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WORKSHOP PISA
NOVEMBER 23, 2017

Circular Economy: Exploitation of low cost - high value fruit and vegetable by-products and other low impact agricultural strategies

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Grupo de Investigación en Alimentos de Origen Vegetal

From the field to the table

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Circular Economy: Exploitation of low cost - high value fruit and vegetable by-products and other low impact agricultural strategies

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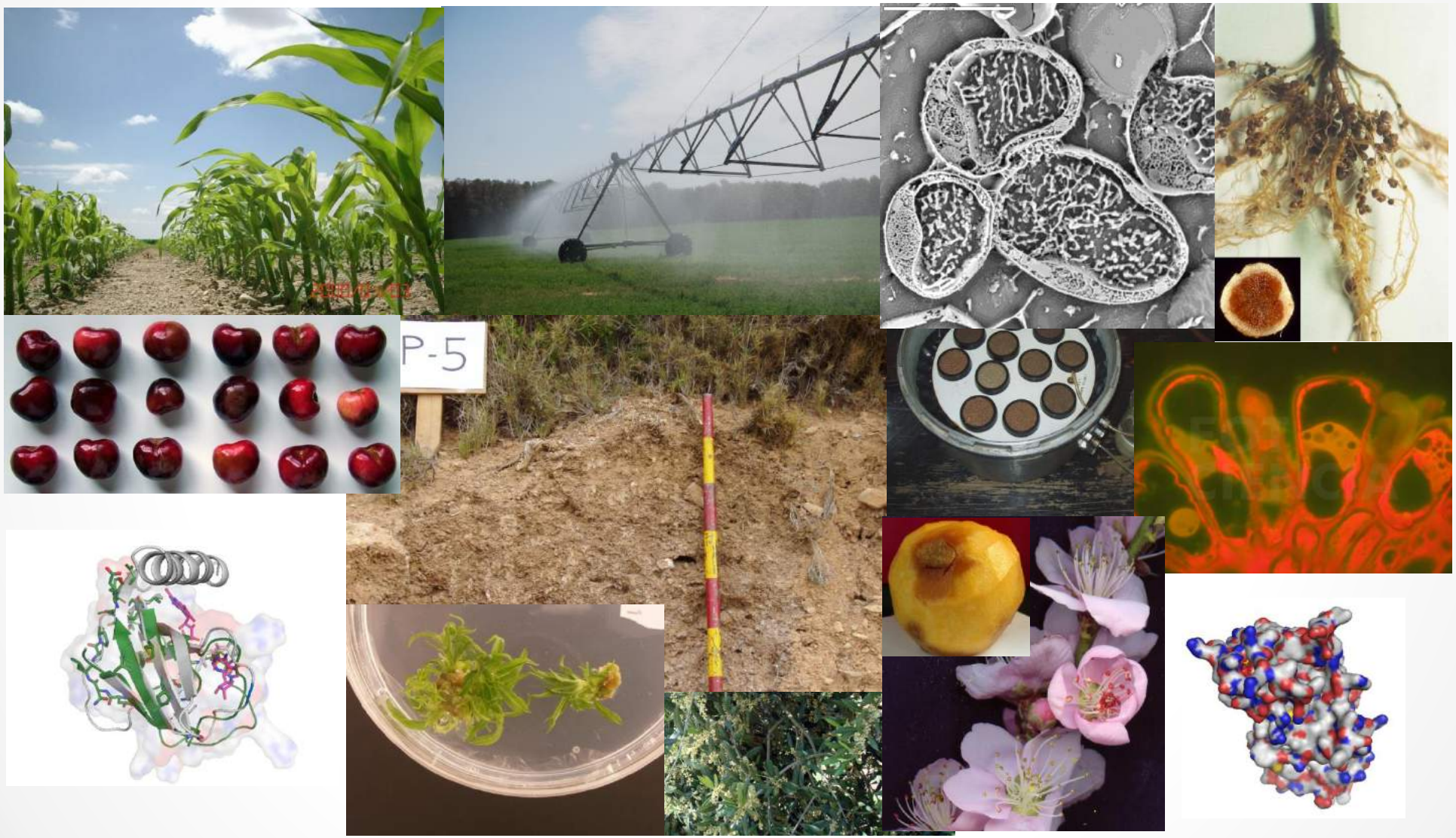

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Nutrition of Fruit Crops

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- The development of **agronomic techniques** to improve fruit quality
- The development of **non-destructive techniques** to evaluate fruit quality
- The study of **calcium metabolism** in fruit trees and development of **strategies for foliar treatments**
- The development of **postharvest physical treatments** to reduce the incidence of physiopathies
- The study of the **proteomics of the fruit** and its physiological alterations
- The study of **allergens** of the fruit

Summary

Re-use of thinned fruit by-products for functional and/or technological applications

CIRCULAR ECONOMY

Calcium foliar applications using only food additives: a sustainable alternative for crop nutrition

REDUCTION OF ENVIRONMENTAL IMPACT

Low impact treatments without chemicals to maintain the quality of fruits during storage

REDUCTION OF ENVIRONMENTAL IMPACT

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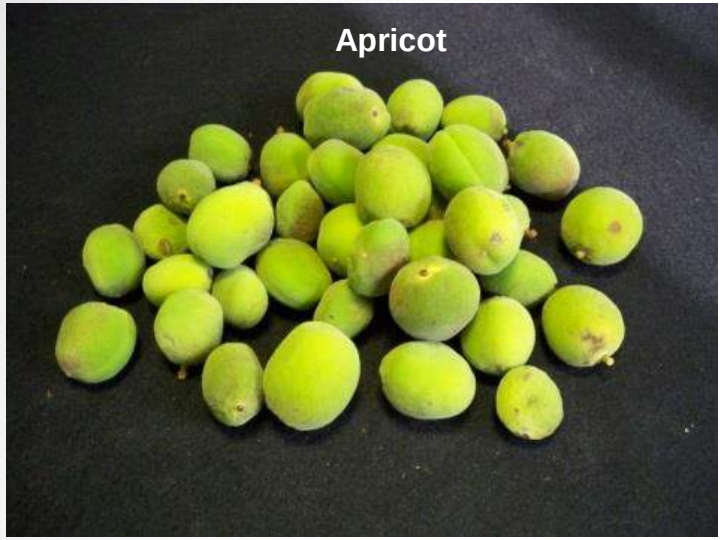
Re-use of thinned fruit by-products for functional and/or technological applications

Fruit thinning

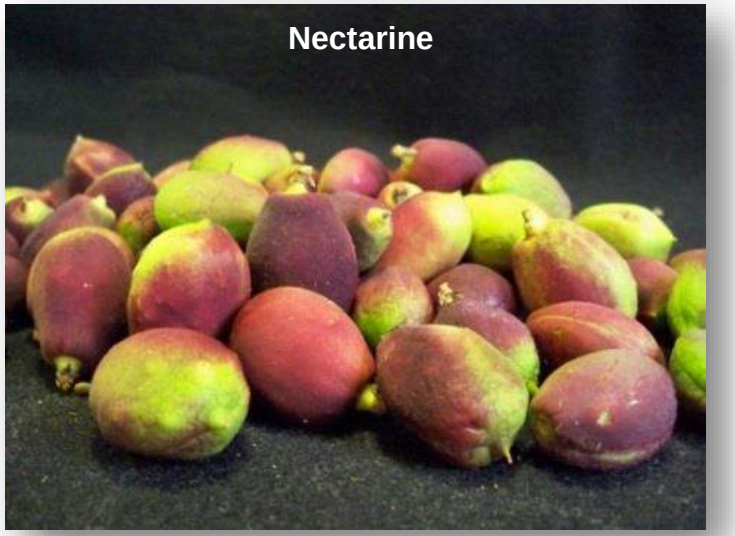
- **Objective**:
  - Increase final size
  - Avoid excessive weight in branches
  - Uniform distribution
  - Minimize alternate bearing
- **Dates:**
  - 30-40 after bloom
- **Size:**
  - 2-5 cm
- **Distance between fruits:**
  - 5-15 cm
- **Cost:**
  - 25-30 min/tree
  - 200-300 hours/ha
  - 3,43-4,11 €/tree
- **Waste generated**
  - 50-80%

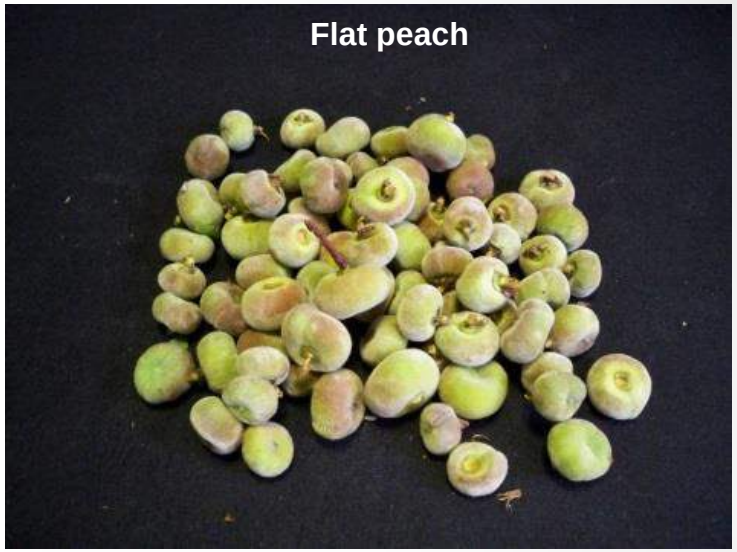
Thinned fruits



Comercial

Thinned fruits





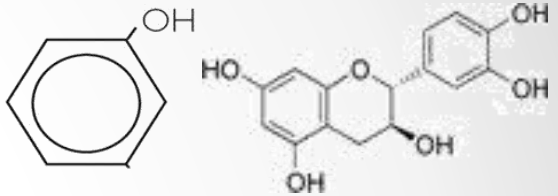
Possible re-use of thinned fruits

- Nowadays, there is no **optimal** procedure for their use
- Fruits at an early stage of maturity → higher content of bioactive compounds
- **Large volume** of by-products: their use might **generate economic profits**

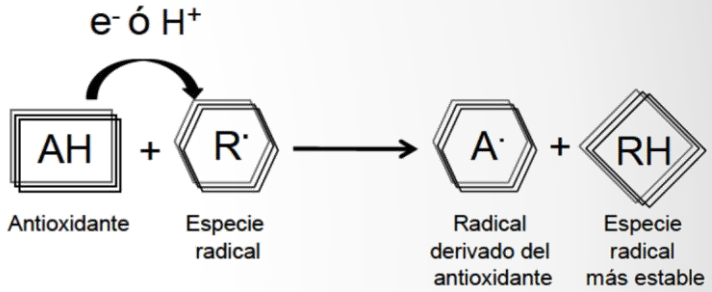
Could thinned fruits be considered a new source of compounds with functional and/or technological interest?

Antioxidant activity

- **Antioxidants**: inhibit the free radicals oxidation
  - Phenols
  - Flavonoids
  - Other compounds

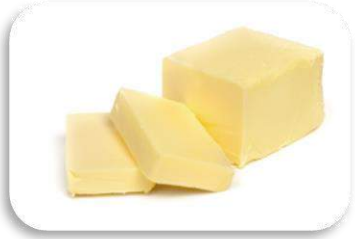


- **Free radicals**: unpaired electron and highly reactive



- **Health effects:**
  - Free radicals causes diseases
  - Endogenous and exogenous antioxidants

- **Effects on food: lipid oxidation**



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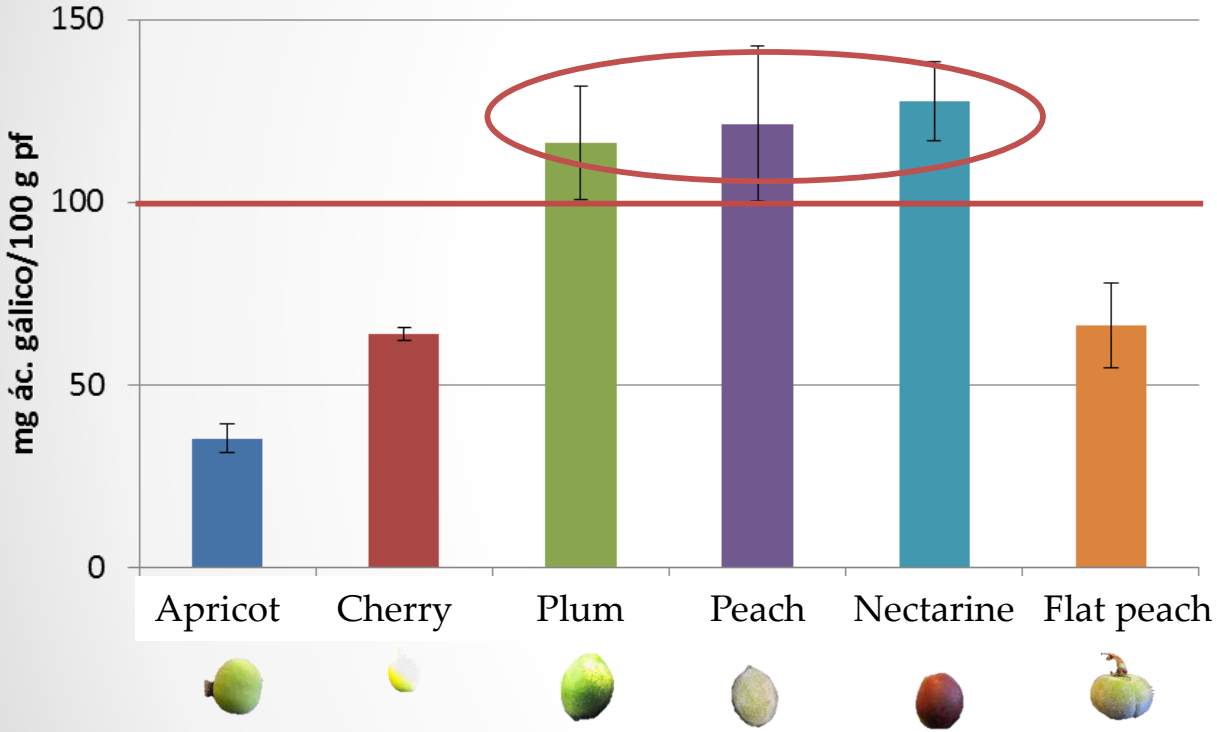
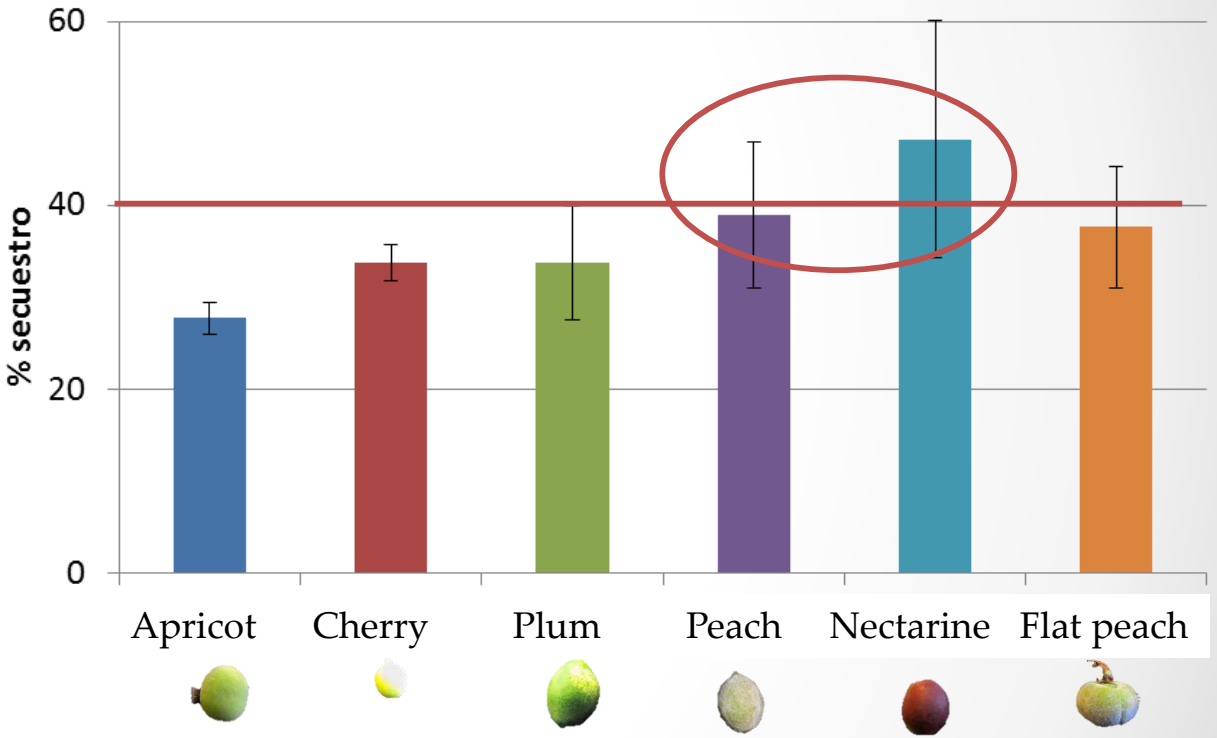
Antioxidant activity

Phenolic content

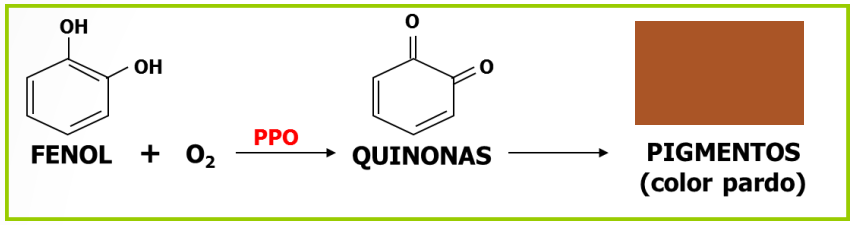


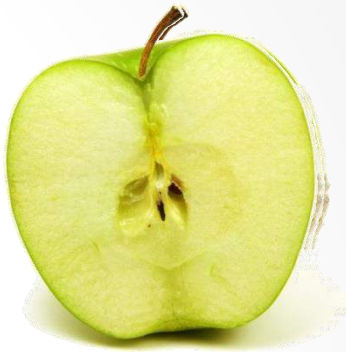
Antioxidant activity (DPPH)



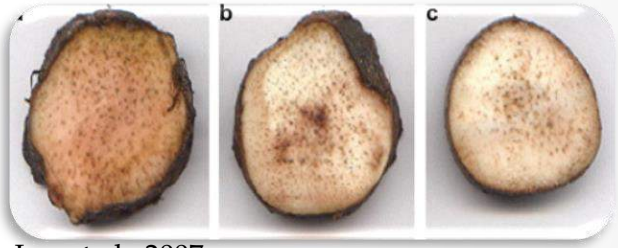
Antibrowning activity

- The problem of **enzymatic browning**

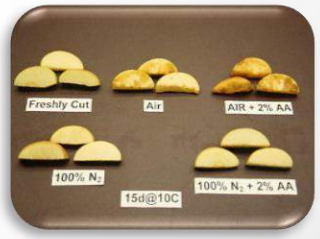




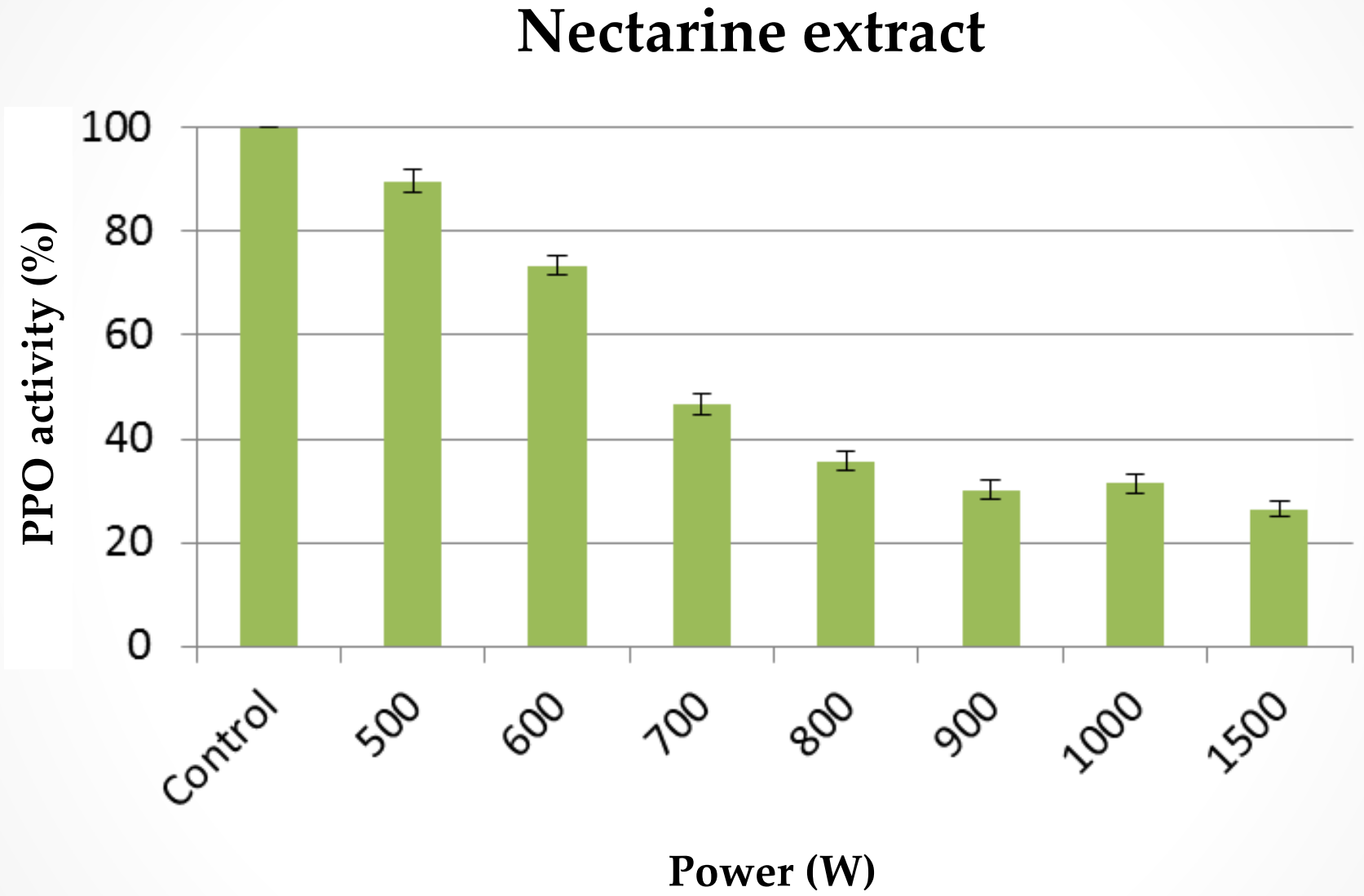
- **Browning control**
  - Modification of pH
  - Use of chelator
  - Complexing agents
  - Reducing agents
  - Enzyme inhibitors



Lee et al., 2007



Antibrowning activity



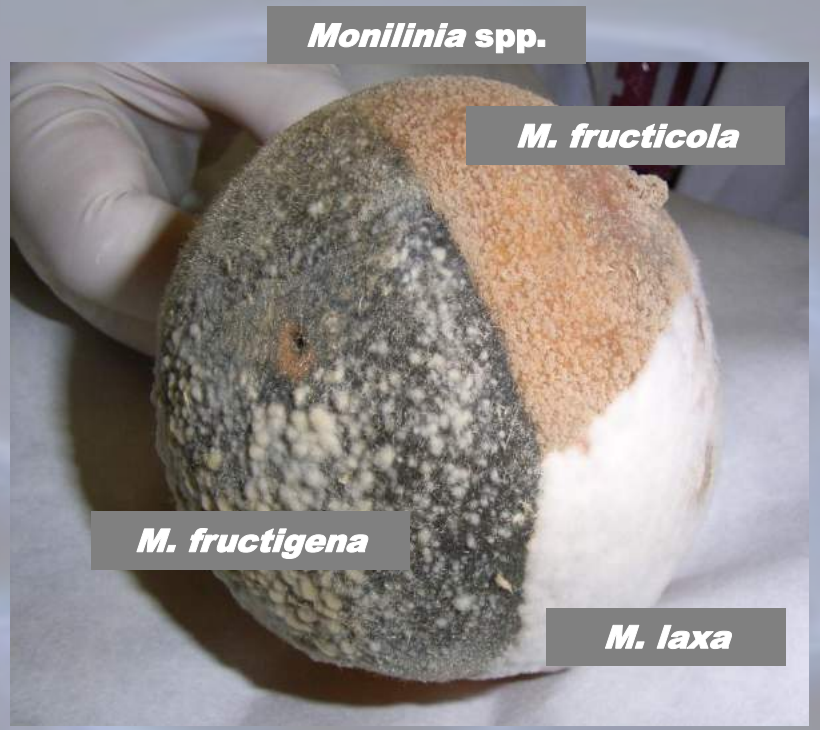
Antimicrobial activity

- Substances that slow down microbial growth or inactivate microorganisms.

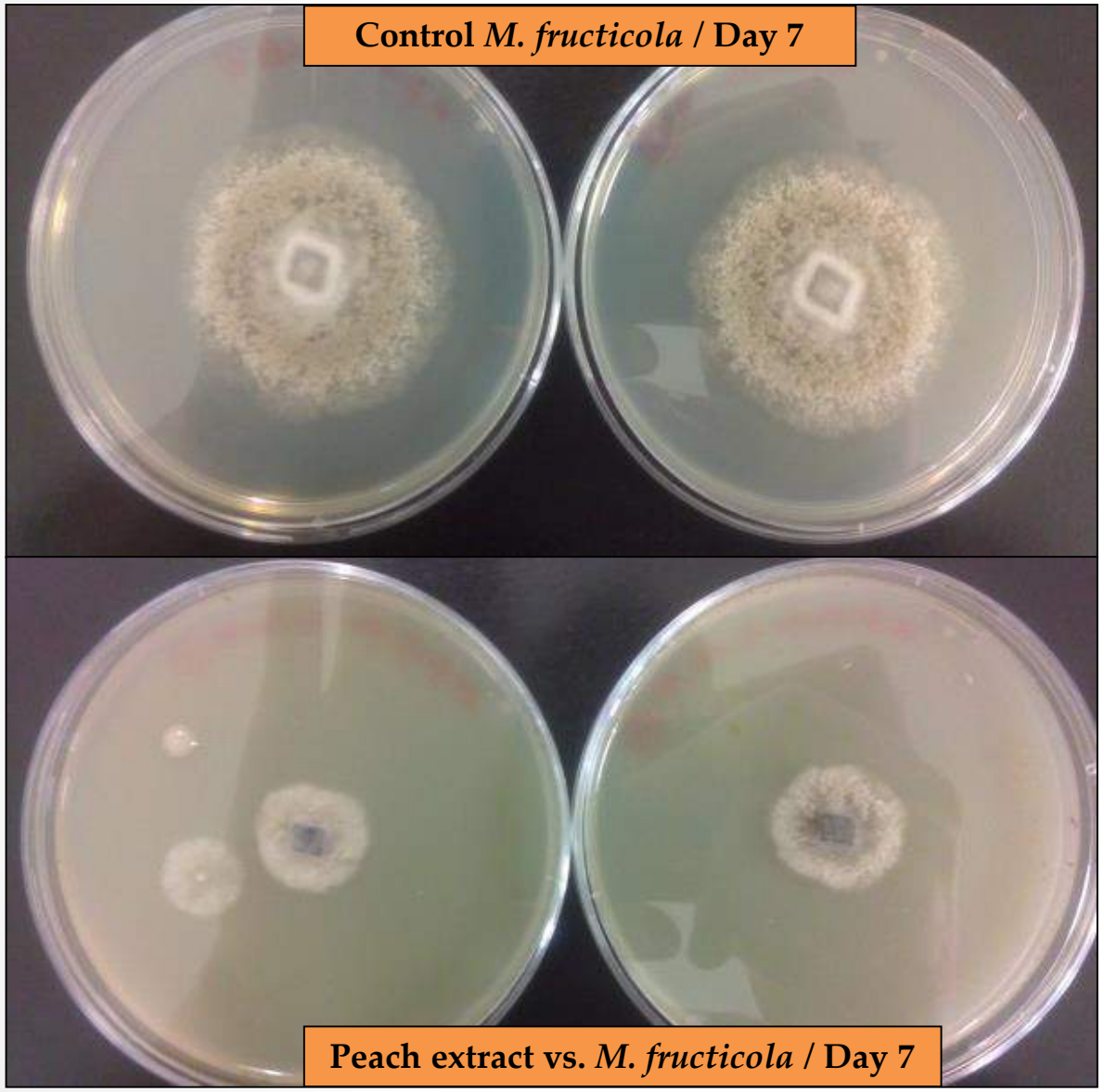
- The search for natural antimicrobials has focused on two aspects: **food safety or microbiological alteration**

Microbiological alteration

By-product	Extract	Microorganism
Pomegrante (peel and seeds)	Methanol	*Penicillium italicum* *Rhizopus stolonifer* *Botrytis cinerea*
Longan (seed)	Water	*Candida albicans* *C. parapsilosis* *C. krusei* *Cryptococcus neoformans*
Grapefruit (peel)	Ethanol	*C. albicans*
Grape (peel)	Ethanol	*Zygosaccharomyces rouxii* *Z. bailii*
Orange (peel)	Essential oil	*Aspergillus flavus*
Orange (pee)	Essential oil	*Aspergillus niger*
Tangerine (peel)	Essential oil	*Aspergillus flavus*
Grapefruit (peel)	Essential oil	*Penicillium chrysogenum* *P. verrucosum*



Antimicrobial activity



Growth Inhibition 26,3%

Antimicrobial activity

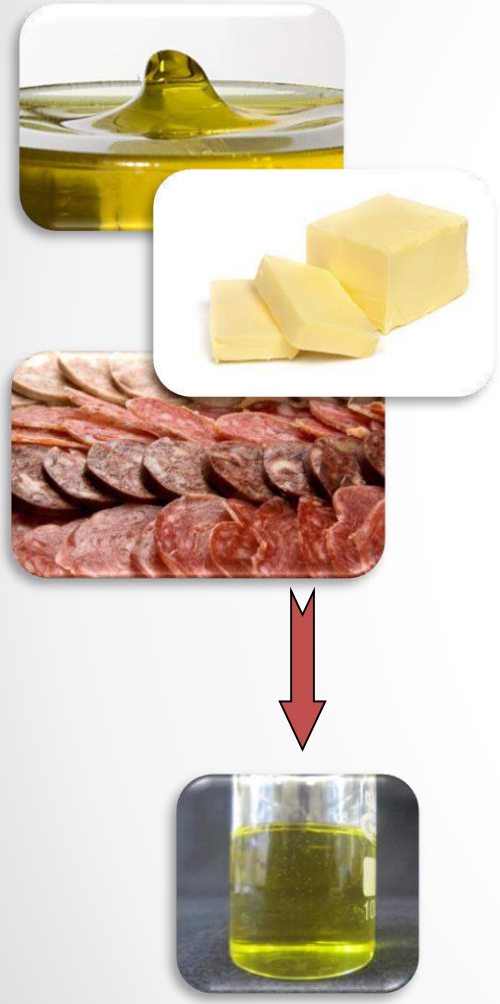
Control *M. laxa* / Day 10

Peach extract vs. *M. laxa* / Day 10

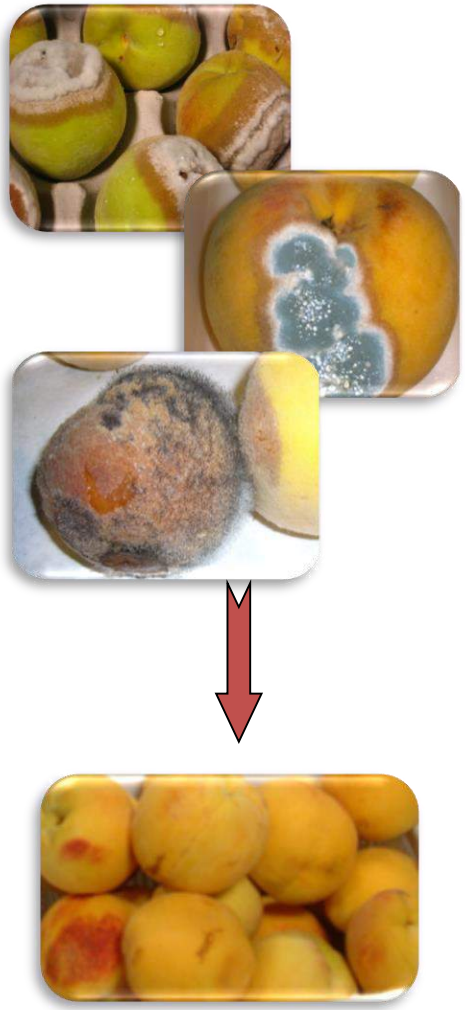
Growth Inhibition 65,2%

Technological applications

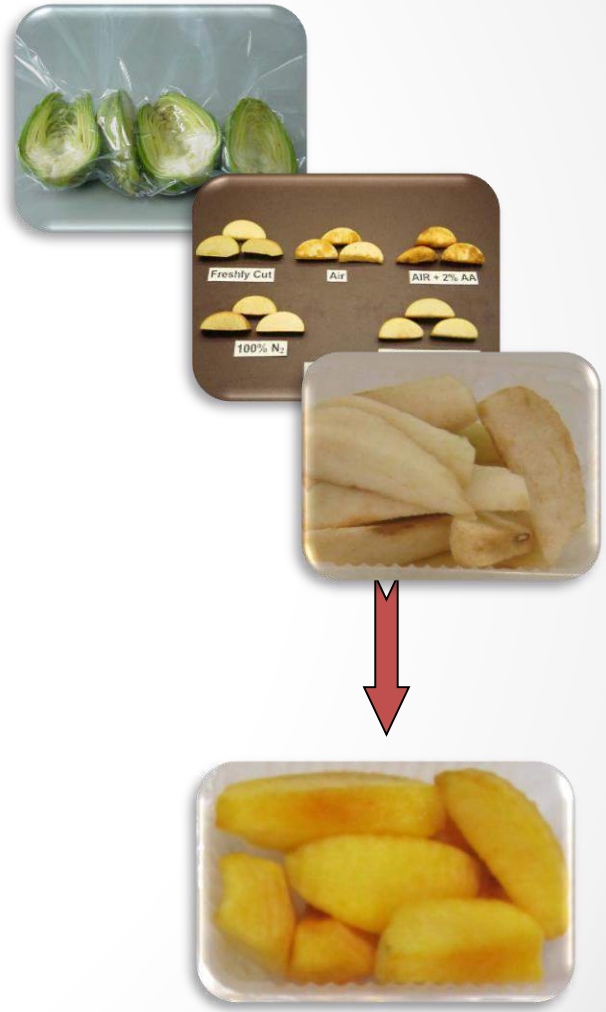
Lipid oxidation



Mold alteration



Enzymatic browning



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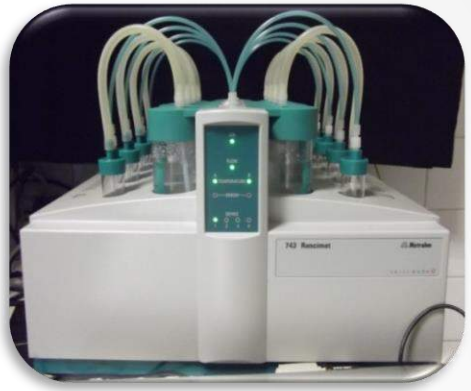
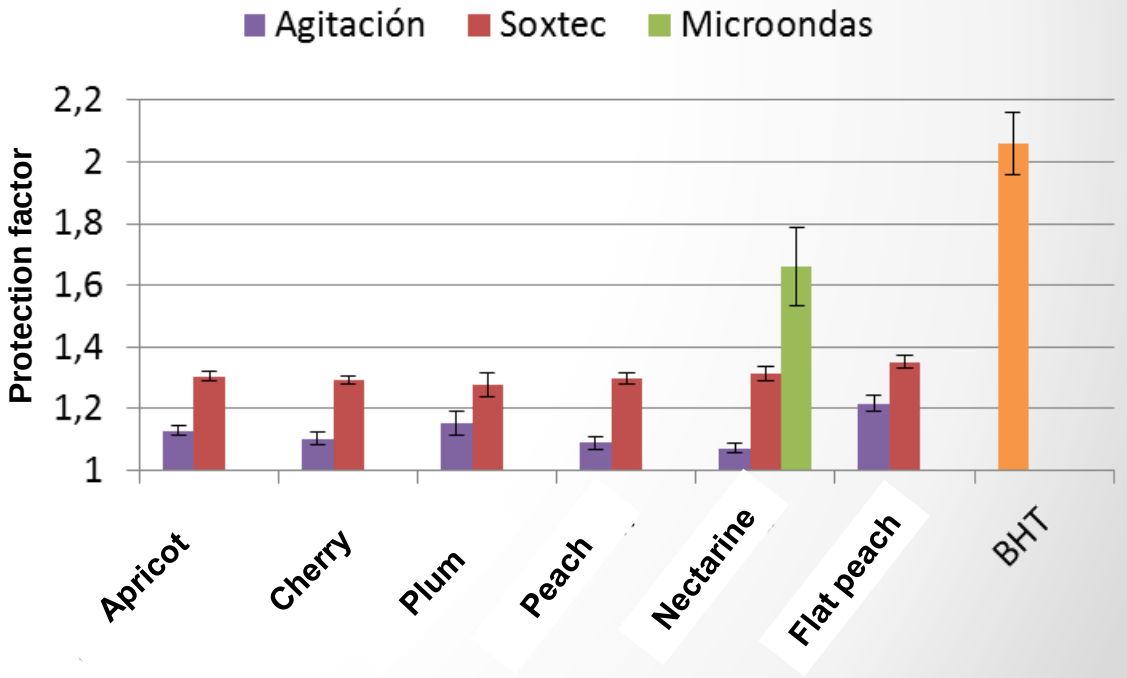
Technological applications: lipid oxidation



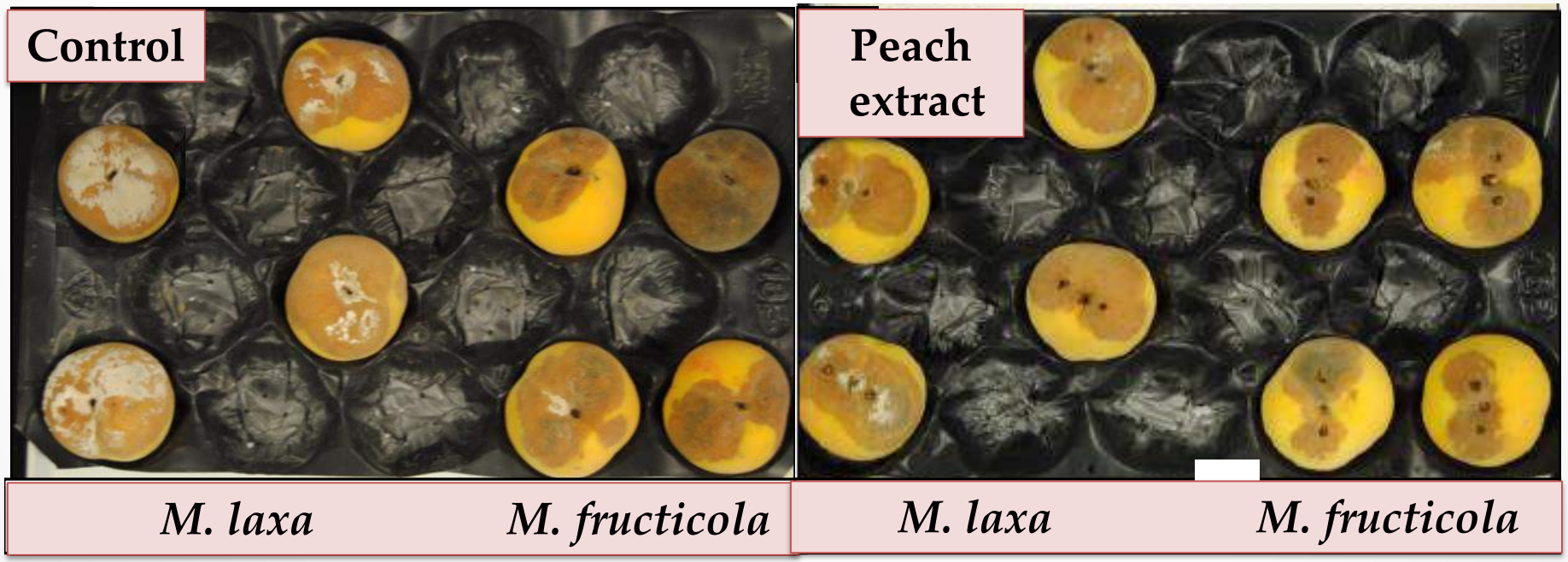
Olive oil before treatment (Control)

Nectarina extract after treatment

Olive oil after treatment

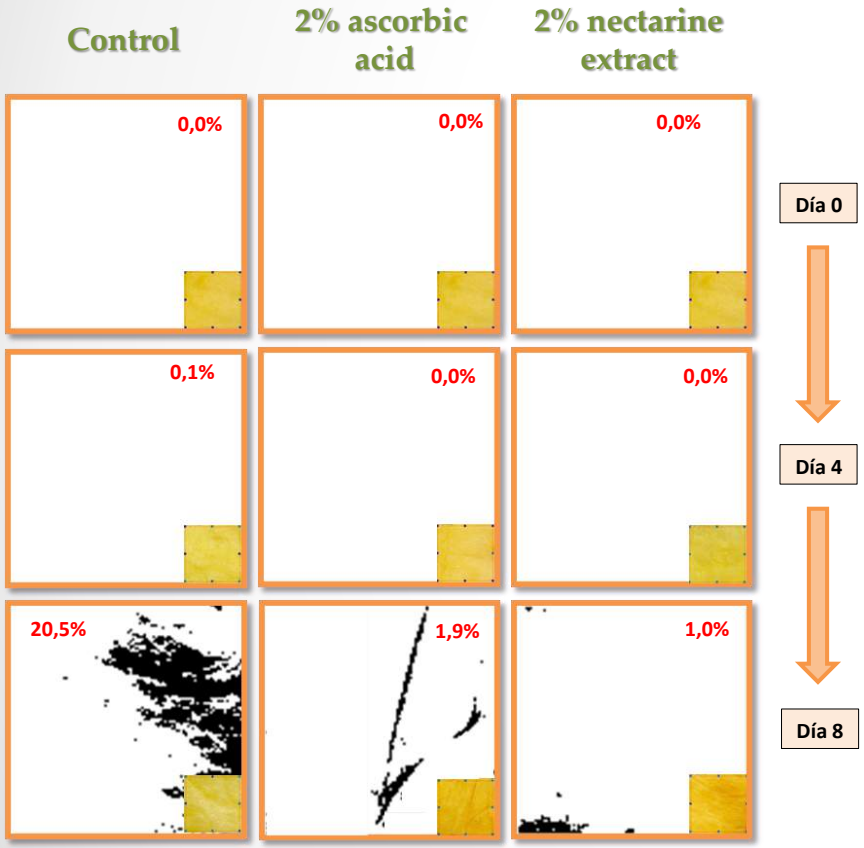


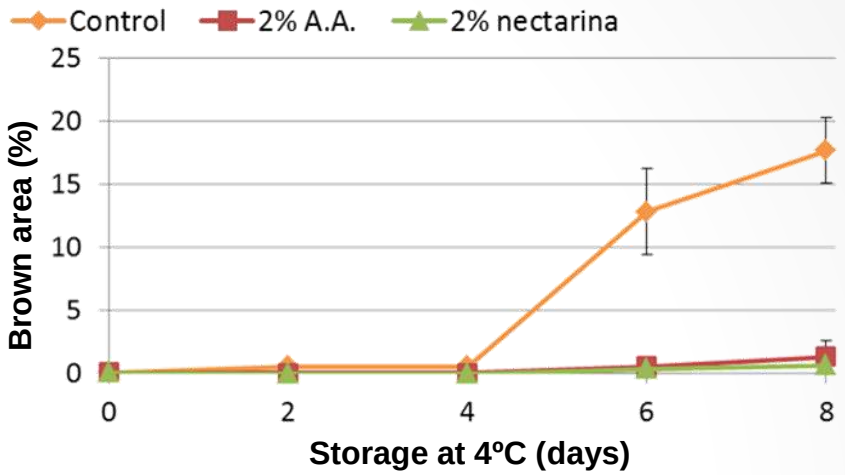
Technological applications: mold alteration

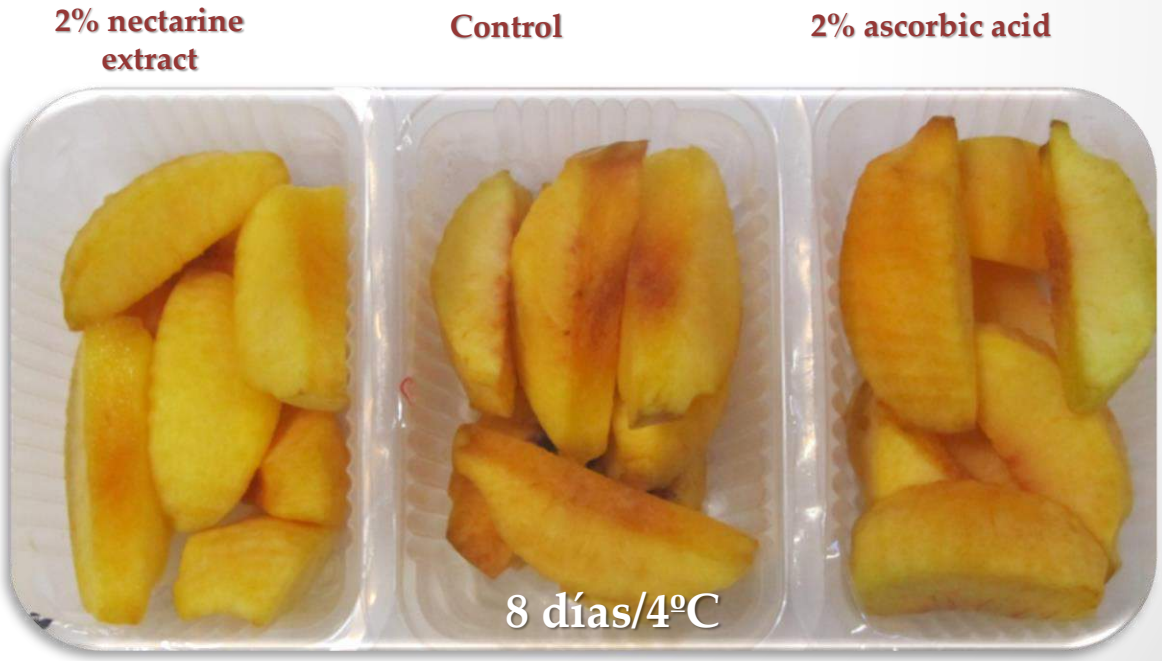


Technological applications: enzymatic browning

PACKAGED IN PCA (10%O_2 + 10% CO_2)







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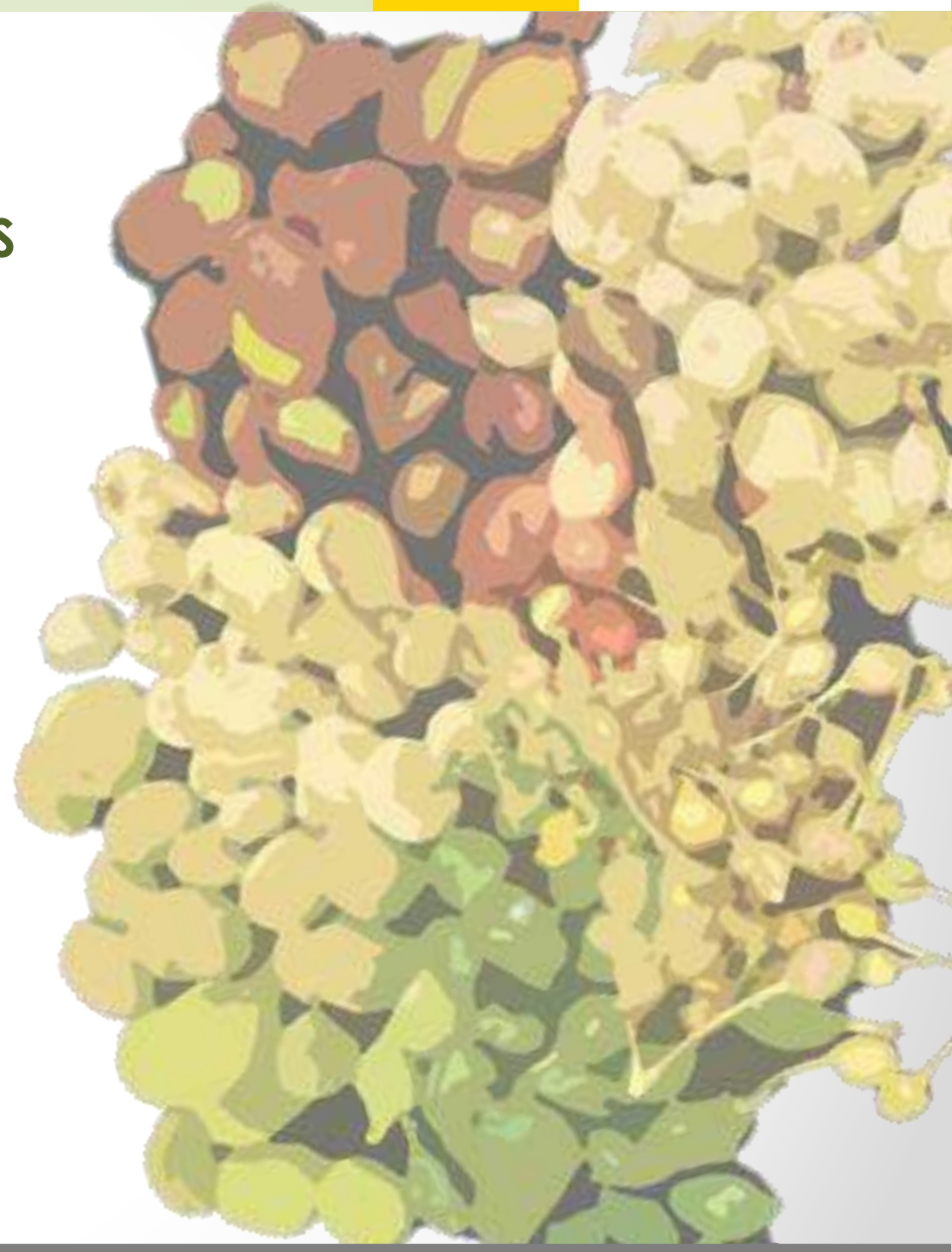
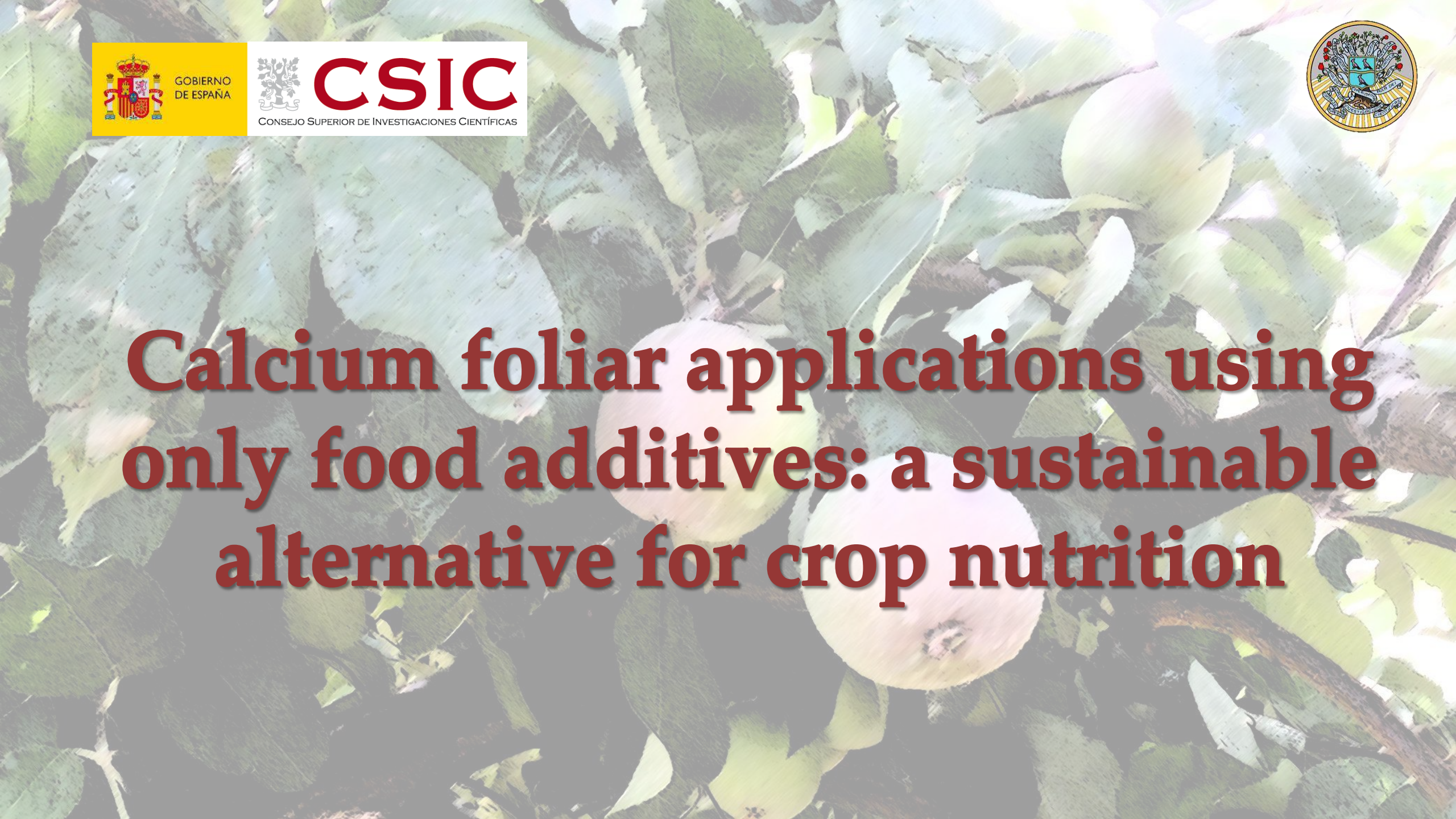
Fruit thinning possibilities

We have demonstrated that thinned fruits have
ANTIOXIDANT, ANTIFUNGAL AND ANTIBROWNING ACTIVITIES
and now, the next step is looking for an
INDUSTRIAL APPLICATION

- Antioxidant for use in plastic package
- Antioxidant extracts for use in processed foods
- Antioxidant extracts for use in cosmetics
- Antibrowning extracts for foods
- Antifungal extracts for fruits
- …





Calcium foliar applications using only food additives: a sustainable alternative for crop nutrition

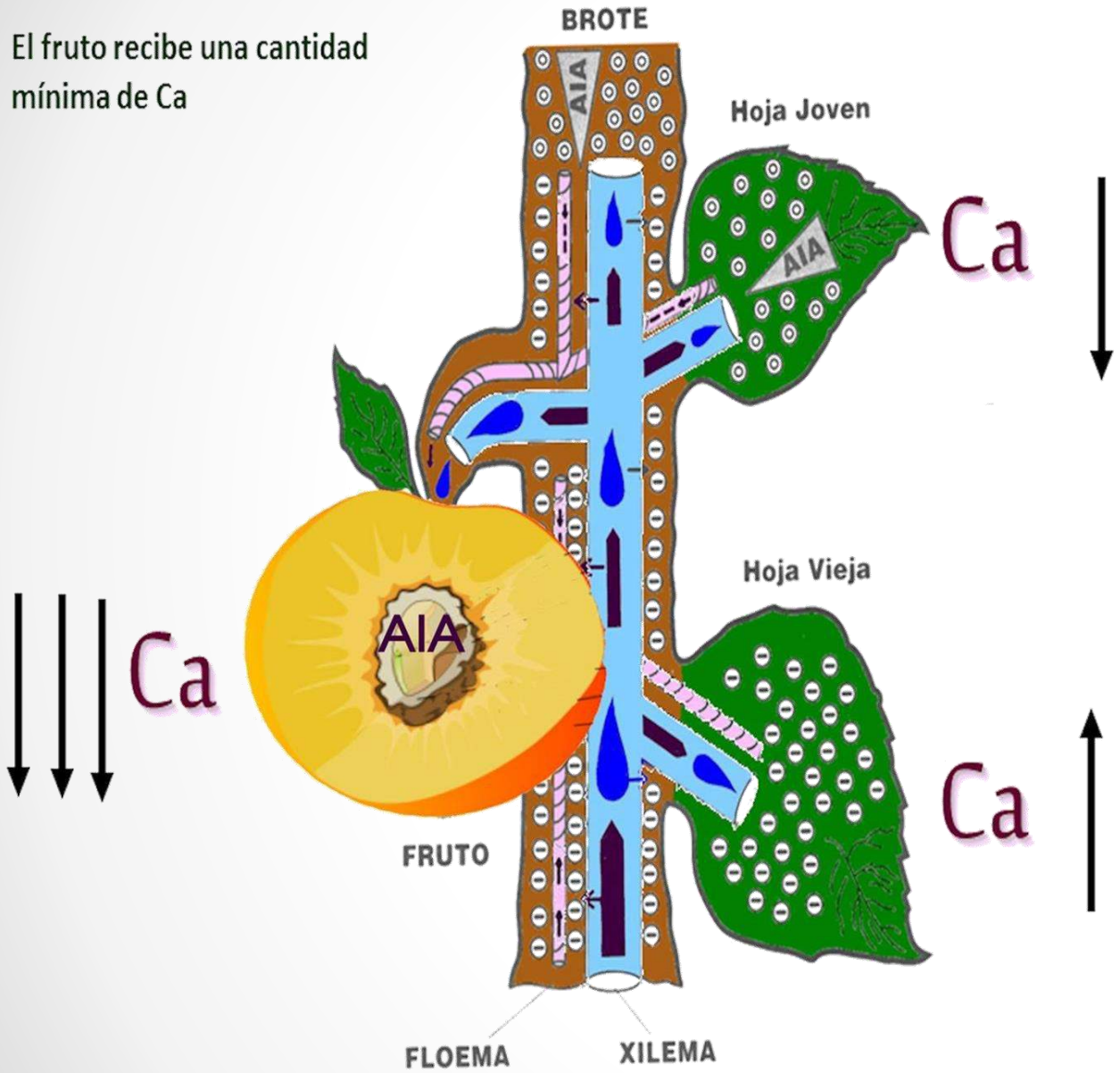
Why calcium is important in fruits?

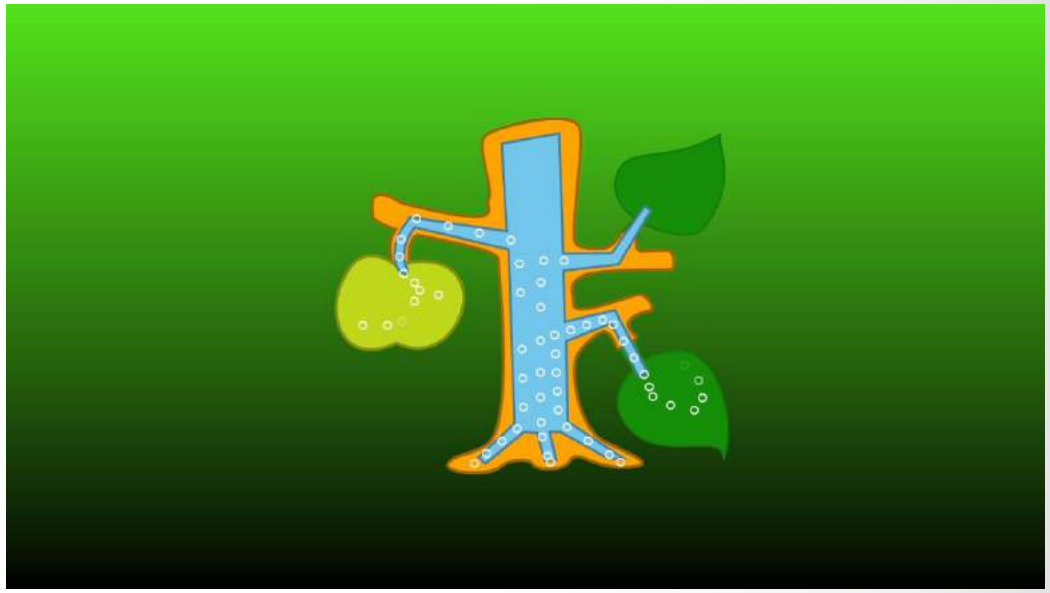
- **Calcium** is the key element implicated in the **fruit quality** and in the develop of **physiological alterations**

- Plant tissues with **high rates of calcium** are firmer, enter later in senescence and resist better the attack of pathogens.

- **The corky spots,** such as bitter pit and lenticel blotch pit in apples and vitrescent dark spot or corky spot in late season peaches**, deteriorate the organoleptic and visual quality of the fruit and cause serious losses in production.**

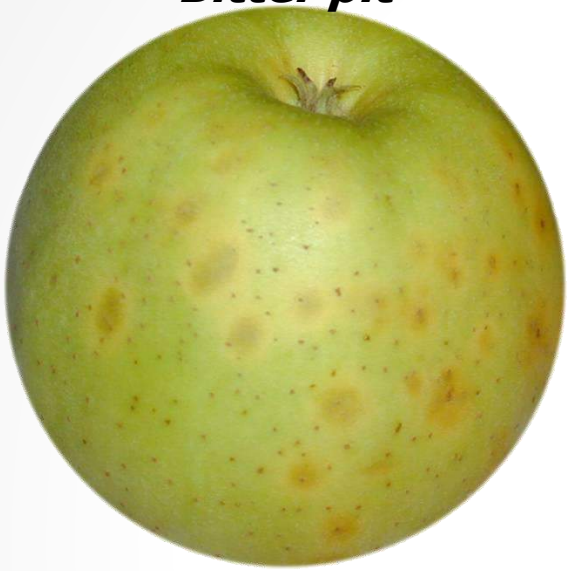
Calcium transport





Physiological alterations

Bitter pit



Vitrescent Dark Spot

Lenticel blotch pit

Corky Spot

Calcium foliar application

Food additives

0,3-0,5% Calcium

Three applications

Calcium foliar application

Coating remains over time

It rehydrates with environmental humidity

Calcium foliar application

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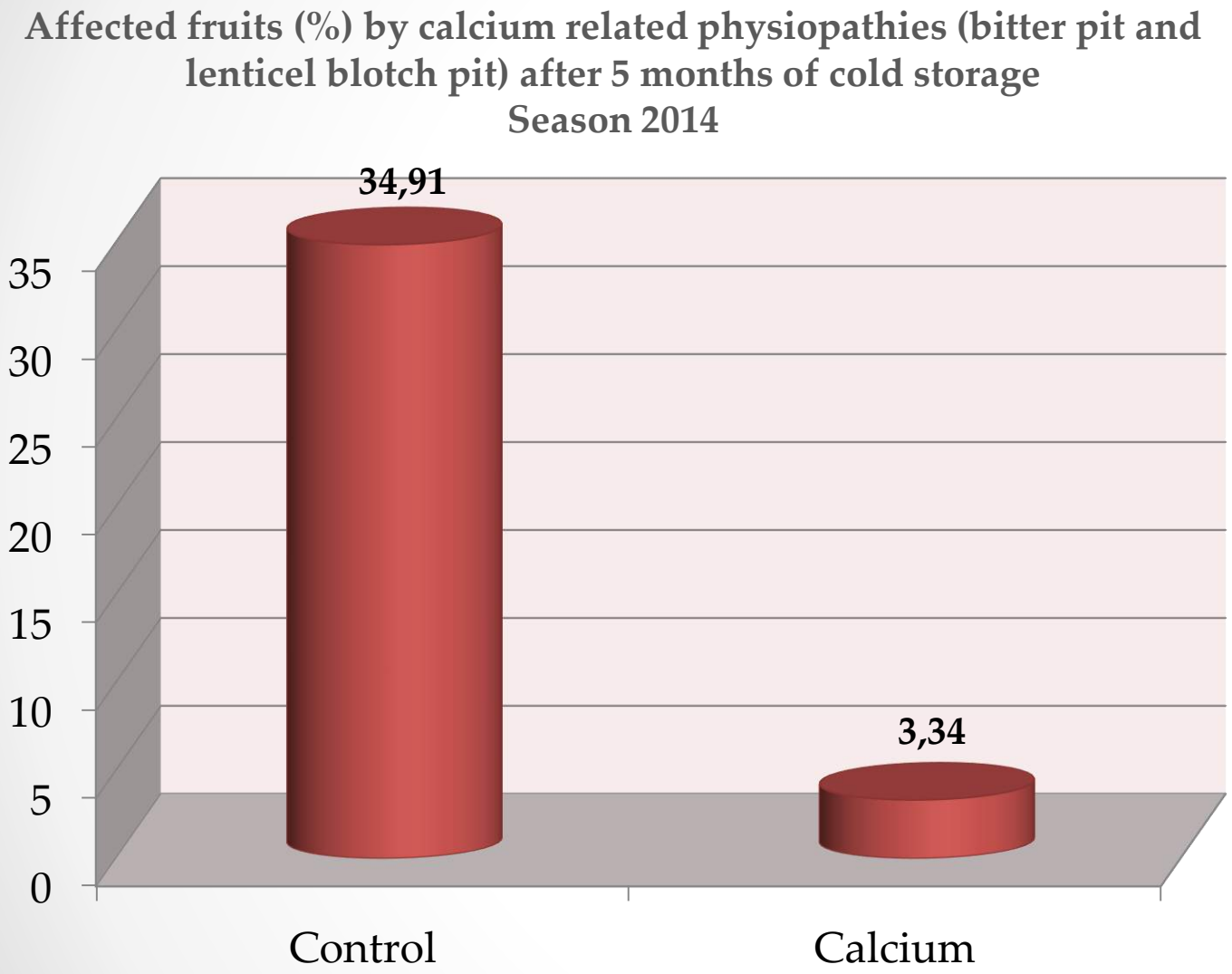
Industrial scale

Calcium foliar application



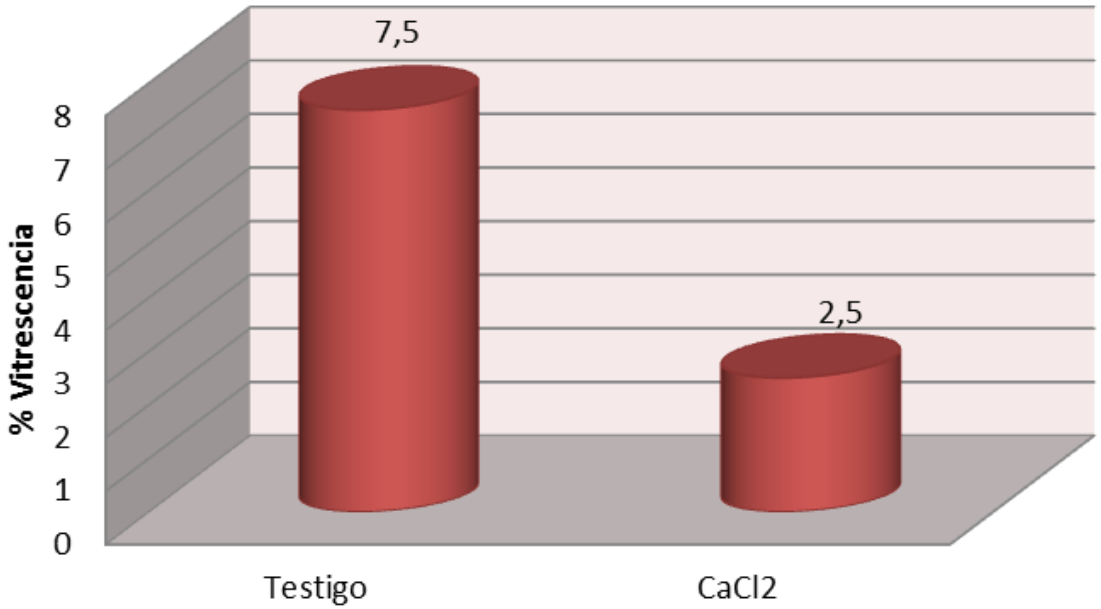
GOLDEN SMOOTHIE APPLES

Practical experience: contracts with private companies during 5 years (50 ha)

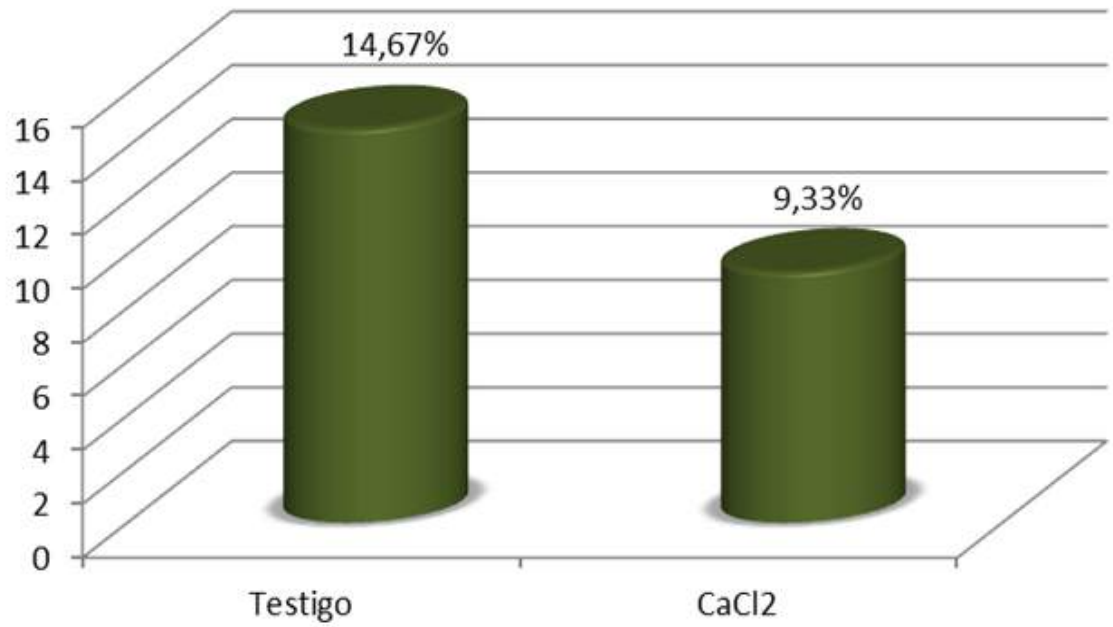
Calcium foliar application

Practical experience: D.O.P. Melocotón de Calanda (Late season peach)

Vitrescent Dark Spot (Season 2015)



Corky Spot (Season 2015)



Calcium foliar application

- Commercial apple orchards with **minimal incidence of BP** and other physiological alterations.
- In late season peaches the **appearance of vitrescent dark spot and corky spot is reduced**.
- **Greater firmness** to improve aptitudes for the long distance transport (export) without losing neither organoleptic properties nor texture.

Low impact treatments without chemicals to maintain the quality of fruits during storage

Low Oxygen Treatment: LOT

- **Details:**
  - Low Oxygen (0-1% O_2)
  - Room temperature
  - 2-10 days

- **Successfully applied to apples:**
  - Hamper the production of ethylene (Gorney et al., 1997, Stow et al., 2000)
  - Control biotic disorders as an alternative to the use of agrochemicals (Chervie et al., 1997, Ke et al. 1992, Liu et al., 2008)
  - Decrease significantly the rate of apple scald (Lurie et al., 1992, Wang et al., 2000, Zanella et al., 2003, Pesis et al., 2007)
  - Decrease the bitter pit incidence during cold storage (Val et al., 2010)

Low Oxygen Treatment: LOT in apples

Control: 4ºC
4 months

LOT: 1-2% O_2
20ºC
10 days

4ºC
4 months

Val et al., 2010

Low Oxygen Treatment: LOT in apples

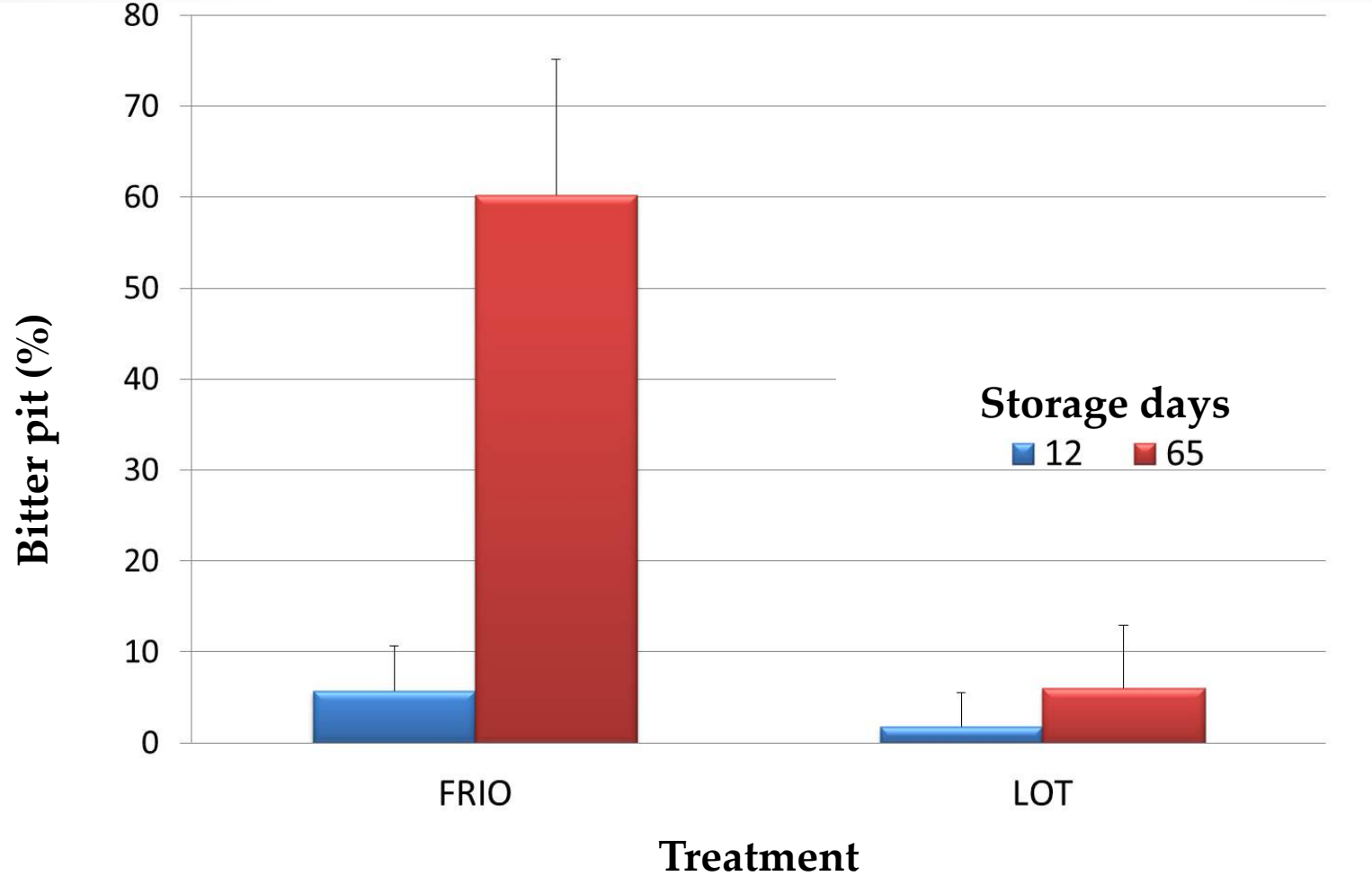
- **Visual aspect of Golden Reinders apples after 4 moths of cold storage:**

CONTROL

LOT

Val et al., 2010

Low Oxygen Treatment: LOT in apples



Low Oxygen Treatment: LOT in apples

Evolution of respiration activity and production of ethylene in close system (mg/h/kg).

	Ethylene			O_2			CO_2		
Days of storage after treatment	LOT	Cold	sign	LOT	Cold	sign	LOT	Cold	LOT
12	2,74	35,59	***	15,89	9,40	***	9,00	7,09	*
27	11,03	44,99	***	8,57	8,85	ns	4,09	7,21	*
65	64,79	70,42	ns	14,87	14,79	ns	10,26	12,87	*

Reducción de fisiopatías en manzana mediante la aplicación de

Tratamientos Postcosecha Combinados de Bajo Impacto

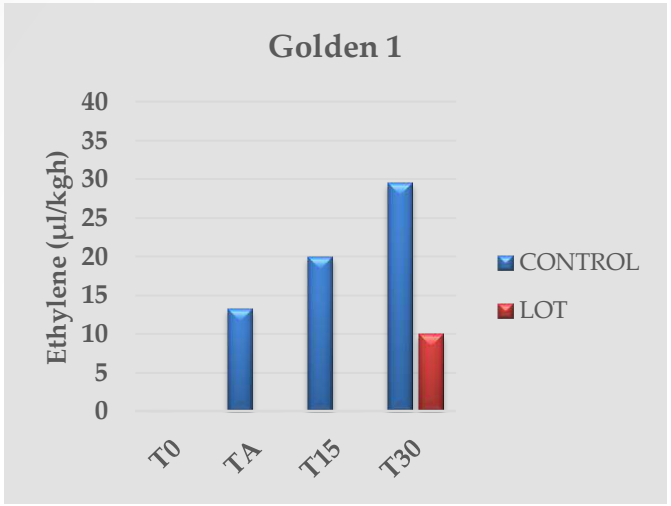
ManzImpacto

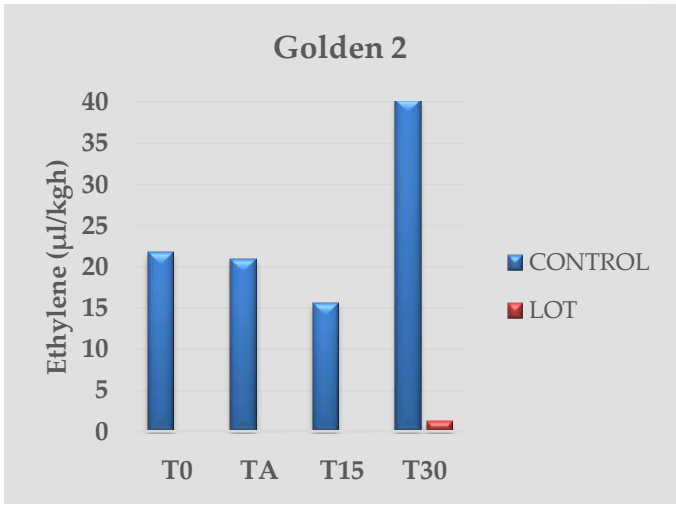
Low Oxygen Treatment: LOT in apples

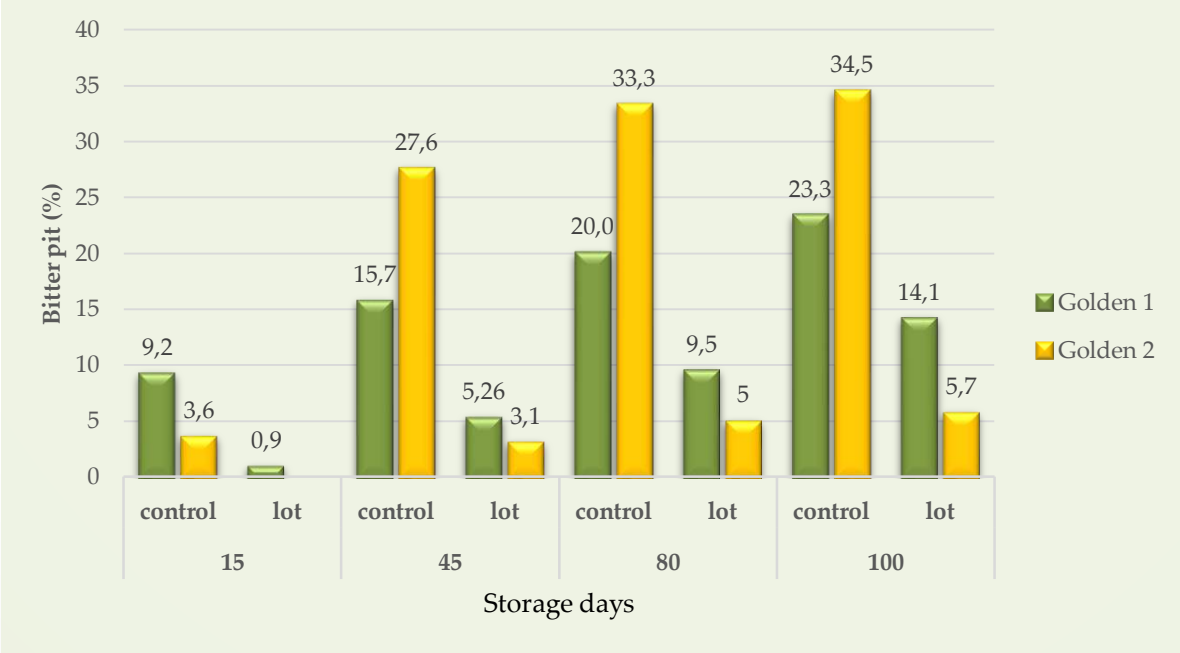
- Illerfred system and Palliflex bags
  Low O_2 (0-1%)
- Room temperature (18-20 ºC)
  10 days

Cold storage (0-1 ºC)

Low Oxygen Treatment: LOT in apples







Low Oxygen Treatment: LOT in apples

- ✓Reduction of the percentage of fruits affected by bitter pit
- ✓Higher firmness
- ✓Brighter and more yellow coloring
- ✓Soluble solid content higher
- ✓Fruits with exceptional organoleptic characteristics and quality

Low Oxygen Treatment: LOT in peaches

LATE SEASON PEACHES

Var. CHATO

October 25, 2016

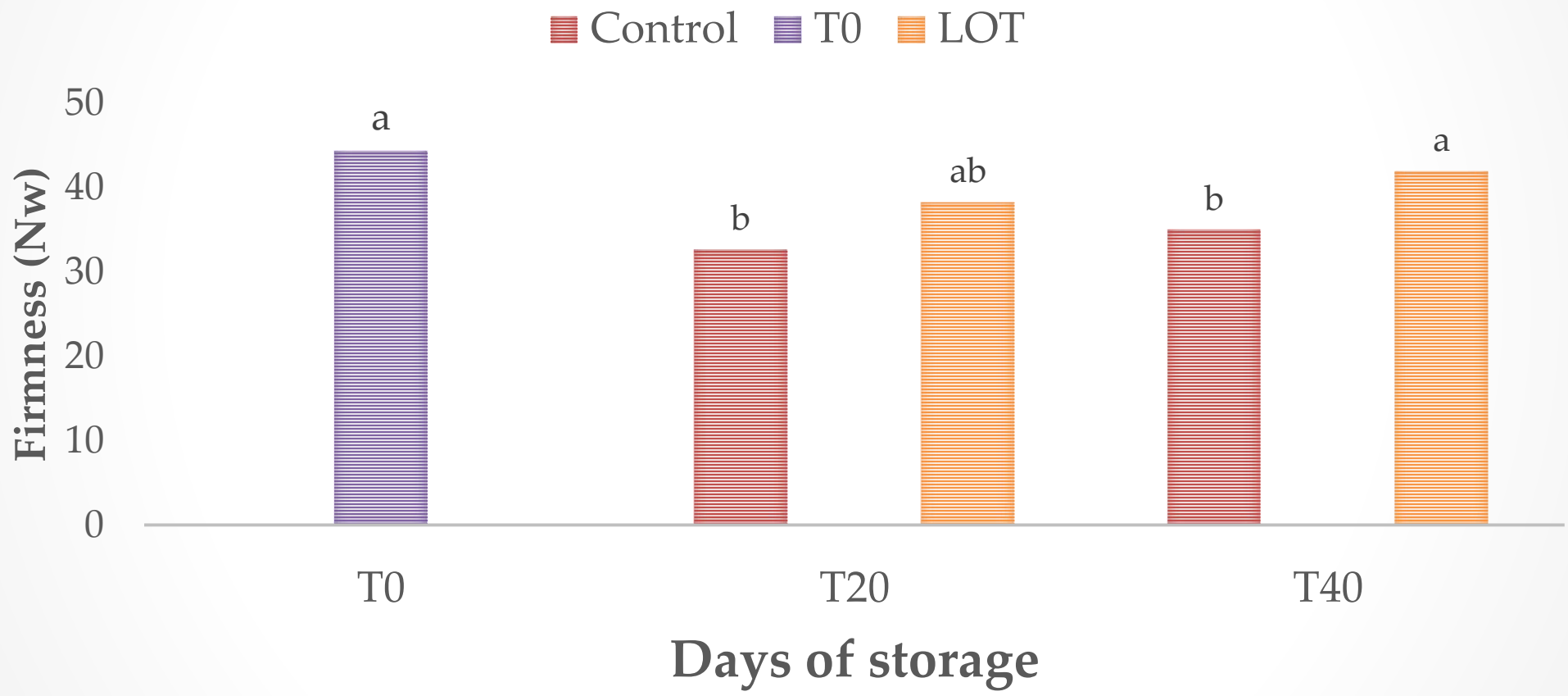
LOW OXYGEN TREATMENT: LOT

- Illerfred system and Palliflex bags
  Low O_2 (0-1%)
- Room temperature (18-20 ºC)
  48 hours

Cold storage (0-1 ºC)
Analysis after 20 and 40 days

Low Oxygen Treatment: LOT in peaches

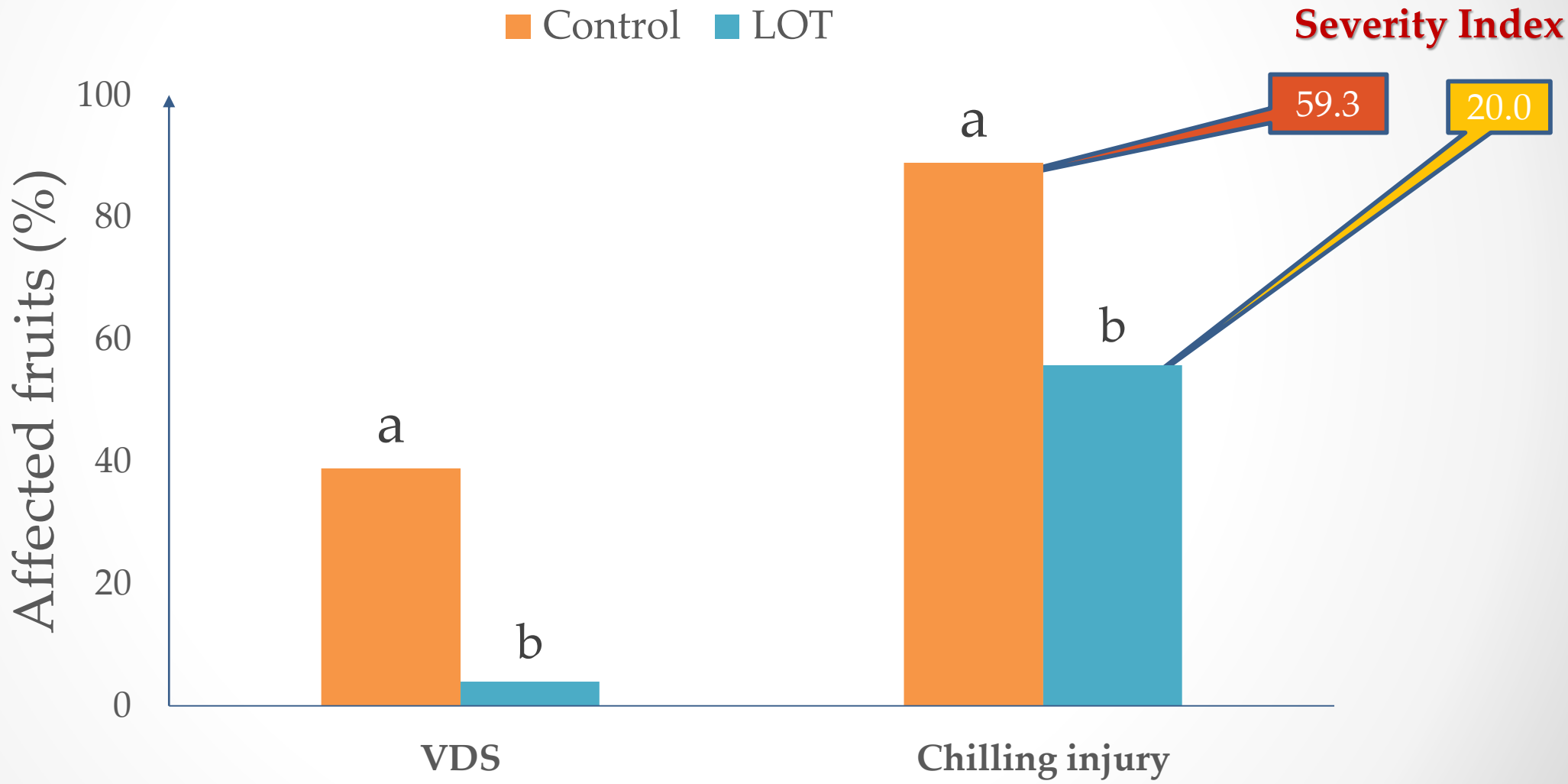
FIRMNESS



LOT modifies firmness of peaches

Low Oxygen Treatment: LOT in peaches

PHYSIOLOGICAL ALTERATIONS



Low Oxygen Treatment: LOT in peaches

- Low oxygen treatment for 2 days at room temperature is effective to maintain firmness after 20 and 40 days of storage, with no effect in other quality parameters.

- LOT reduces incidence of vitrescence dark spot and chilling injury in peaches. Visual aspect of treated fruits is better.

- Sensorial analysis shows better ratings for LOT fruits

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From the field to the table

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