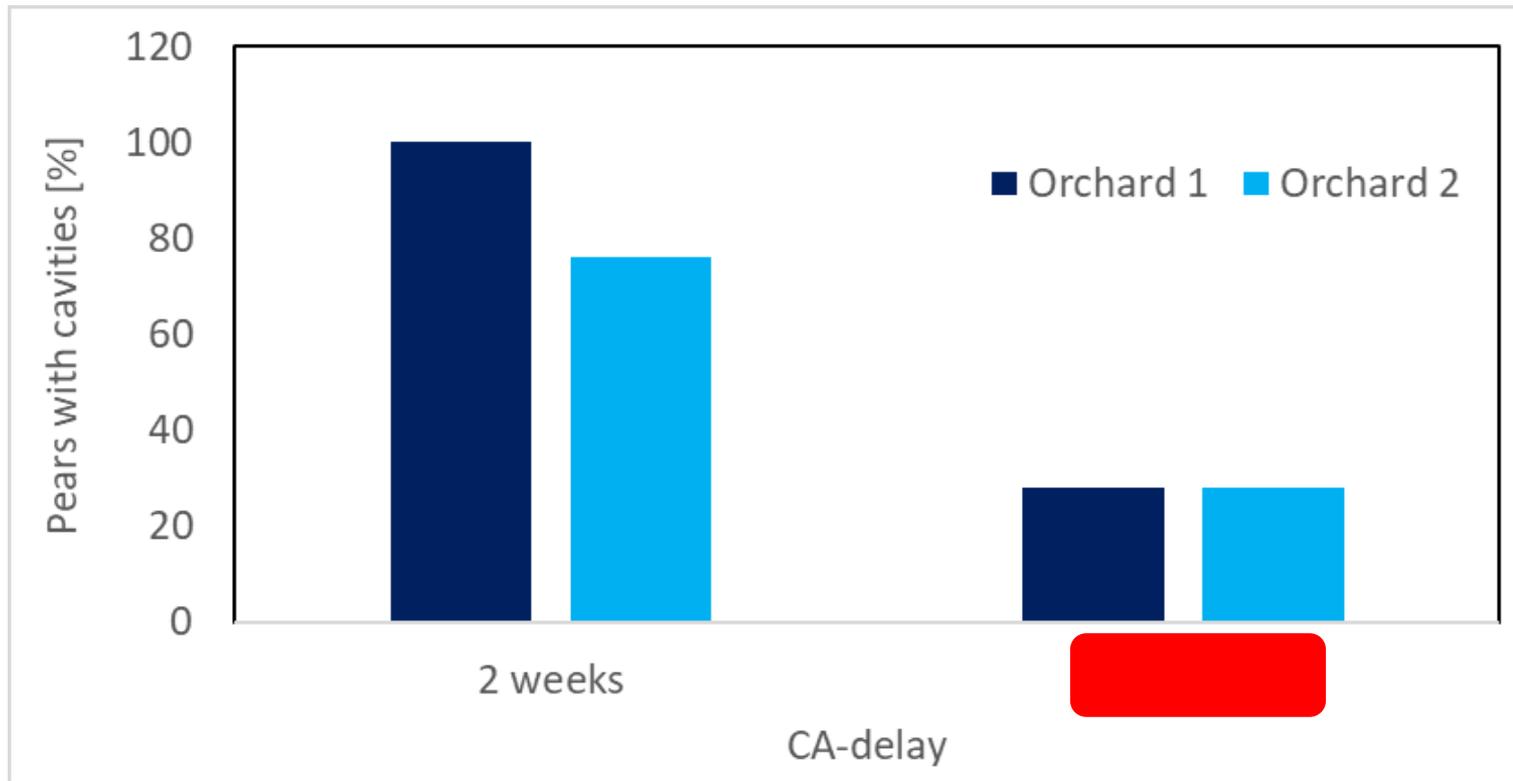
Storage conditions: 0.5 °C, 92 % r.H., 1 % CO₂ and 4 weeks CA-delay (trials 2018-19)
8 months of storage + 7 days at 20 °C

A high CO₂ level also increases incidence of cavities



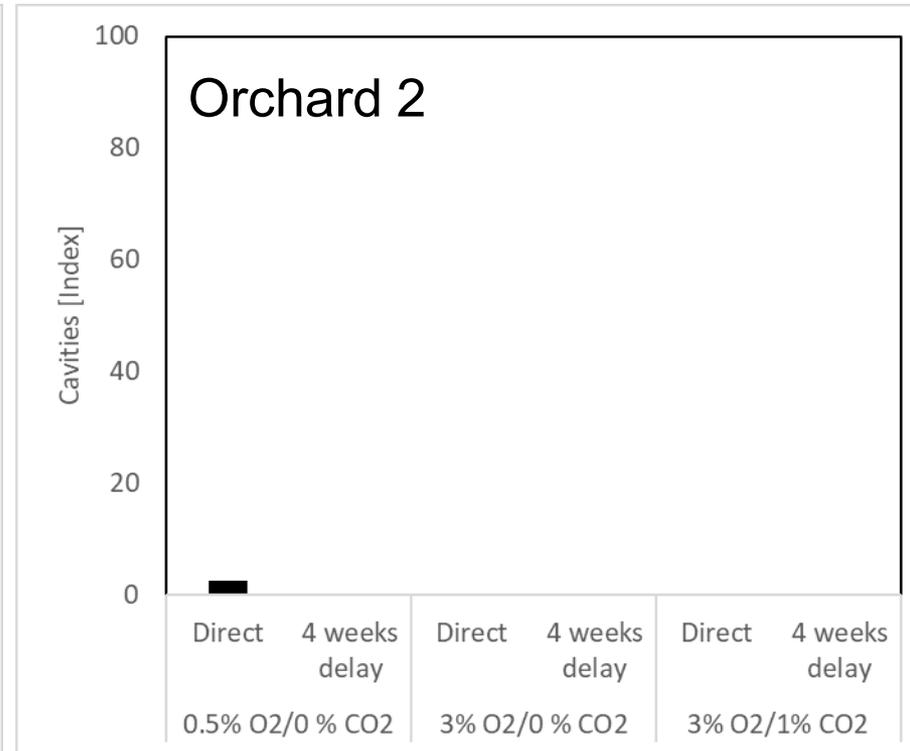
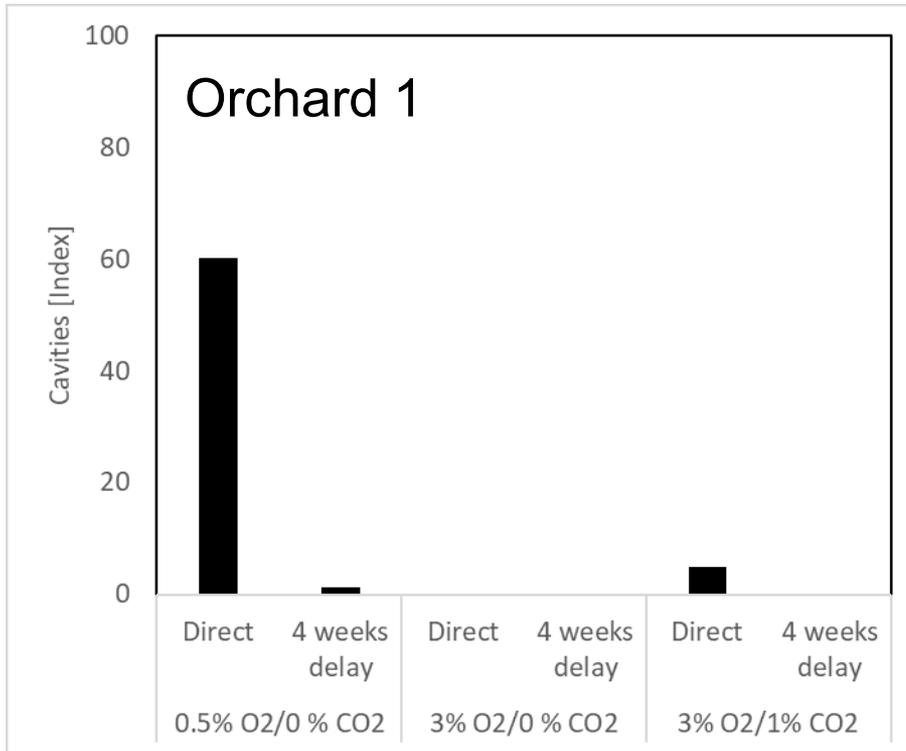
Storage conditions: 0.5 °C, 92 % r.H., 2 % O₂ and 4 weeks CA-delay
5 months of storage + 7 days at 20 °C

A 4-week CA-delay decreases the risks of CA-related disorders



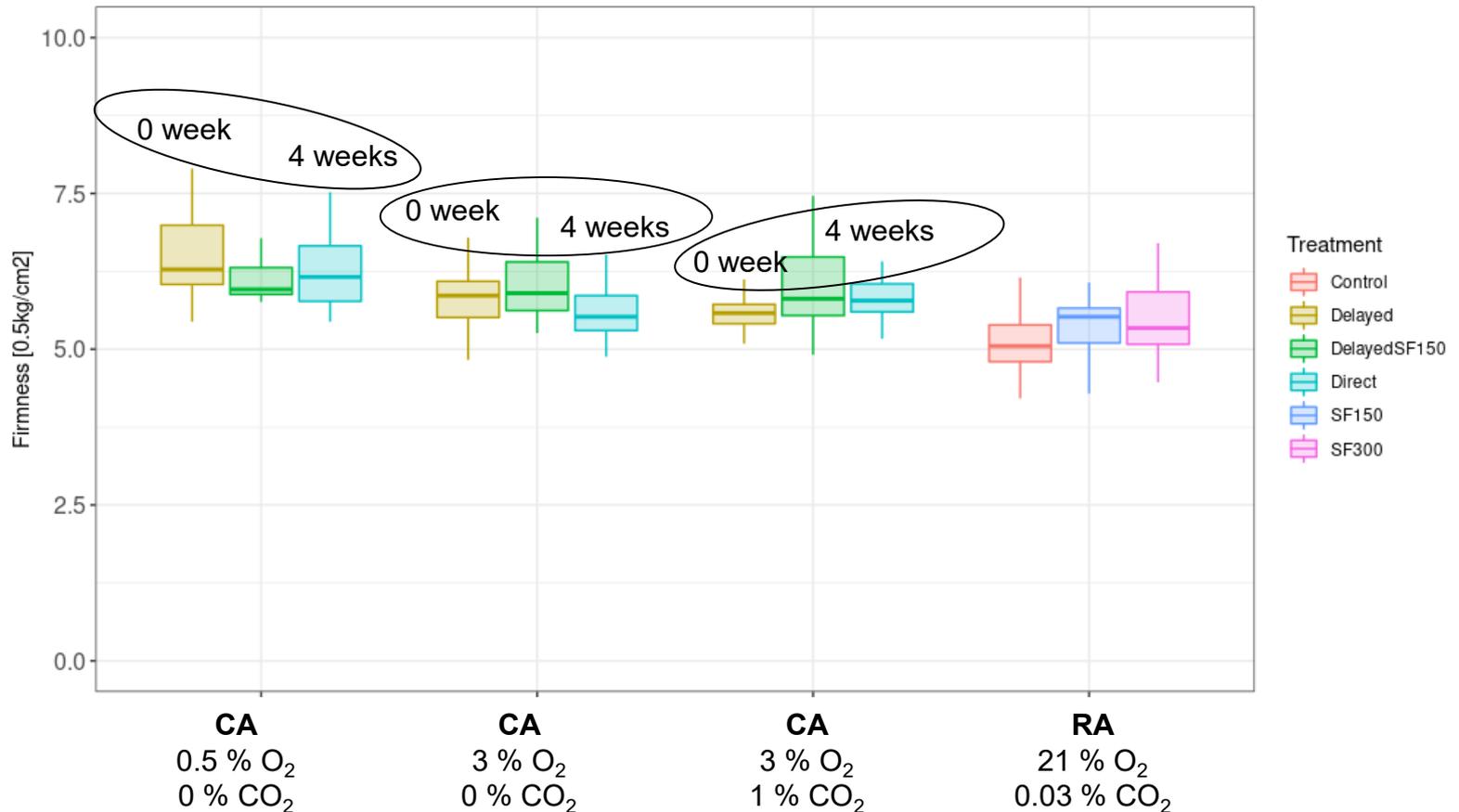
Storage conditions: 0.5 °C, 92 % r.H., 2 % O₂, 1 % CO₂ (Trials 2017-18)
9 months of storage + 10 days at 20 °C

Influence of CA-delay varies according to CA conditions and the orchard



Storage conditions: 0.5 °C, 92 % r.H., 3 % O₂, 1 % CO₂ (Trials 2021-22)
5 months of storage + 7 days at 20 °C

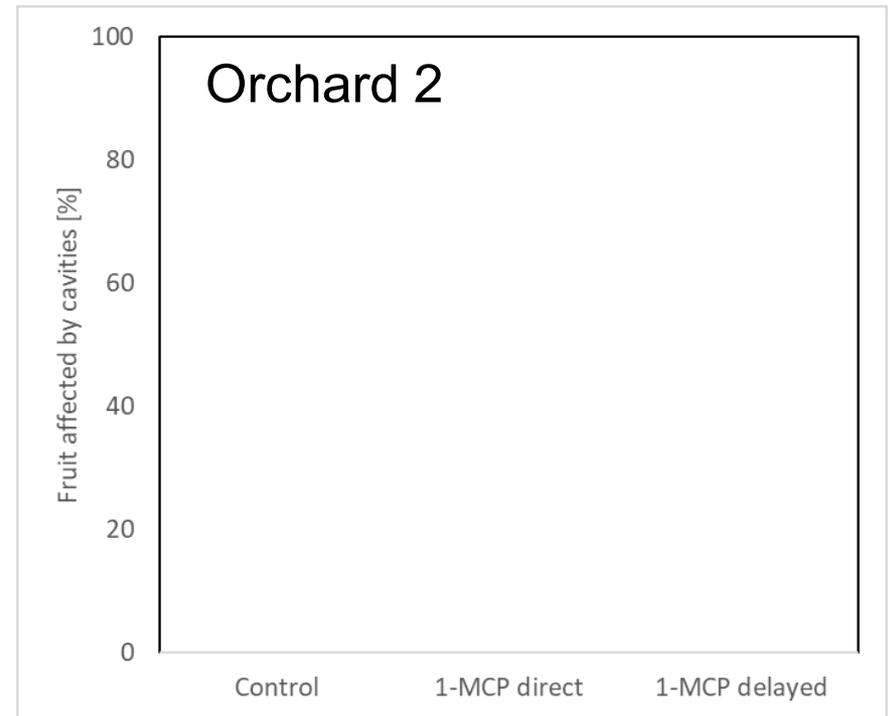
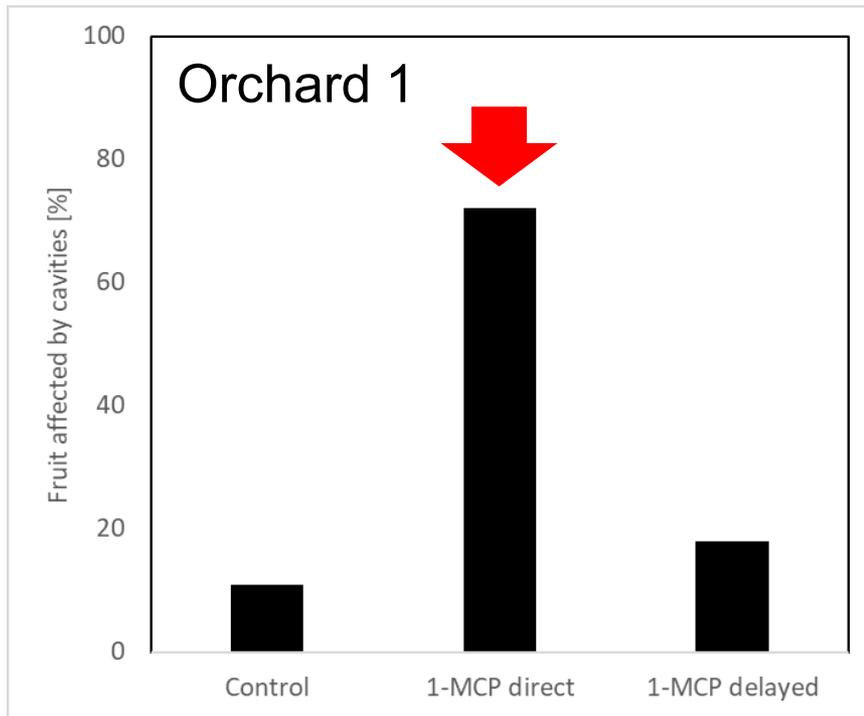
But no influence of CA-delay was observed on firmness after storage





1-MCP increases cavities, in particular when applied directly after harvest

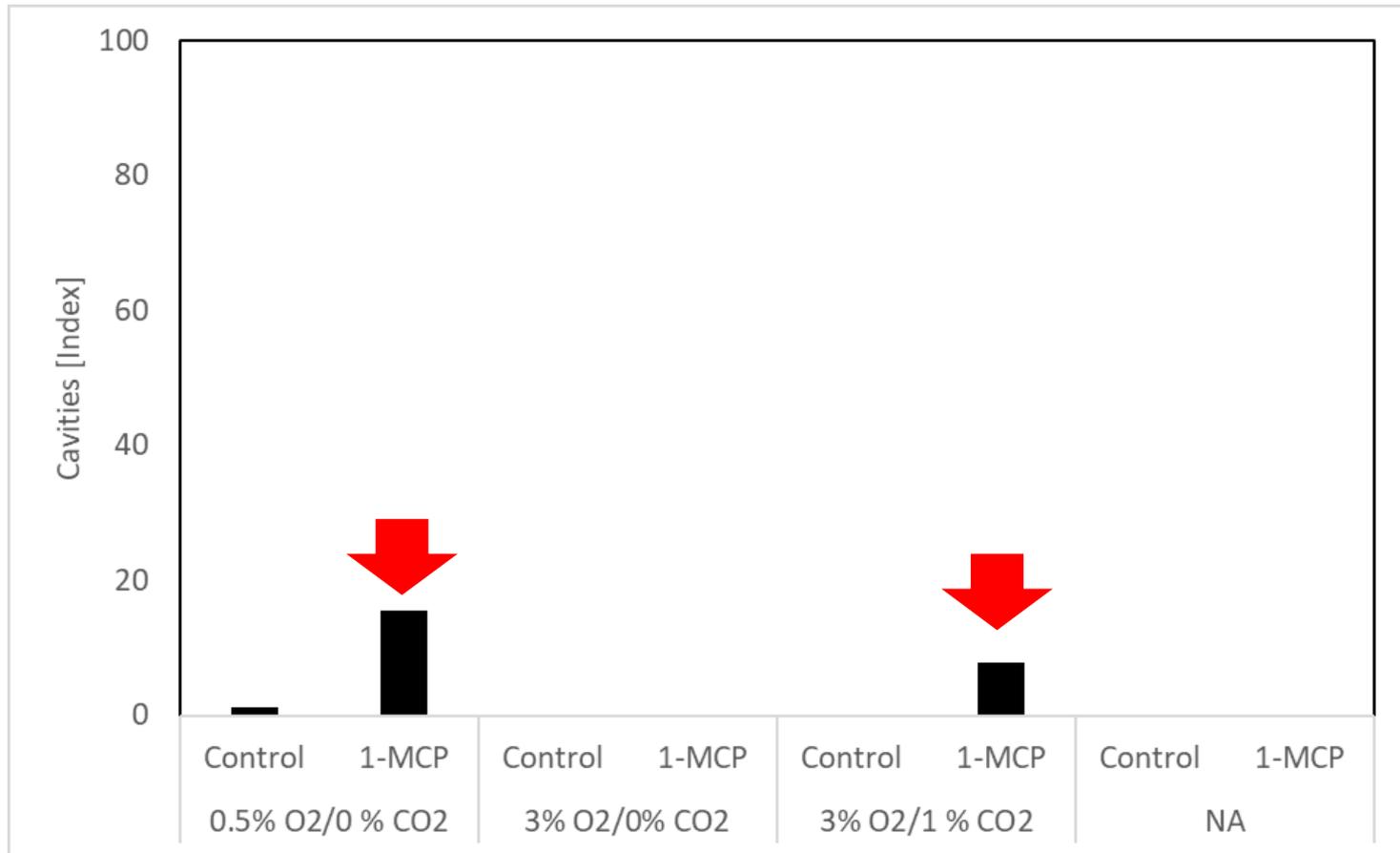
- This effect is orchard-dependant



Storage conditions: 0.5 °C, 92 % r.H., 3 % O₂, 1 % CO₂ (Trials 2020-21), 1-MCP applied at 325 ppb.
8 months of storage + 7 days at 20 °C



This effect increases with low O₂ and/or high CO₂ levels





In conclusion, our studies showed that the following post-harvest factors trigger CA-related disorders:

- Low O₂-levels
- High CO₂-levels
- Direct CA
- 1-MCP treatment, in particular when applied close to harvest and at high concentration
- The influence and extent of impact of these factors **varies according to the orchard !**



2/ Focus on CA-related disorders

- Physiological background
- Post-harvest factors influencing CA-related disorders
- Pre-harvest factors influencing CA-related disorders**

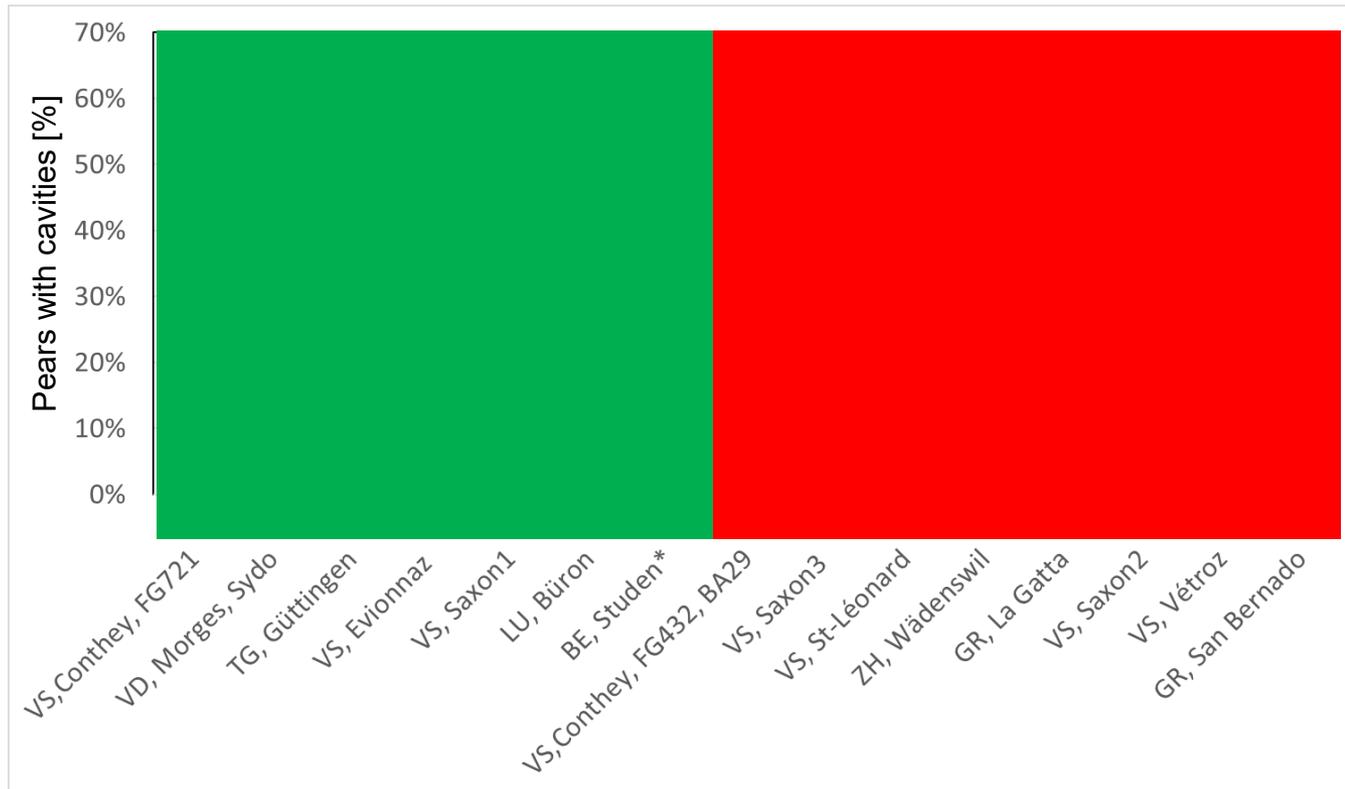
Studies with different orchards stored in the same CA-room have been set up

- Network of 15 orchards (2020-21)



Storage conditions: 0.5 °C, 92 % r.H., 5 % O₂, 1 % CO₂, 4 weeks CA-delay (trials 2020-21)

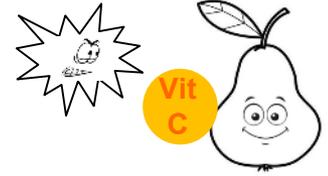
Trees ≤ 4 years of growth were more prone to develop cavities



5 months of storage + 7 days at 20 °C

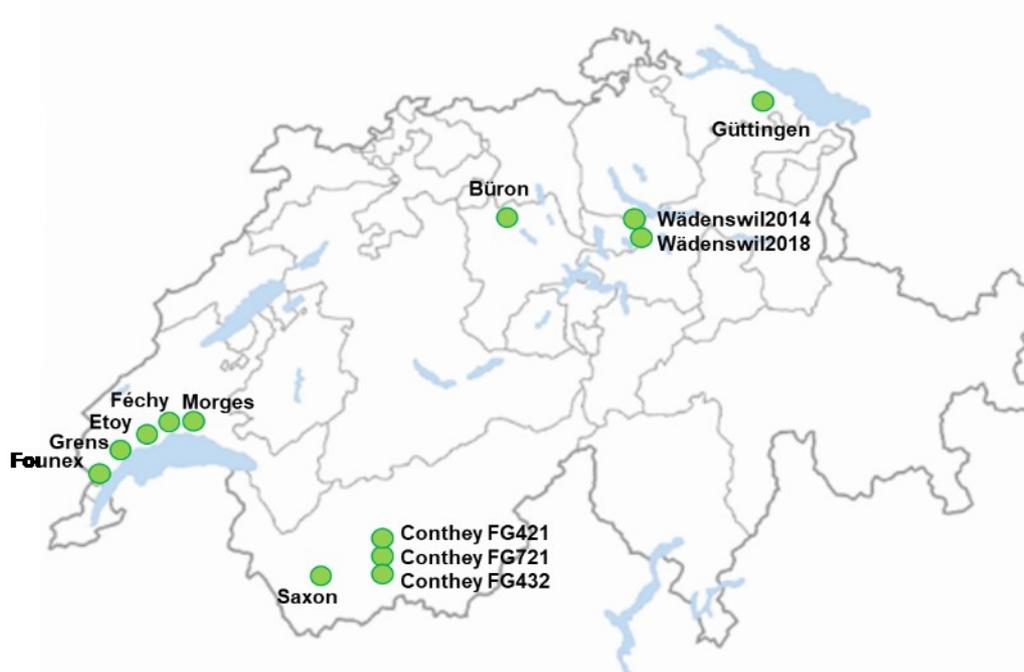


Ascorbic acid was tendencially higher in pears without cavities



In 2021-22, the «network» study has been repeated

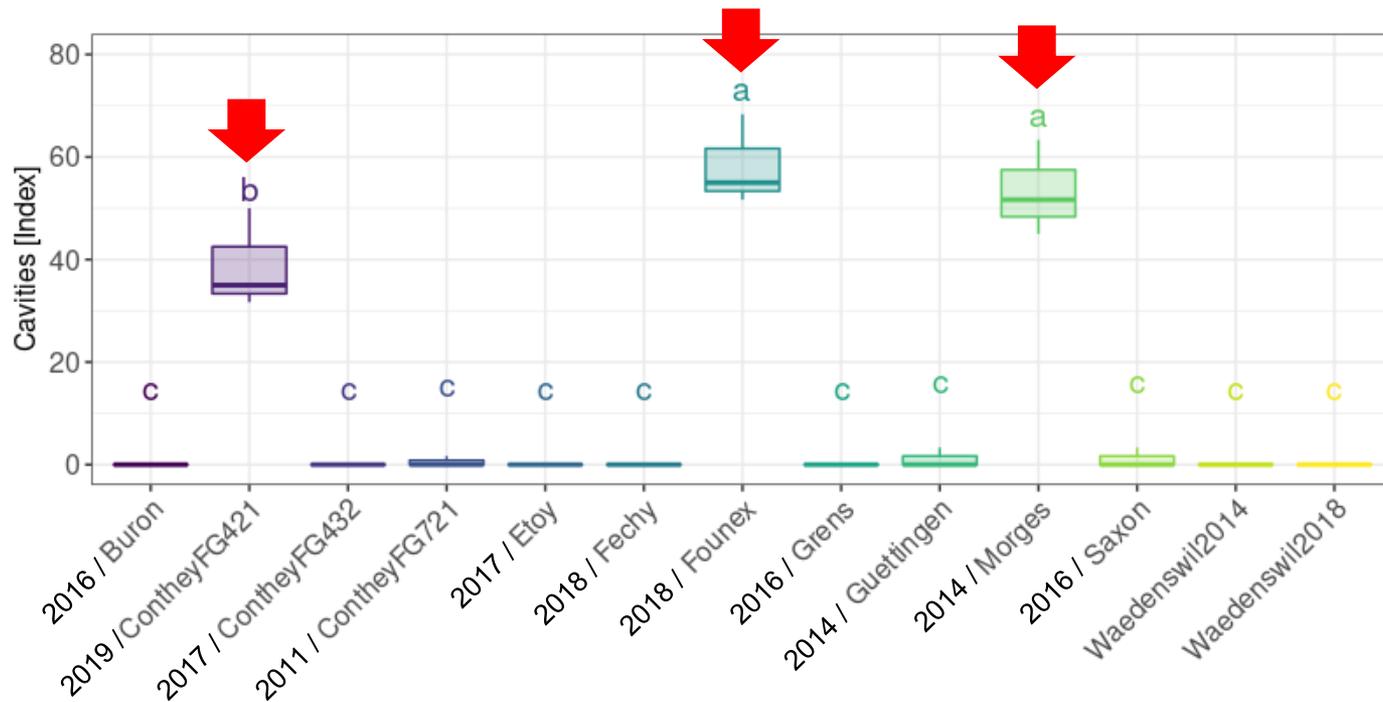
- 13 orchards



Storage conditions: 0.5 °C, 92 % r.H., 3 % O₂, 1 % CO₂, 4 weeks CA-delay (trials 2021-22)

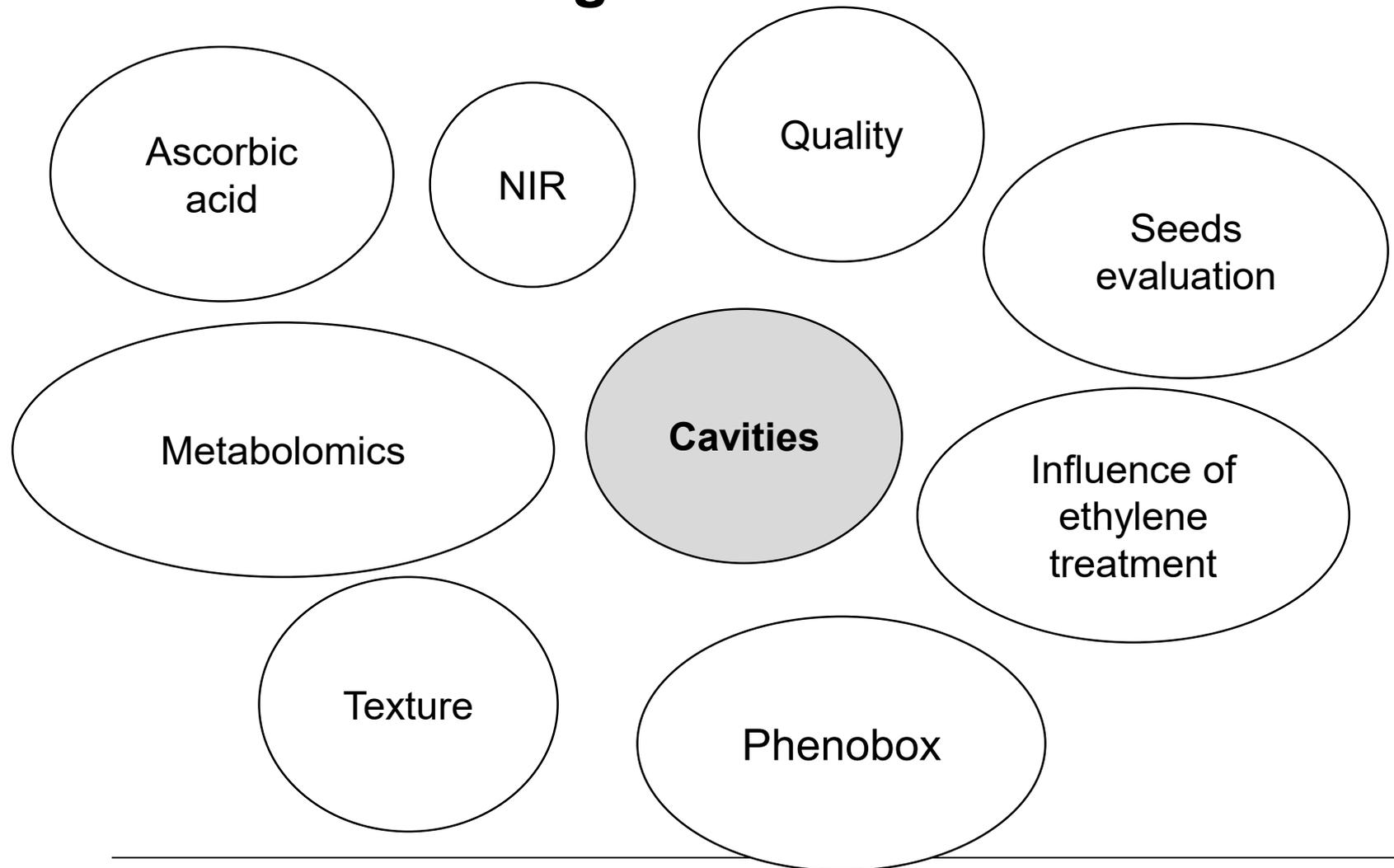


Young and unbalanced trees are more prone to develop cavities



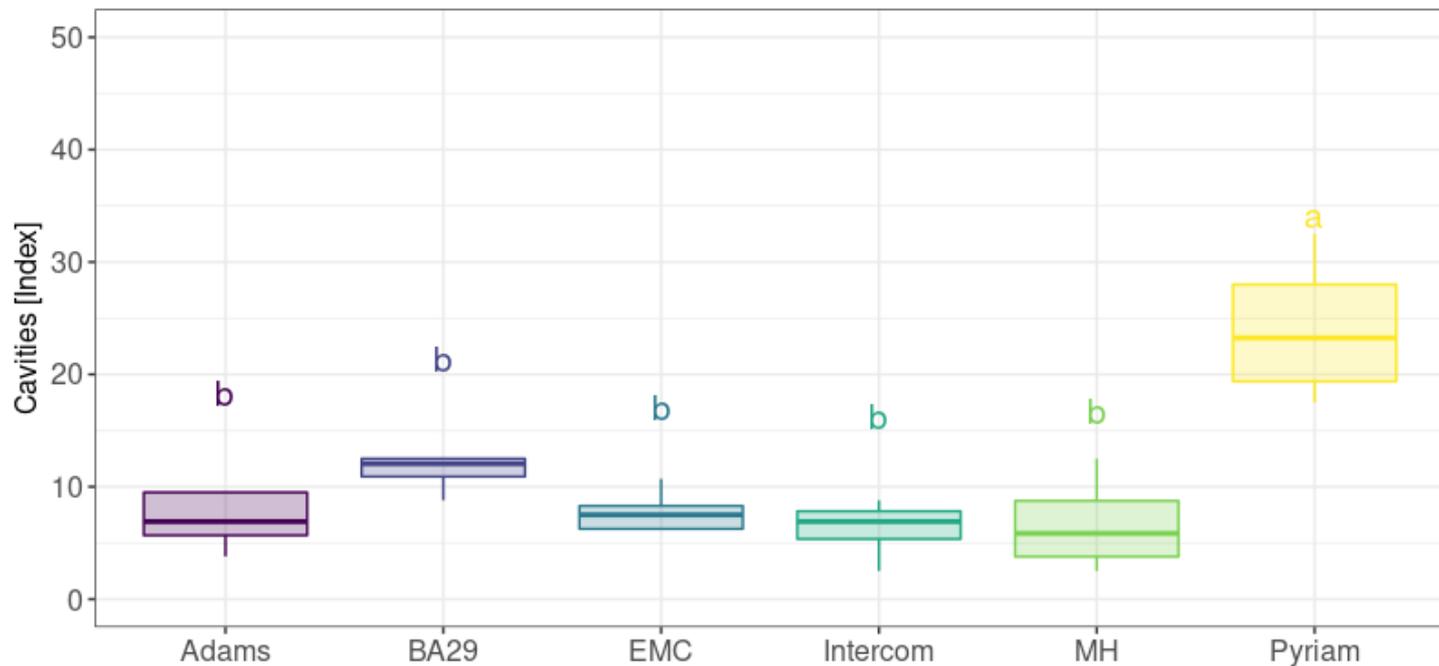
5 months of storage + 7 days at 20 °C

Many analyses are still underway to identify other influencing factors



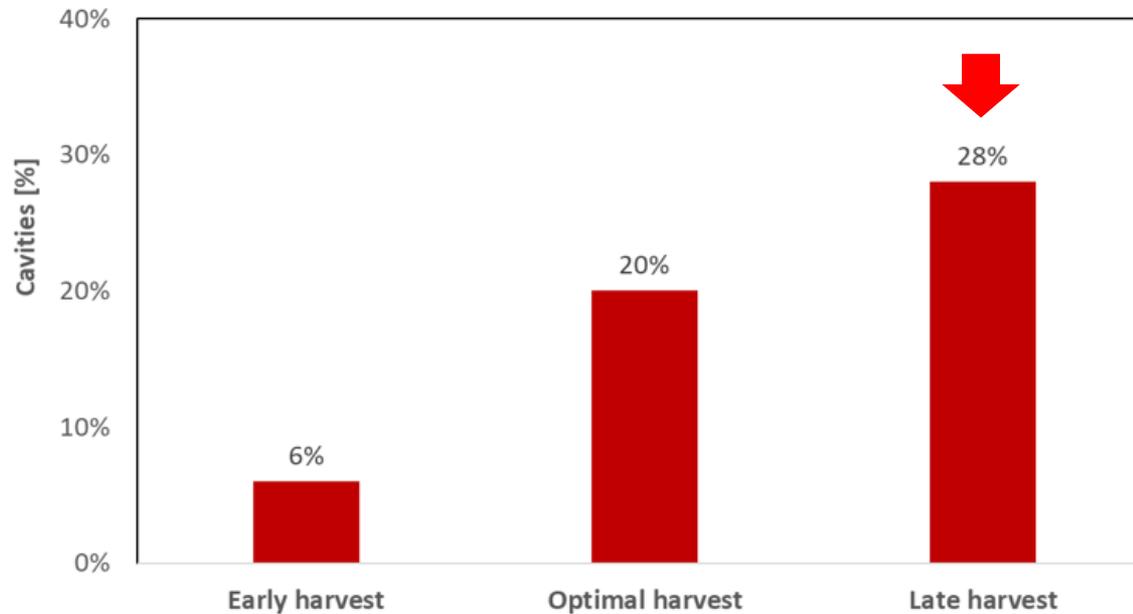
Additional pre-harvest factors of influence: Rootstock

- Pyriam triggers more cavities compared to Quince types
- Tree vigor is higher on Pyriam in our conditions



Storage conditions: 0.5 °C, 92 % r.H., 1 % CO₂, 5 % O₂, 4 weeks CA-delay (trials 2020-21)
5 months of storage + 7 days at 20 °C

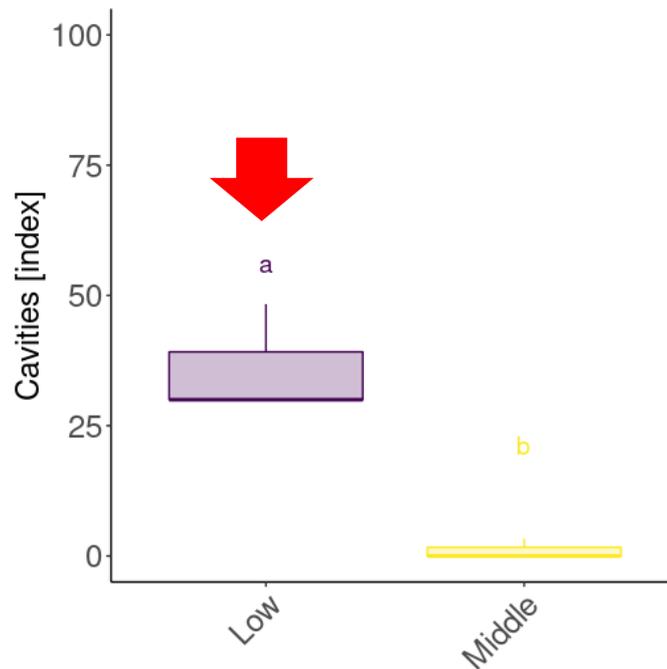
Pears from late harvests are more prone to develop cavities



Storage conditions: 0.5 °C, 92 % r.H., 1 % CO₂, 2 % O₂, 4 weeks CA-delay (trials 2014-15)
5 months of storage + 7 days at 20 °C



Pears from trees with low fruit load are more prone to develop cavities



Storage conditions: 0.5 °C, 92 % r.H., 1 % CO₂, 3 % O₂, 4 weeks CA-delay (trials 2021-22)
5 months of storage + 7 days at 20 °C



In conclusion, our studies showed that the following pre-harvest factors trigger CA-related disorders:

- Trees < 4 years of growth
 - Trees with low crop load
 - Late harvest
 - Rootstocks that foster tree vigor (Pyriam)
-
- Analyses from our last study on 13 orchards are still underway to identify and characterize additional pre-harvest factors

Current best practices recommendation for storage

- **Young orchards, low crop load, high vigor:**
 - Regular atmosphere
 - CA or MA (Janny™ Modules) with complete adsorption of CO₂, CA with 5 % O₂, no 1-MCP
- **Orchards > 4 years, middle to high crop load, middle vigor:**
 - CA at 2-3 % O₂ with 0-1 % CO₂, 1-MCP treatment possible



2 / Methods to predict at harvest susceptibility to CA-related disorders during storage

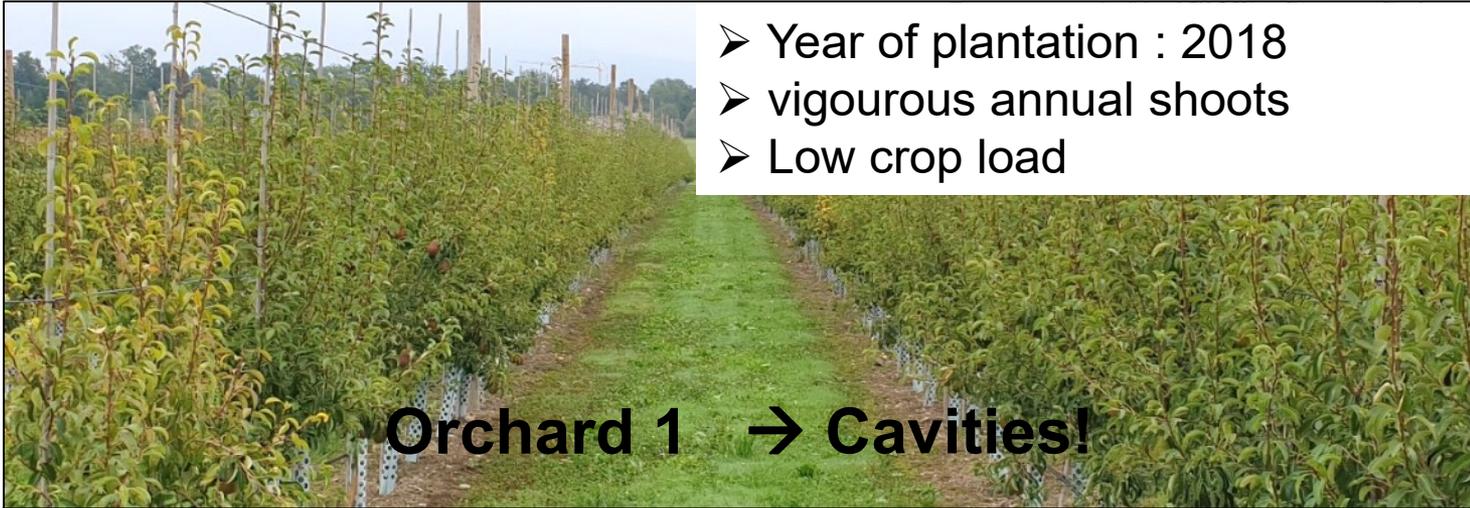
- Visual assessment of trees
- Storage with high CO₂-level
- Non destructive measurements with NIR
- Metabolomics



2 / Methods to predict at harvest susceptibility to CA-related disorders during storage

- Visual assessment of trees**
- Storage with high CO₂-level
- Non destructive measurements with NIR
- Metabolomics

Which orchard will develop cavities in CA?



Trees with a high wood-leaf / fruit ratio are more prone to develop CA-related disorders

Parameter	Increase risks of CA-related disorders
Year of plantation	< 4 years
Tree vigor	High
Number (total length) of annual shoots	Large number
Crop load	low
...	

- Parameters related to the trees need to be determined in a more objective and scientific approach (i.e. measuring annual shoots total length)
- **More research is needed!**



2 / Methods to predict at harvest susceptibility to CA-related disorders during storage

- Visual assessment of trees
- Storage with high CO₂-level**
- Non destructive measurements with NIR
- Metabolomics



Pears are stored in small containers with high CO₂-level

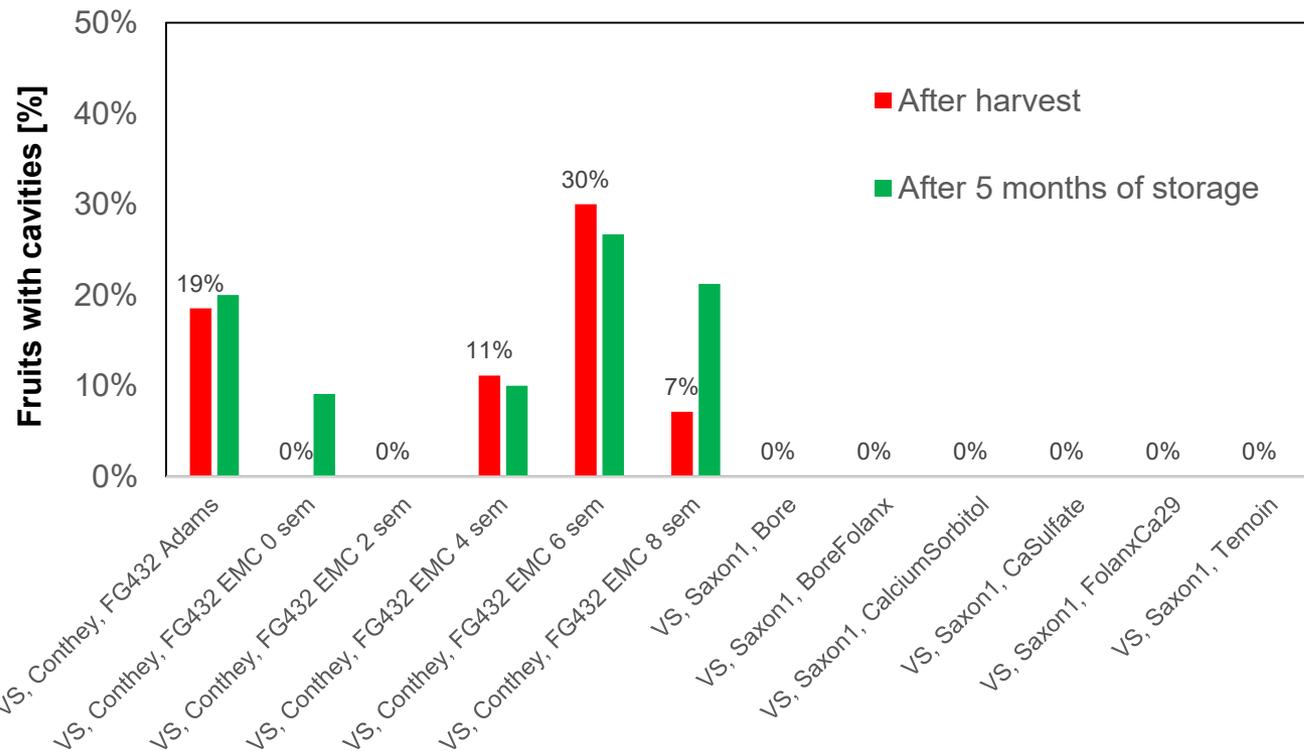
■ Protocol:

- 20 % of CO₂
- 5-10 % of O₂
- 3 days of storage at 3 °C
- 10 days shelf life at 20 °C
- Control of disorders





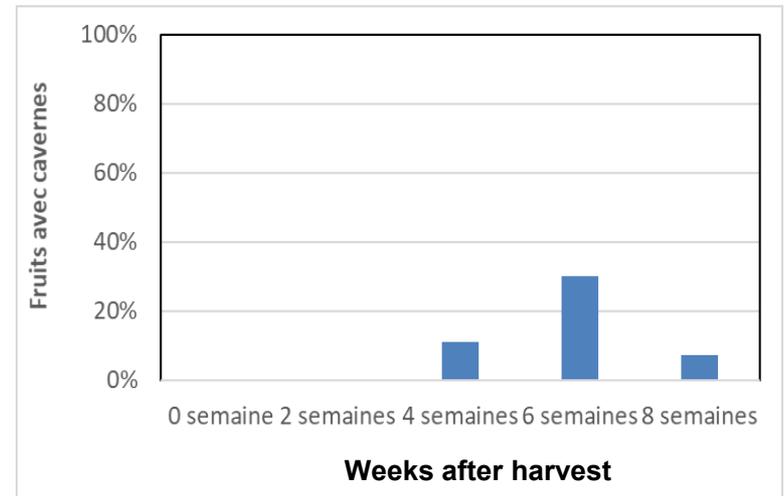
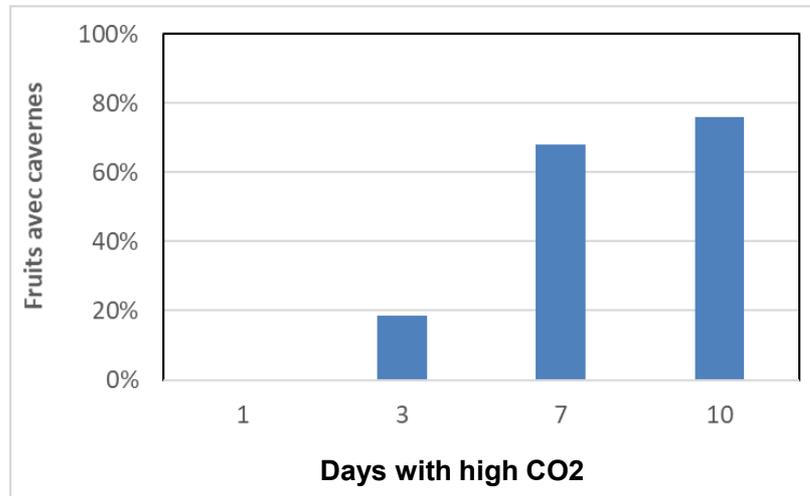
This method enables predicting fruit susceptibility to the development of cavities





But more tests are needed !

- Temperature of treatment (3 °C : good predictions in 2020-21 but same protocol at 0.5 °C resulted in wrong predictions in 2021-22)
- Number of days of treatment
- Timing of treatment after harvest
- ...





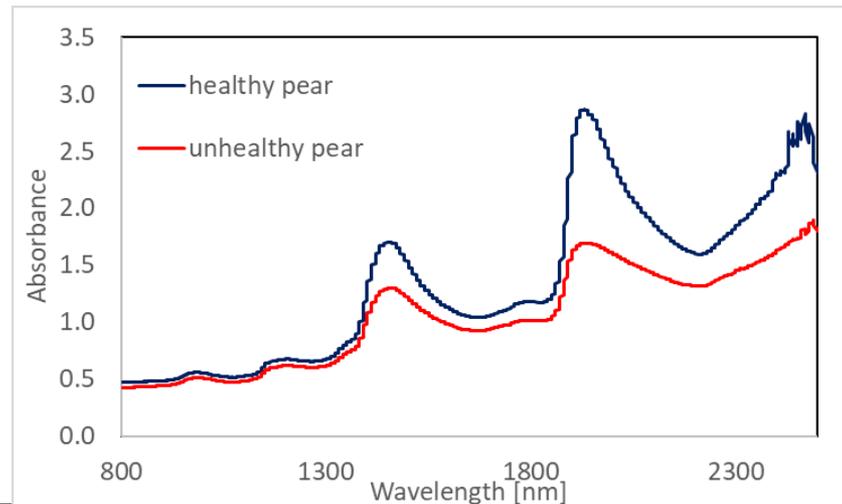
2 / Methods to predict at harvest susceptibility to CA-related disorders during storage

- Visual assessment of trees
- Storage with high CO₂-level
- Non destructive measurements with NIR**
- Metabolomics

NIR fingerprint is obtained on each pear...

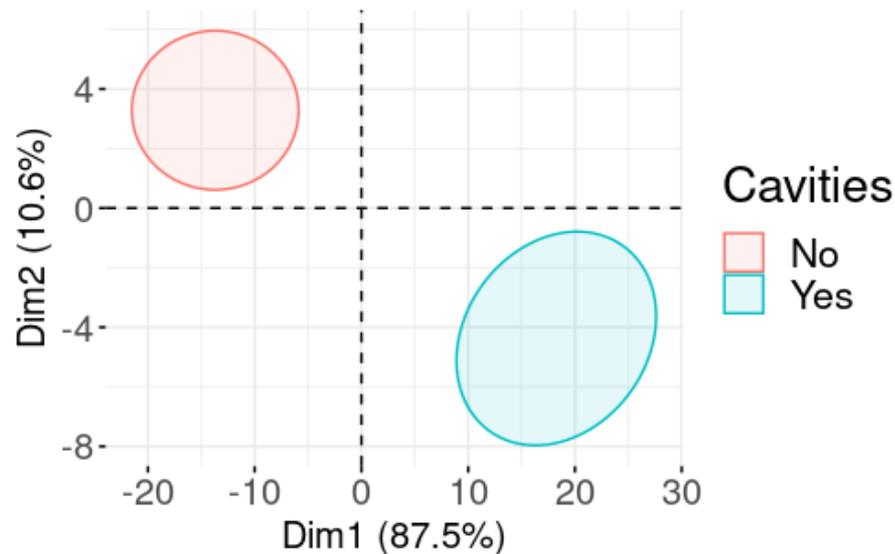


Multi Purpose Analyzer, Bruker



... and shows high potential to discriminate healthy and diseased fruits

- Measurements performed before CA-storage
- NIR fingerprint seems to correlate with the development of cavities after CA storage



- **External validation is planned to confirm these results**

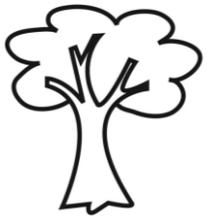


2 / Methods to predict at harvest susceptibility to CA-related disorders during storage

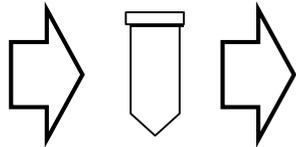
- Visual assessment of trees
- Storage with high CO₂-level
- Non destructive measurements with NIR
- Metabolomics**

Metabolomics aims at identifying metabolites related to CA-related disorders at harvest

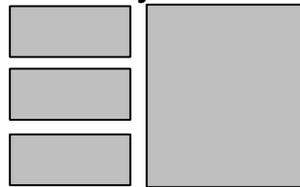
Harvest



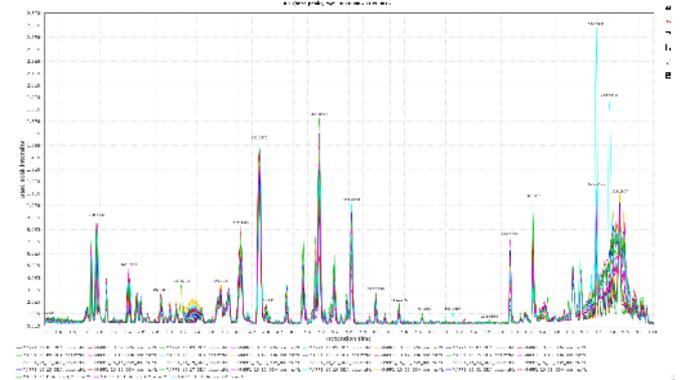
Sample preparation



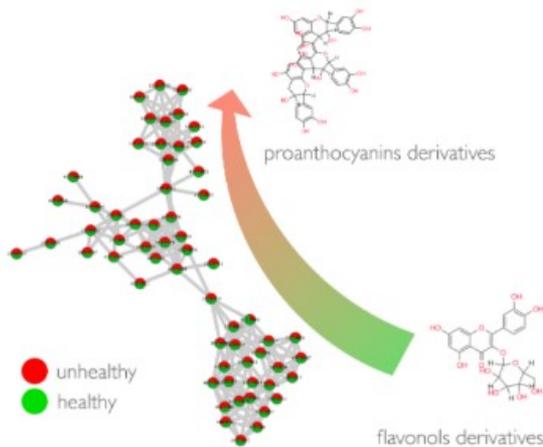
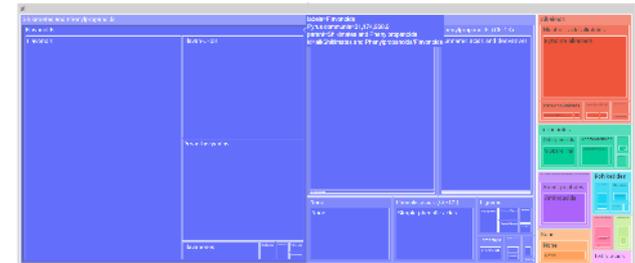
LC-MS analyses



Total ion chromatogram



Metabolite Annotation

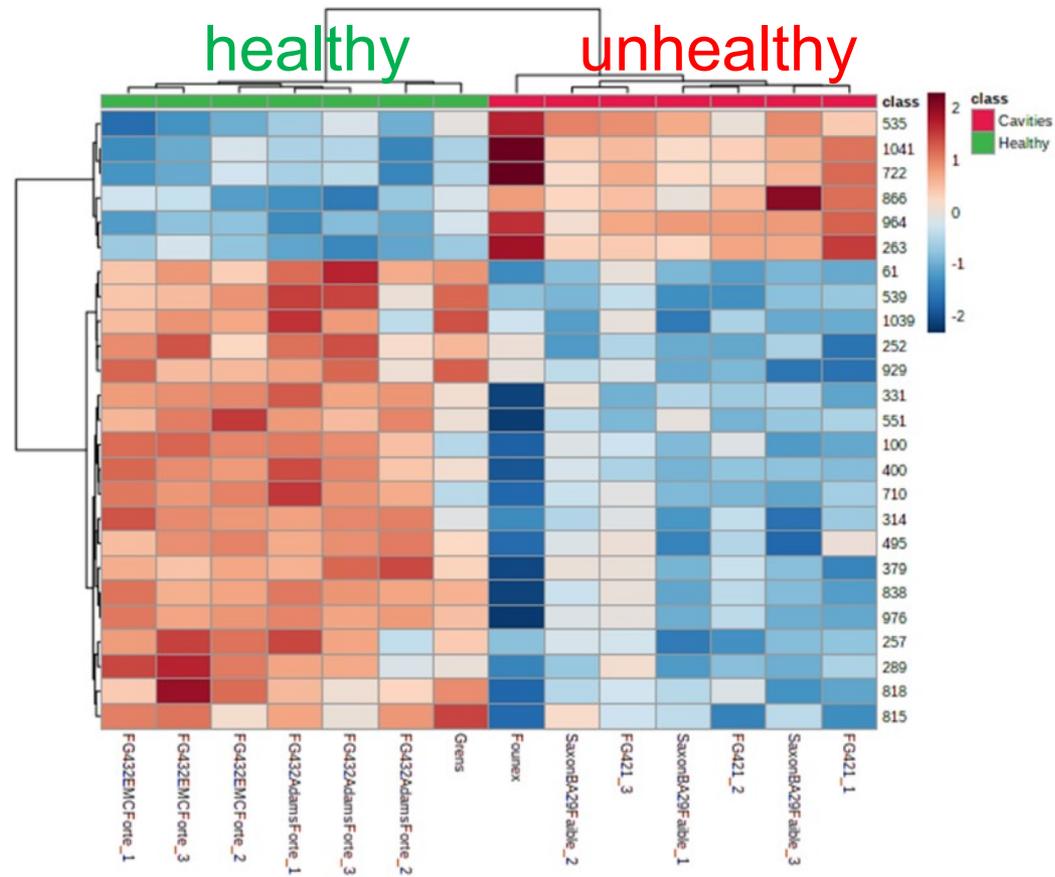


Molecular Network



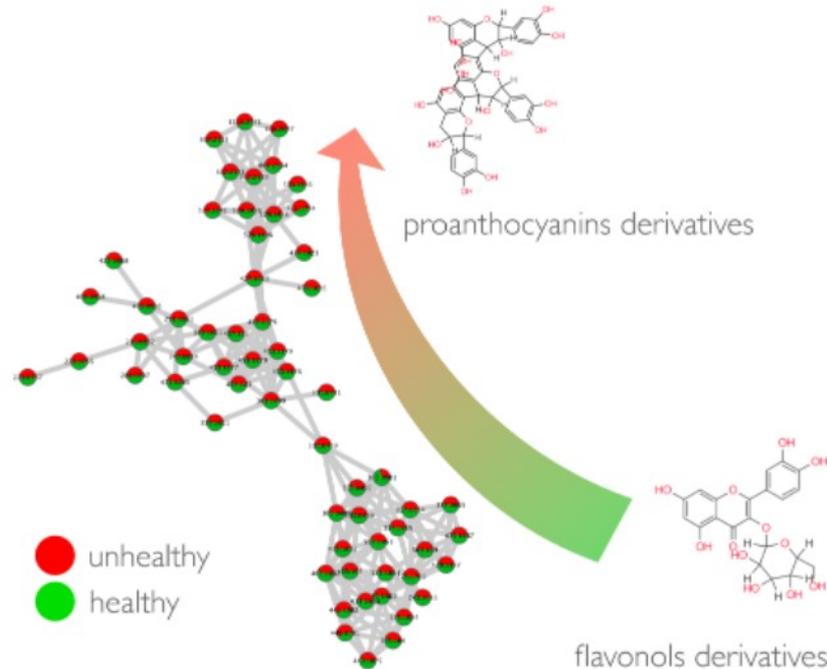


First data enable identifying features that are apparently differentially expressed between healthy and unhealthy samples





Preliminary interpretations show that flavonols appear to be slightly more present in healthy fruit



- The next step is to **link metabolomics results to actionable best-practice recommendations**



Conclusions

- **CA-related disorders:**

- cannot be entirely solved by post-harvest techniques.
- Many influencing factors have been identified so far.
- Additional parameters related with the orchards still need to be investigated: pruning, fertilization, gibberellin application,...

- **Methods to predict at harvest susceptibility to CA-related disorders during storage:**

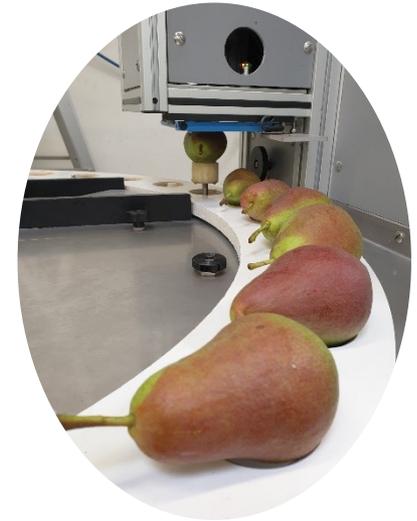
- First studies showed promising results.
- Further research is needed to confirm the results and implement these methods in practice.

- An **acceleration of the global research** on 'CH 201' is necessary to quickly provide pre- and post-harvest recommendations sustaining high quality fruit production and high return on investment.



Many thanks to all the people who worked, helped and collaborated on these studies

- Danilo Christen
- Michael Weber
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- Pierre-Marie Allard and team, Uni Fribourg
- Daniel Neuwald and Team, KOB
- Adriano Saquet
- ...





Thank you for your attention

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