POSTHARVEST ANCONA 2024
INNOVATIONS IN FOOD LOSS AND WASTE MANAGEMENT

Aula Magna - Department of Agricultural Food and Environmental Sciences, Università Politecnica delle Marche, Ancona

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INTEGRATED ALTERNATIVE CONTROL MEANS AGAINST POSTHARVEST DISEASES OF POMEGRANATES AND CITRUS FRUIT

Annamaria Mincuzzi, Antonio Ippolito

Di.S.S.P.A. – Università degli Studi di Bari Aldo Moro - annamaria.mincuzzi@uniba.it

WORK PACKAGE 1: Use of physical means to extend shelf-life of fruit, vegetables, and aromatic plants, and reduce waste

TASK 1.1 Application of electrolysed water to citrus and pomegranate fruit

TASK 1.2 Application of ozone to citrus and pomegranate fruit

LEAD BENEFICIARY: DI.S.S.P.A. – UNIVERSITY OF BARI ALDO MORO **- UNIBA**

Prof. Antonio Ippolito
Dr. Annamaria Mincuzzi

POMEGRANATE: POSTHARVEST DISEASES

Before harvest :
18%

Abiotic damages →
- Bad handling
- Weather

From **harvest** till **transportation :**
23%

From **transportation** to **marketing :**
21%

(Pienaar, 2021)

POSTHARVEST FUNGAL DISEASES

LATENT PATHOGENS
- In the **field**
- **65%**

WOUND PATHOGENS
- **Production chain**
- **35%**

CITRUS: POSTHARVEST DISEASES

Francesca Garganese - Di.S.S.P.A. – Università degli Studi di Bari Aldo Moro

BROWN SPOT
***Alternaria* spp.**

GREEN/BLUE MOLD
***Penicillium* spp.**

ANTHRACNOSE
***Colletotrichum* spp.**

Production chain: incidence about yield losses are not up-dated

POMEGRANATES: PREVIOUS TRIALS

1. *Phytotoxicity tests*:

- **Potassium sorbate**
- **Sodium bicarbonate**
- **Sodium metabisulfite**
- **Calcium propionate**

NEUTRAL ELECTROLYZED WATER (NEW)

- **Gaseous ozone** (various concentrations and exposure timings)
- **Ozonated water**

Potassium sorbate, **sodium bicarbonate**, and **sodium metabisulfite** **phytotoxicity** at **1.25%**

2. *In the field treatments*:

F1. **Red seaweed** fertilizer(commercial product)

F2. ***Aureobasidium pullulans*** (DSM 14940 andDSM 14941 strains, commercial product)

F3. ***Bacillus amyloliquefaciens*** subs. *plantarum* (strain D747, commercial product).

F4. **Hydrochloride chitosan** (commercial product)

POMEGRANATES: PREVIOUS TRIALS

3. *Dipping*:

D1. **Ozonized H_2O**

D2. Neutral Electrolyzed H_2O (**NEW**)

D3. **NEW** + 0.625% **sodium metabisulfite**

D4. **NEW** + 0.625% **potassium sorbate**

D5. **NEW** + 0.625% **sodium bicarbonate**

D6. **NEW** + 0.625% **calcium propionate**

4. *Gaseous O_3 shock treatments*:

- **750 ppb**
- **4 h** exposure time

G1. **1** treatment per **month** every 30 days → **3** treatments.
G2. **2** treatments per **month** every 15 days → **6** treatments.
G3. **4** treatments per **month** every 7 days → **12** treatments.

CRACKED FRUIT:
Access via for fungal **wound pathogens** (*Penicillium s.l.*)

POMEGRANATES: INTEGRATED APPROACH

best treatments of the previous trials

PREHARVEST TRIAL: *Bacillus amyloliquefaciens* subs. *plantarum*

- **2** application during the **blooming stage** (**BA-2**)
- **4** application during the **blooming stage + 1 just before harvest** (**BA-5**)

- **4 months** of **cold storage + 2 weeks** of **shelf life**

POSTHARVEST TRIAL:

Dipping

NEW + 0.625% calcium propionate (**CP**)

Gaseous ozone treatment

750 ppb O_3 x **4 h** exposure time. **4 treatments/month** (**O3**)

THESES	IN THE FIELD	NEW POSTHARVEST DIPPING	POSTHARVEST GASEOUS O_3
1	Water control	Calcium propionate	0_3 exposure
2			No 0_3
3		Water control	0_3 exposure
4			No 0_3
5	Amylo-X5	Calcium propionate	0_3 exposure
6			No 0_3
7		Water control	0_3 exposure
8			No 0_3
9	Amylo-X2	Calcium propionate	0_3 exposure
10			No 0_3
11		Water control	0_3 exposure
12			No 0_3

Factorial ANOVA

EVALUATION OF DECAY INCIDENCE AND SEVERITY

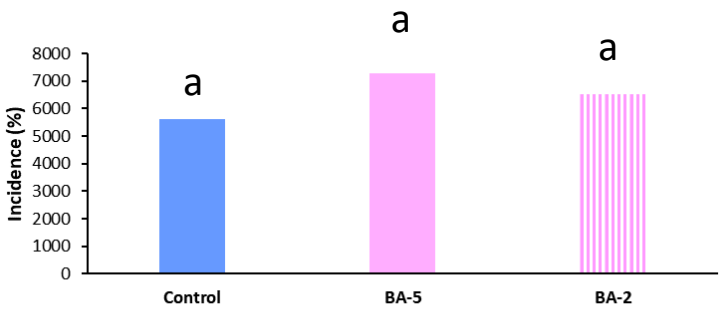
EPIPHYTIC POPULATION

QUALITATIVE ANALYSES (color, pH, TSS, TA)

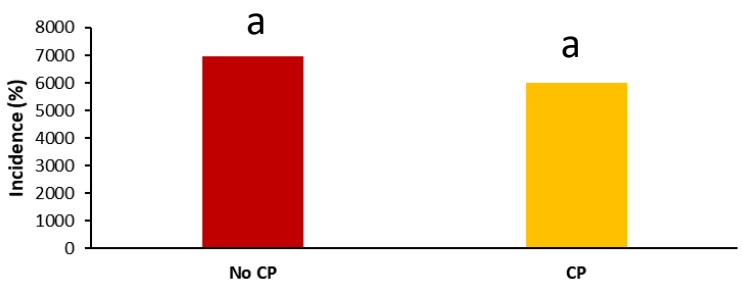
5. POMEGRANATES: INTEGRATED APPROACH

EPIPHYTIC POPULATION

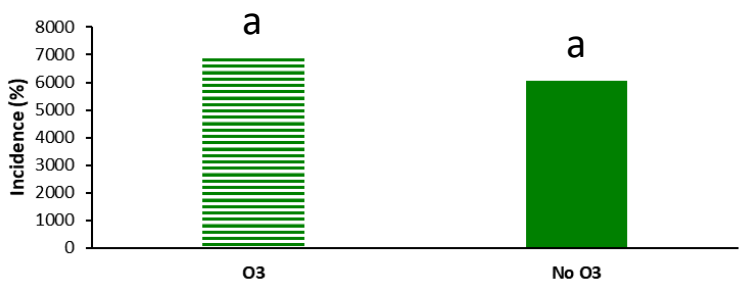
In the field application
Filamentous fungi



Calcium propionate
Filamentous fungi



Ozone
Filamentous fungi



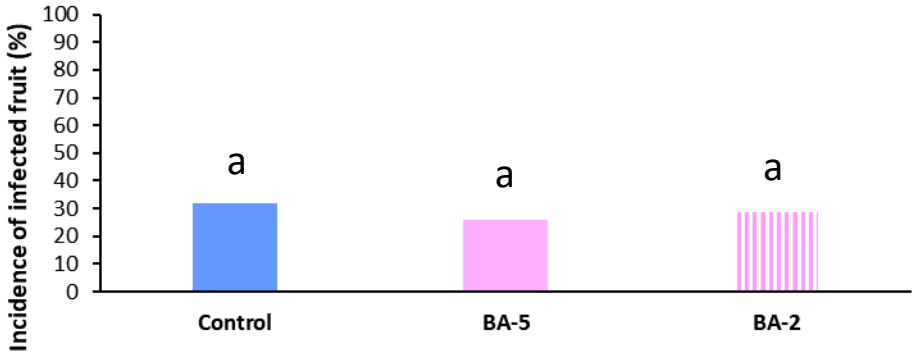
BA-5 = *B. amyloliquefaciens*/ 5 treatments
BA-2 = *B. amyloliquefaciens*/ 2 treatments
CP = NEW+Calcium propionate/postharvest dipping
O3 = gaseous ozone/exposure

No significant differences

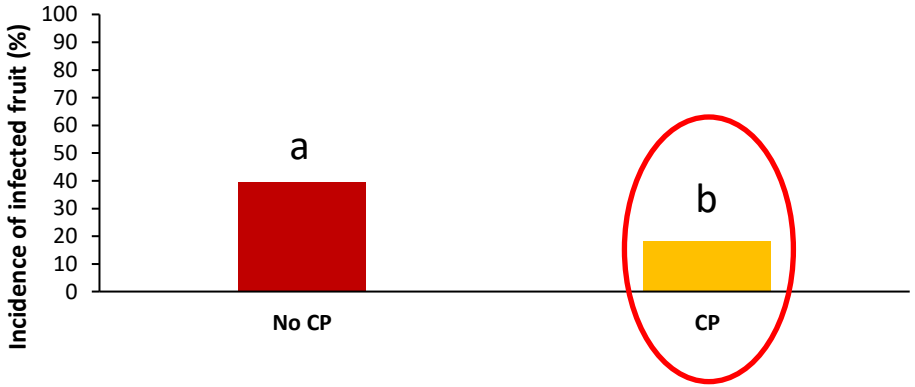
5. POMEGRANATES: INTEGRATED APPROACH

DISEASE INCIDENCE AFTER 4 MONTHS OF COLD-STORAGE

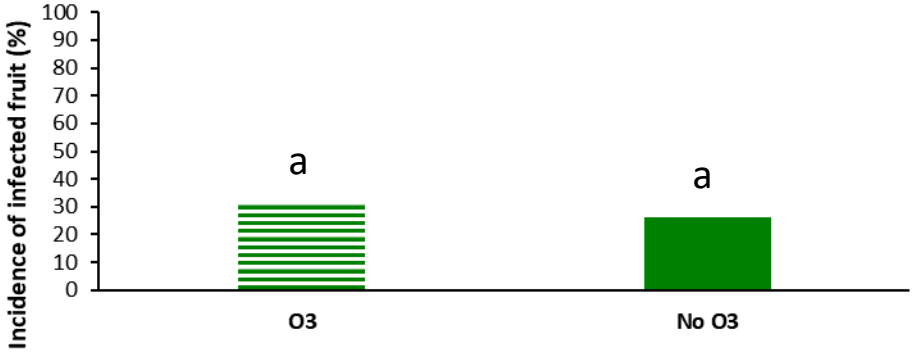
Pomegranate cold-storage
In the field application



Pomegranate cold-storage
Calcium propionate



Pomegranate cold-storage
Ozone



BA-5 = *B. amyloliquefaciens*/ 5 treatments
BA-2 = *B. amyloliquefaciens*/ 2 treatments
CP = NEW+Calcium propionate/postharvest dipping
O3 = gaseous ozone/exposure

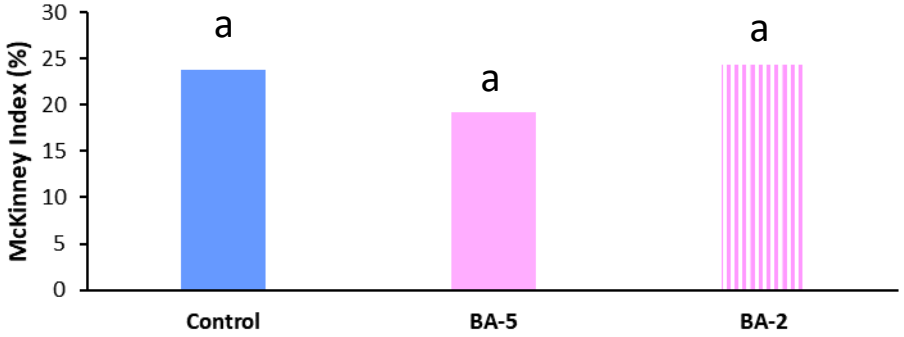
-56%

- Incidence

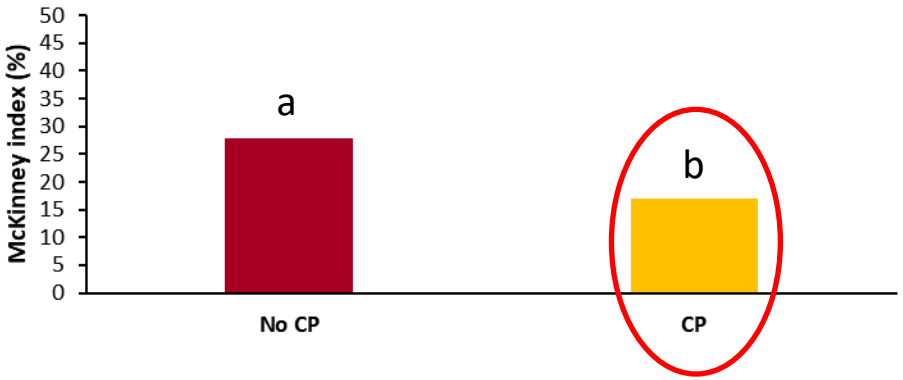
5. POMEGRANATES: INTEGRATED APPROACH

DISEASE INCIDENCE AFTER 4 MONTHS OF COLD-STORAGE AND 2 WEEKS OF SHELF-LIFE

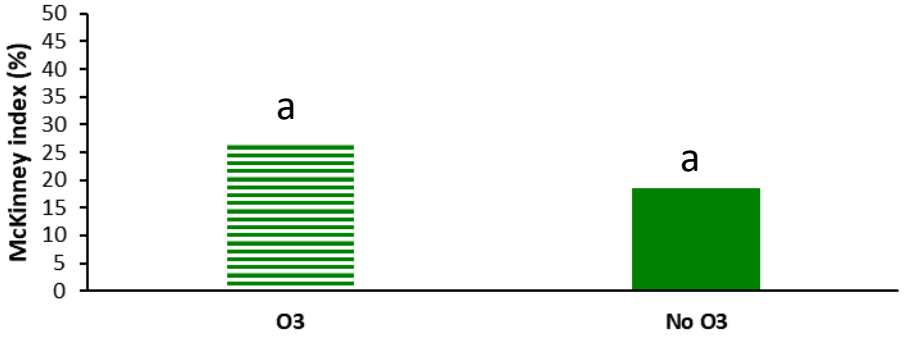
Pomegranate shelf-life
In the field application



Pomegranate shelf-life
Calcium propionate



Pomegranate shelf-life
Ozone



BA-5 = *B. amyloliquefaciens*/ 5 treatments
BA-2 = *B. amyloliquefaciens*/ 2 treatments
CP = NEW+Calcium propionate/postharvest dipping
O3 = gaseous ozone/exposure

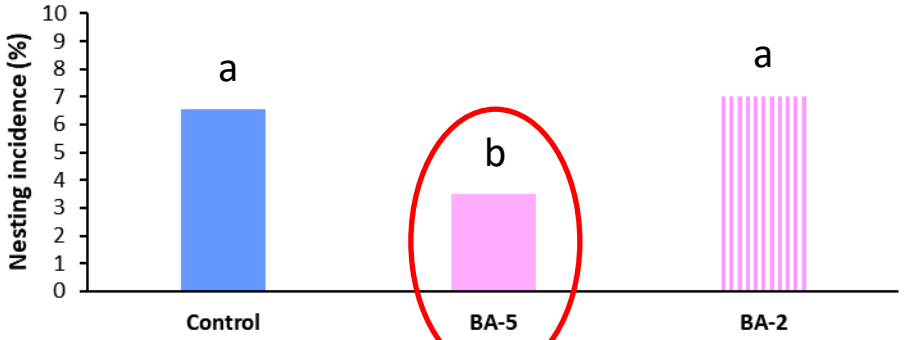
-40%

- Incidence
- Severity

5. POMEGRANATES: INTEGRATED APPROACH

NESTING INCIDENCE AFTER 4 MONTHS OF COLD-STORAGE AND 2 WEEKS OF SHELF-LIFE

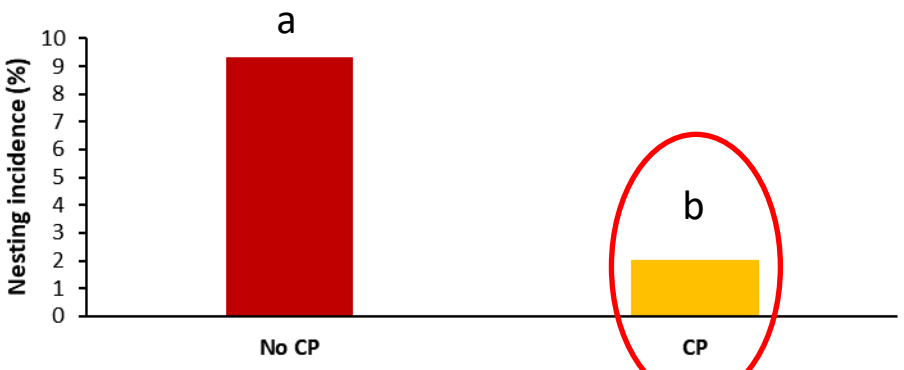
Incidence of nesting
In the field application



BA-5 = *B. amyloliquefaciens*/ 5 treatments
BA-2 = *B. amyloliquefaciens*/ 2 treatments
CP = NEW+Calcium propionate/postharvest dipping
O3 = gaseous ozone/exposure

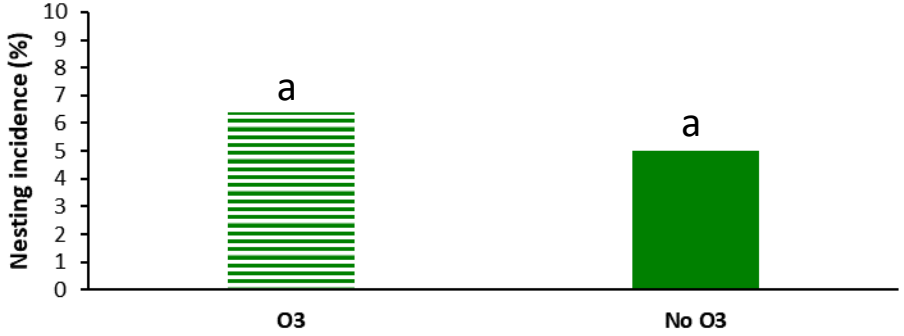
-47%

Incidence of nesting
Calcium propionate

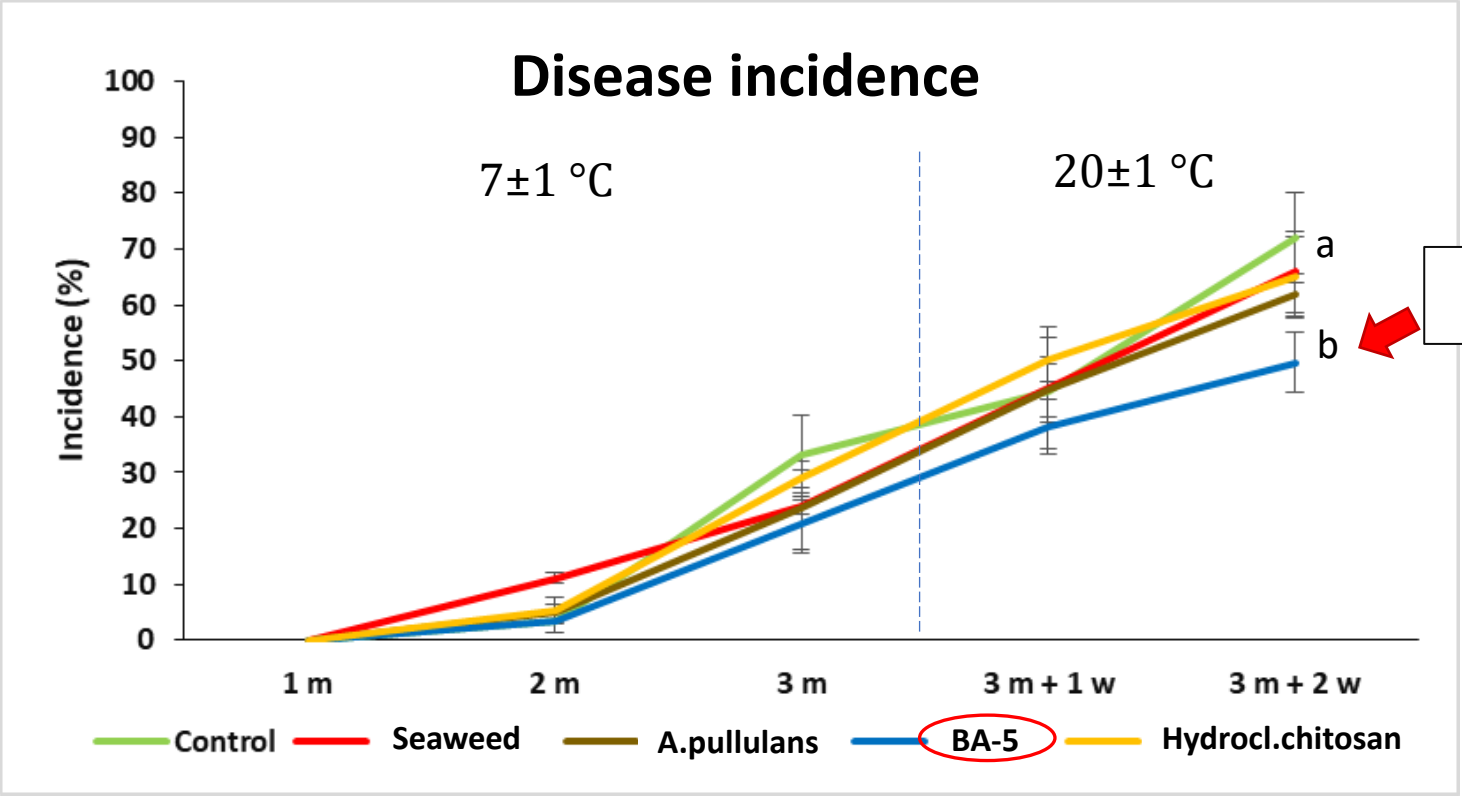


-78%

Incidence of nesting
Ozone



POMEGRANATES 2021: IN THE FIELD TRIAL



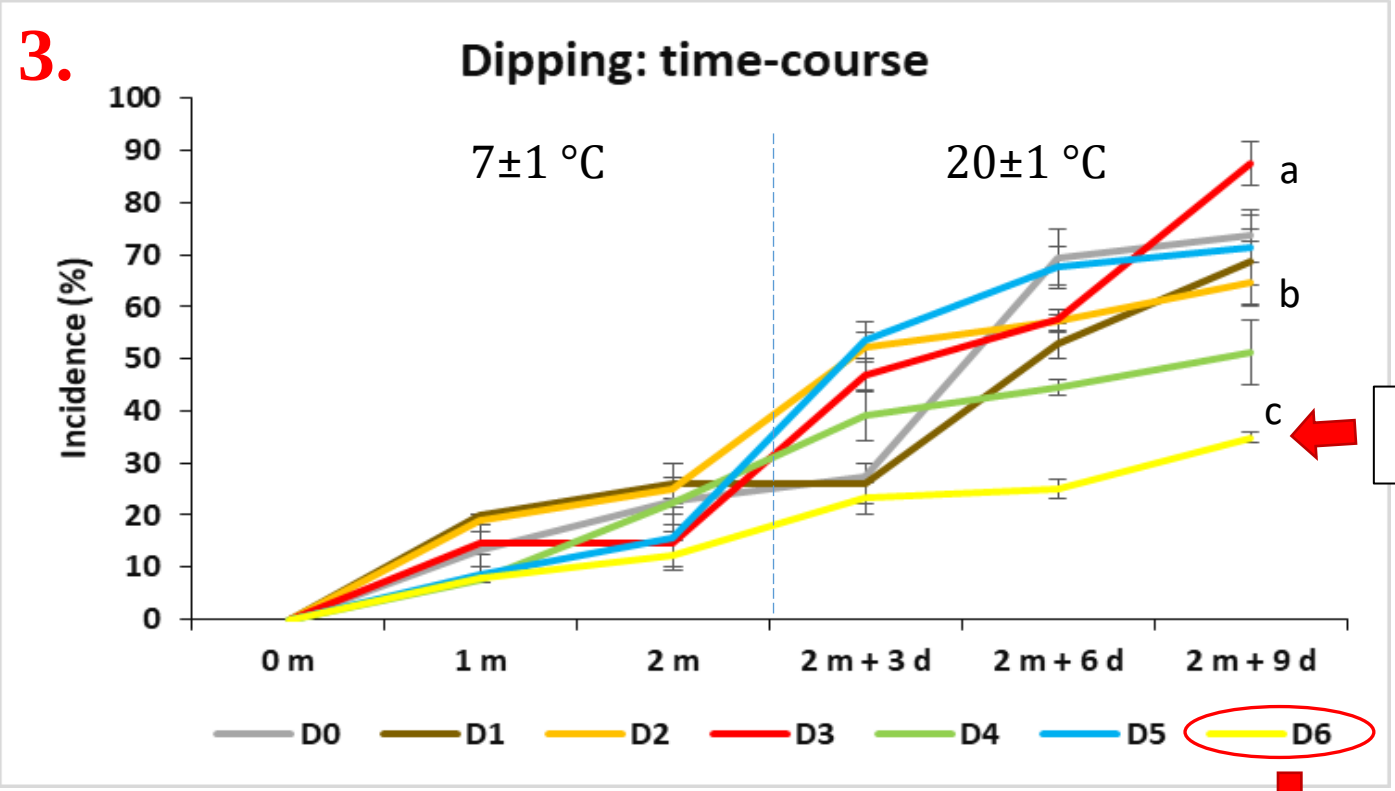
-43%

B. amyloliquefaciens

- Reduction by **43% postharvest decays**
- **Grey mold incidence** is more than **halved.**
- **Nesting** represents **20%** of decay incidence

POMEGRANATES 2021: POSTHARVEST TRIAL

3.



-58%

Calcium propionate

D1 = Ozonized H_2O
D2 = Neutral Electrolyzed H_2O (NEW)
D3 = NEW + 0.625% sodium metabisulfite
D4 = NEW + 0.625% potassium sorbate
D5 = NEW + 0.625% sodium bicarbonate
D6 = NEW + 0.625% calcium propionate

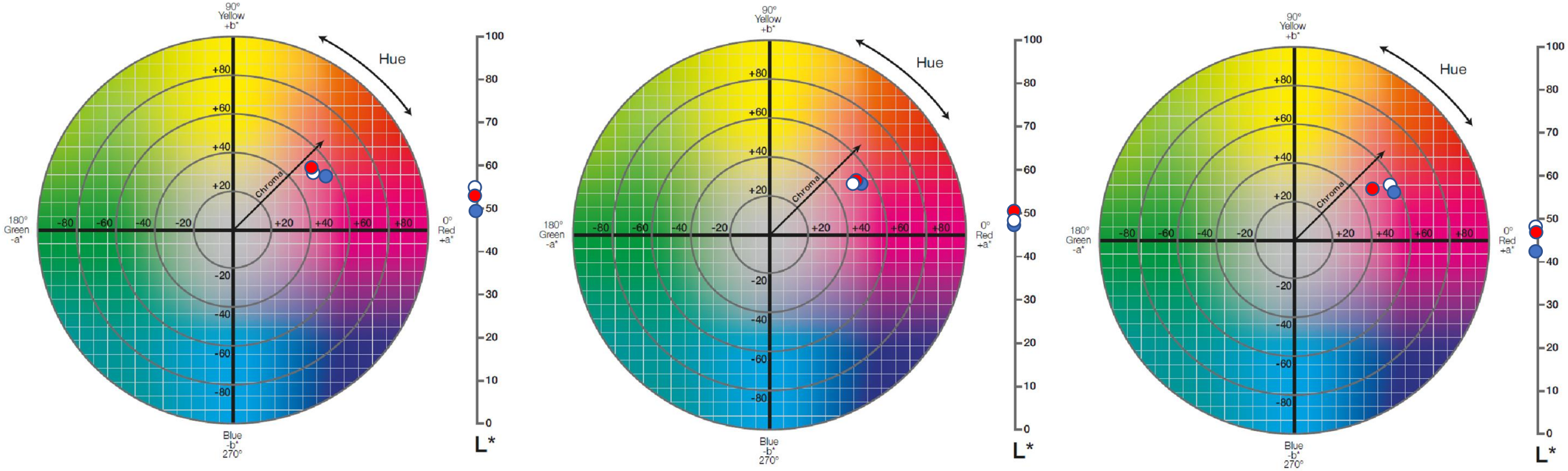
Effectiveness of CP previously confirmed by dipping trial with cracked fruit

To **prolong shelf-life** of second-class pomegranates

5. POMEGRANATES: INTEGRATED APPROACH

QUALITY PARAMETERS: COLOR ASSESSMENT

Before postharvest treatments



Calyx area

Equatorial area

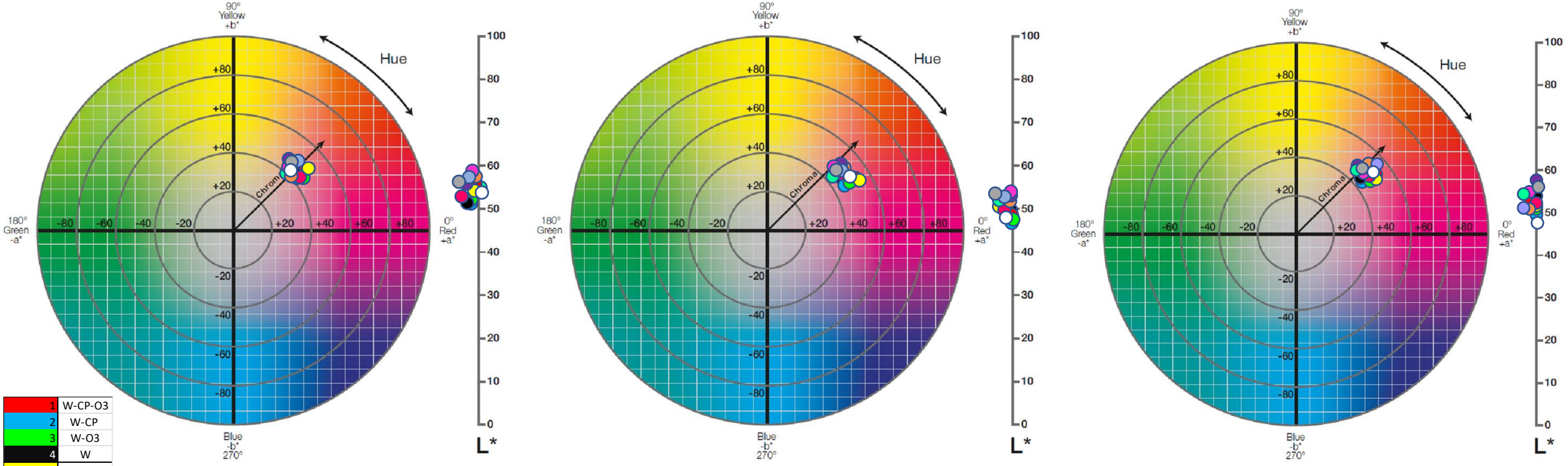
Peduncle area

- Water control
- *B. amyloliquefaciens* x 2
- *B. amyloliquefaciens* x 4 + 1

5. POMEGRANATES: INTEGRATED APPROACH

QUALITY PARAMETERS: COLOR ASSESSMENT

2 months of cold-storage



1	W-CP-O3
2	W-CP
3	W-O3
4	W
5	FLUD
6	AX 4-CP-O3
7	AX 4-CP
8	AX 4-O3
9	AX 4
10	AX 2-CP-O3
11	AX 2-CP
12	AX 2-O3
13	AX 2

Calyx area

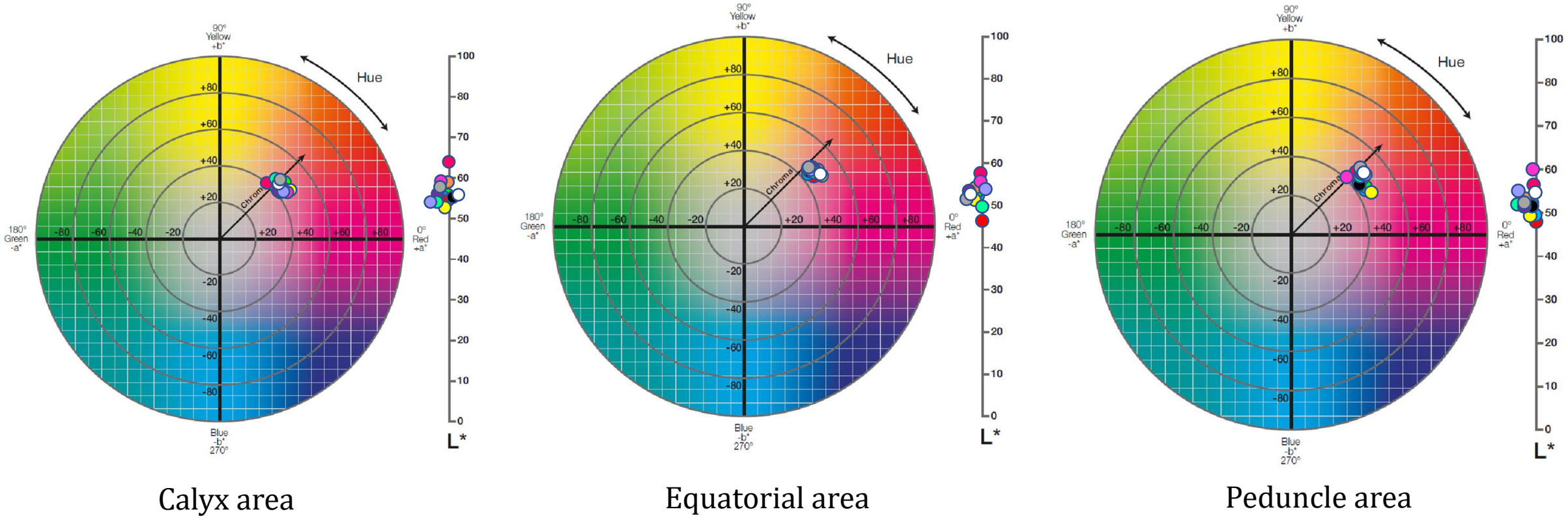
Equatorial area

Peduncle area

5. POMEGRANATES: INTEGRATED APPROACH

QUALITY PARAMETERS: COLOR ASSESSMENT

4 months of cold-storage



Calyx area | Equatorial area | Peduncle area

Steady values over time and among treatments like pH, titratable acidity (TA), and total soluble solids (TSS)

CITRUS: POSTHARVEST TRIALS

1) *In vitro*: **conidial survival** of ***Penicillium digitatum*** and ***Penicillium italicum***:
   - **continuous** exposure
   - **1-min** exposure

ARTIFICIAL WOUNDS & NATURAL INFECTIONS

2) *In vivo*: **injured citrus** (mandalate [Fortune mandarin (2x) × Avana mandarin (4x)]):
   - **continuous ozone**
   - **3** gaseous ozone **concentration** (**250**, **500**, **750 ppb**)
   - **4 time** of exposure (**3**, **6**, **9**, **12 h**)

3) *In vivo*: **injured citrus** (Navelina): **SEMI-COMMERCIAL SCALE**
   - **3** ozone **treatments/day**
   - **7 g/h O_3**

4) *In vivo*: **injured citrus** (clementines):
   - **NEW** amended with 0.625% **calcium propionate**

5) *In vivo*: **injured citrus** (Femminello): **INTEGRATED APPROACH**

5. CITRUS: INTEGRATED APPROACH

best treatments

In vivo: **injured citrus** ('Femminello' lemon)**:**

- ***Dipping***

1) **H_20 with/without O_3**
2) **Imazalil with/without O_3**
3) **0.625% calcium propionate with/without O_3**
4) **NEW + 0.625% calcium propionate with/without O_3**
5) **0.625% sodium bicarbonate with/without O_3**
6) **NEW + 0.625% sodium bicarbonate with/without O_3**

- ***Gaseous ozone treatment***

- **750 ppb O_3 x 3h exposure time**
- **Daily** treatment (**7** treat./**week**).

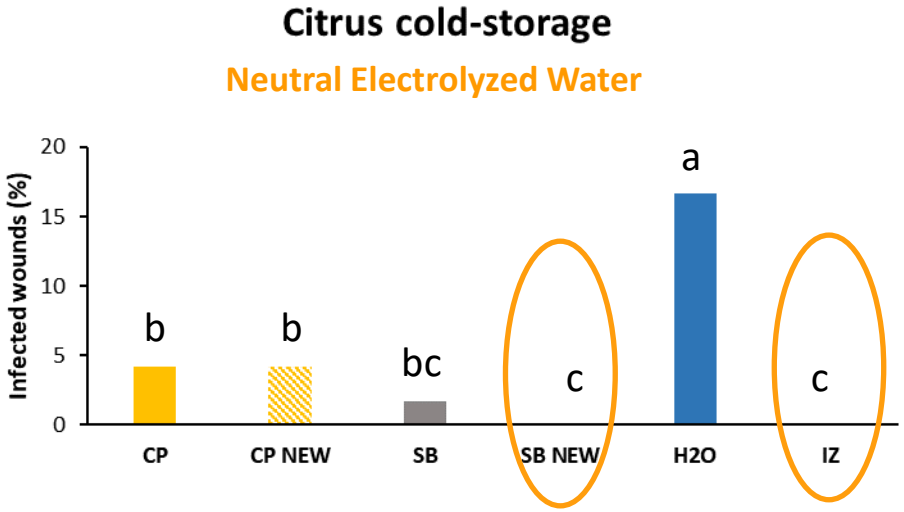
THESES	POSTHARVEST DIPPING	POSTHARVEST GASEOUS O_3
T1.1	Calcium propionate	No O_3
T2.1		O_3 exposure
T1.2	NEW + calcium propionate	No O_3
T2.2		O_3 exposure
T1.3	Sodium bicarbonate	No O_3
T2.3		O_3 exposure
T1.4	NEW + sodium bicarbonate	No O_3
T2.4		O_3 exposure
T1.5	Water	No O_3
T2.5		O_3 exposure
T1.6	Imazalil	No O_3
T2.6		O_3 exposure

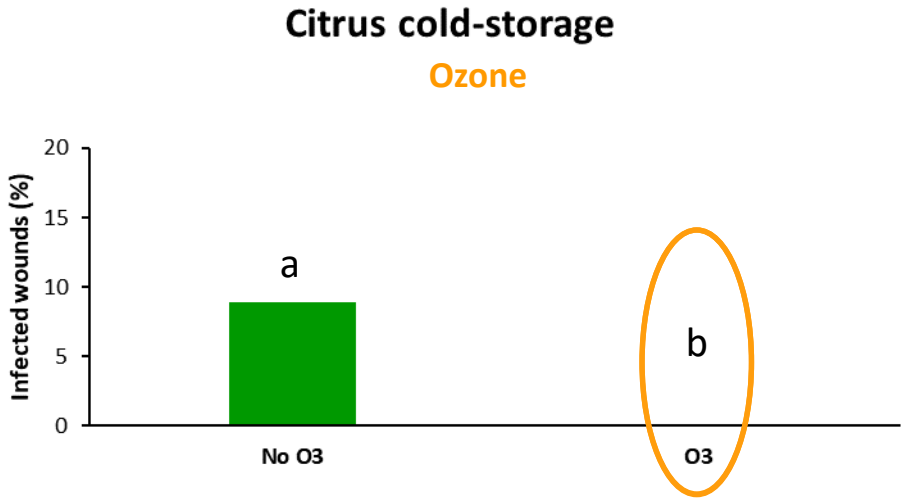
Factorial ANOVA

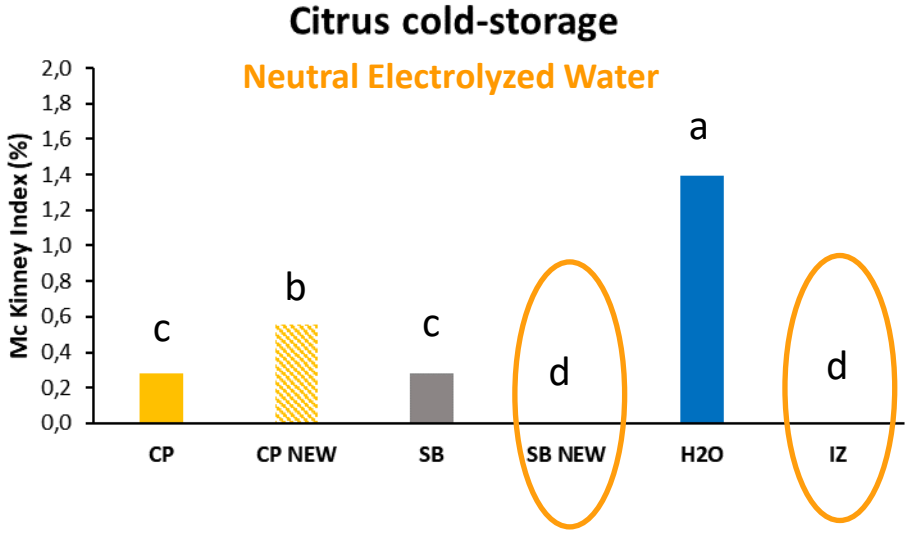
- **EVALUATION OF DECAY INCIDENCE AND SEVERITY**
- **QUALITATIVE ANALYSES** (color, pH, TSS, TA)

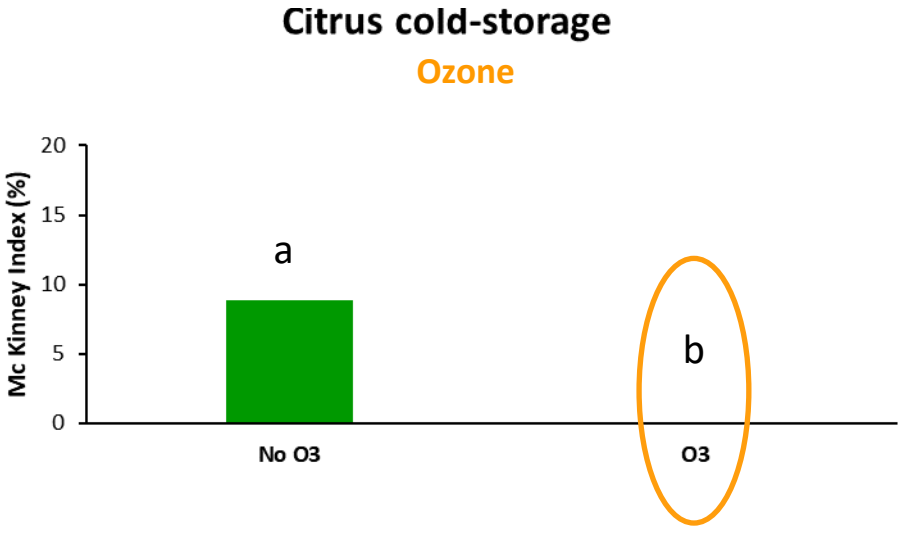
5. CITRUS: INTEGRATED APPROACH

DISEASE INCIDENCE AFTER 2 WEEKS OF COLD-STORAGE









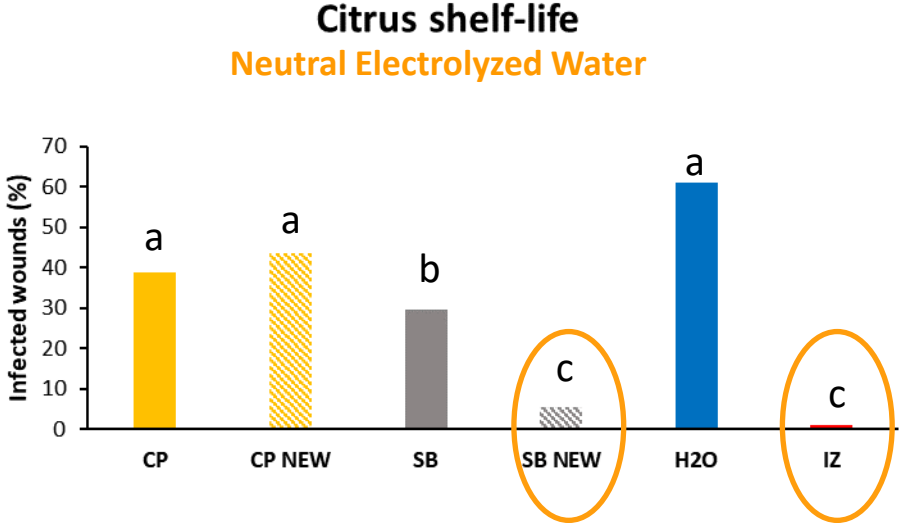
- Rot incidence and severity were reduced by 70-90% in other treatments
- **NEW + SB** and **ozone**

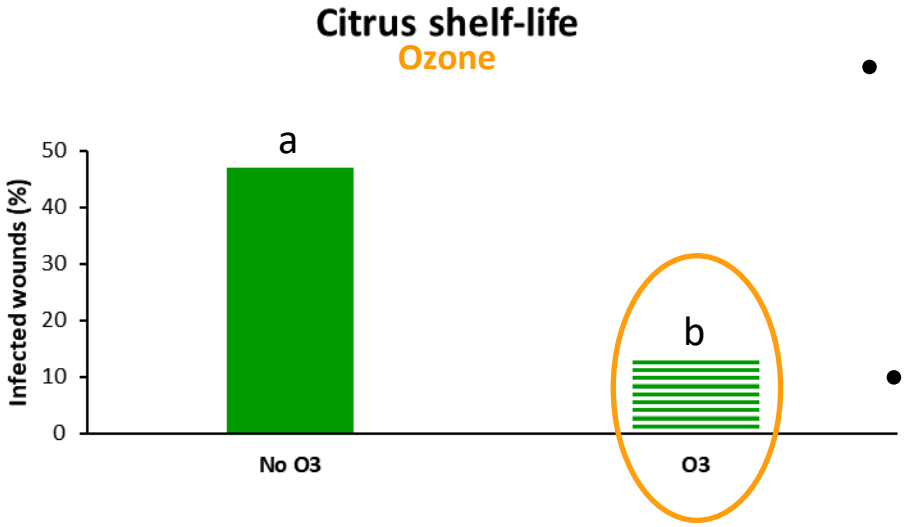
-100%

CP = Calcium propionate/postharvest dipping
SB = Sodium bicarbonate/postharvest dipping
NEW = Neutral Electrolyzed Water
IZ = Imazalil//postharvest dipping
O3 = gaseous ozone/exposure

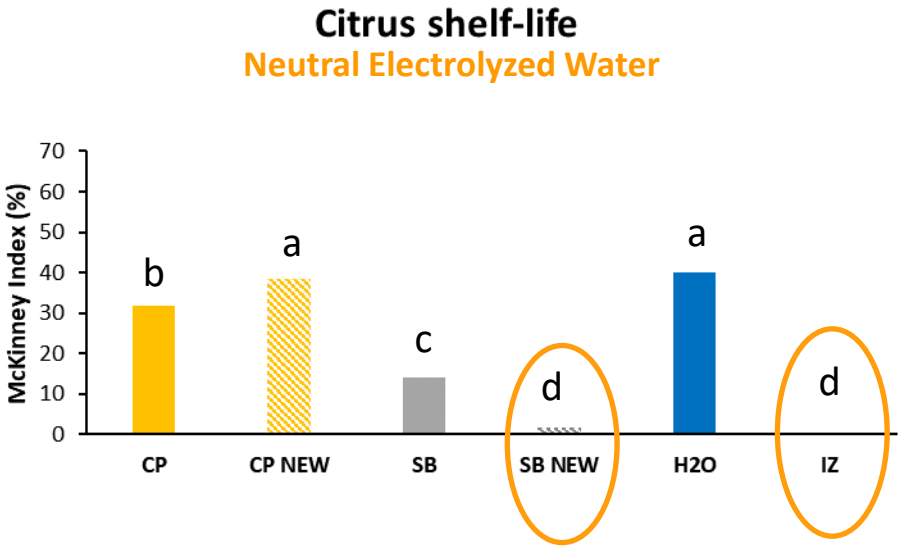
5. CITRUS: INTEGRATED APPROACH

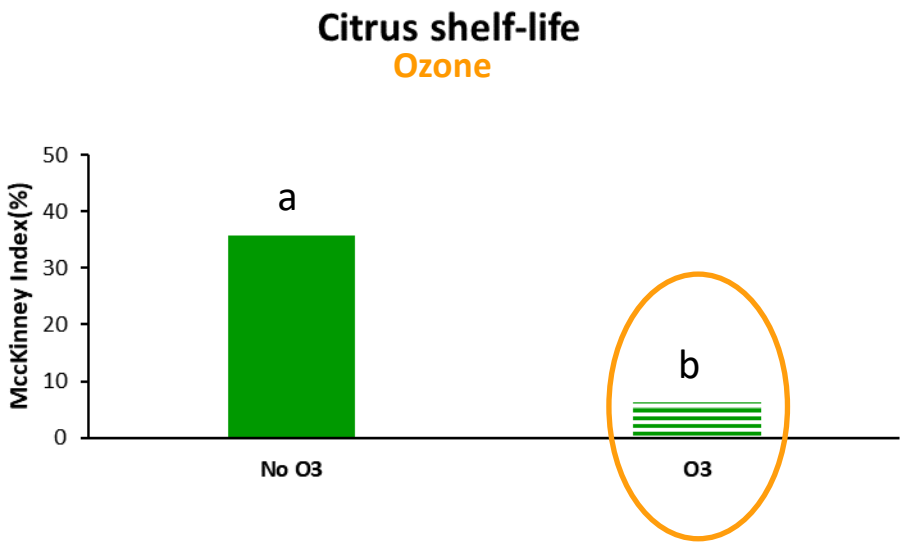
DISEASE INCIDENCE AFTER 2 WEEKS OF COLD-STORAGE AND 3 DAYS OF SHELF-LIFE





- **NEW + SB** reduced by **91-96%** disease incidence and severity
- **Ozone** reduced by **72-83%** disease incidence and severity



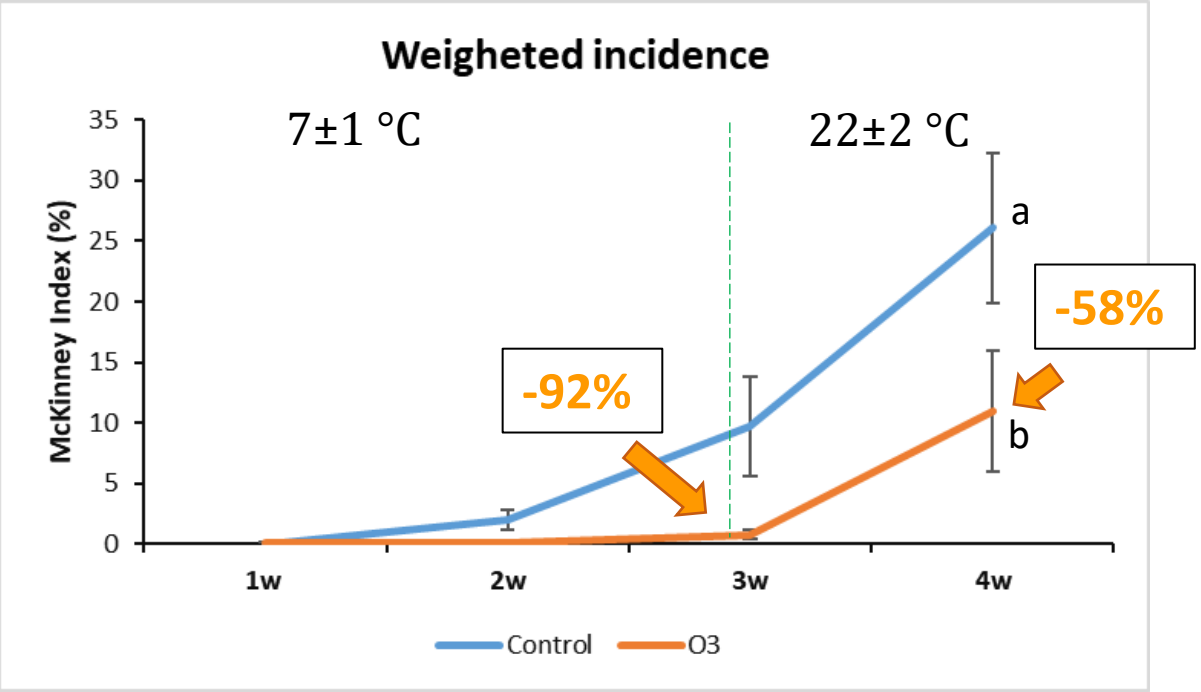


CP = Calcium propionate/postharvest dipping
SB = Sodium bicarbonate/postharvest dipping
NEW = Neutral Electrolyzed Water
IZ = Imazalil//postharvest dipping
O3 = gaseous ozone/exposure

CITRUS: POSTHARVEST TRIALS

3. *In vivo*: injured citrus (Navelina): SEMI-COMMERCIAL SCALE

Effectiveness of **ozone** previously confirmed in the **semi-commercial scale trial**

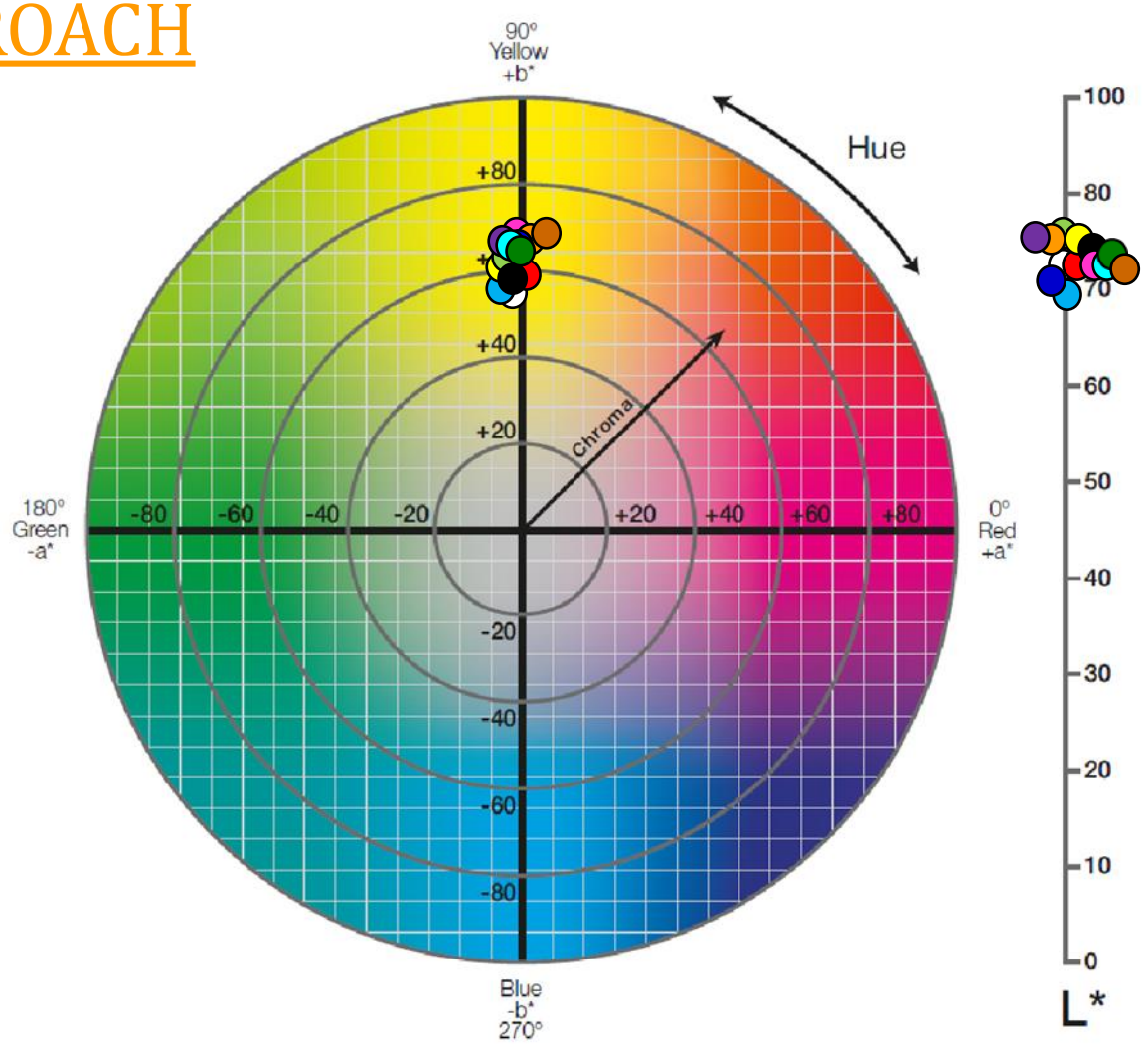


O3 = gaseous ozone/exposure

5. CITRUS: INTEGRATED APPROACH

THESES	POSTHARVEST DIPPING	POSTHARVEST GASEOUS O_3
T1.1	Calcium propionate	No O_3
T2.1		O_3 exposure
T1.2	NEW + calcium propionate	No O_3
T2.2		O_3 exposure
T1.3	Sodium bicarbonate	No O_3
T2.3		O_3 exposure
T1.4	NEW + sodium bicarbonate	No O_3
T2.4		O_3 exposure
T1.5	Water	No O_3
T2.5		O_3 exposure
T1.6	Imazalil	No O_3
T2.6		O_3 exposure

- Standard values



Steady values over time and among treatments like pH, titratable acidity (TA), and total soluble solids (TSS)

INTEGRATED APPROACH

I. **In the field** treatments
II. **Postharvest** treatments

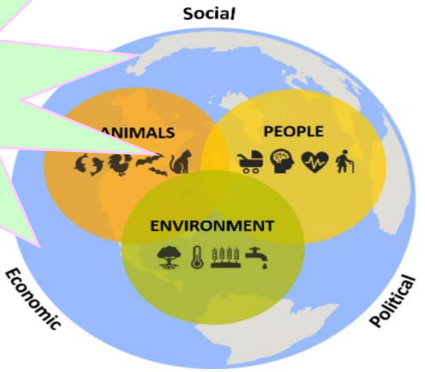
I. **Latent** pathogens
II. **Wound** pathogens

WASTE REDUCTION

FOOD QUALITY

PESTICIDE REDUCTION

ONE HEALTH APPROACH



DETAILING…

1. ***B. amyloliquefaciens*** and **NEW + Calcium propionate**

2. **NEW + Sodium bicarbonate** and **gaseous ozone**

→ 1. **Pomegranate** postharvest diseases

→ 2. **Citrus** postharvest diseases

POMEGRANATES

CITRUS

Thank you!

Annamaria Mincuzzi, University of Bari Aldo Moro (Italy)
annamaria.mincuzzi@uniba.it