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Garlic volatile compounds mimic nitric oxide (NO) effects on ripening of sweet pepper (*Capsicum annuum* L.) fruits and improve their commercial and nutritional properties

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Capsicum annuum L.

(General features)

- **Hundreds of varieties with a number of common names:**

Sweet pepper, bell pepper, habanero, cachucha, paprika, chili, Padrón, morrón, Piquillo, jalapeño, ají, cayena, chipotle, and many others

- **Second most distributed vegetable worldwide**

- **Nutritional value:**

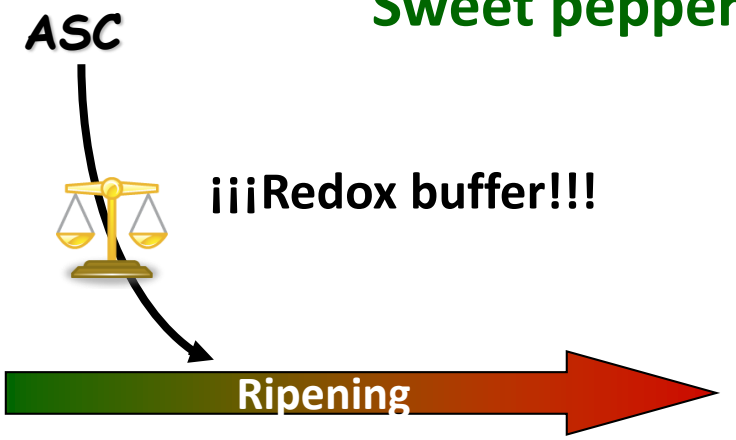
High contents of ascorbate, β-carotene, capsaicin, flavonoids and minerals

- **Non climacteric fruit**

- **Conversion of chloroplasts into chromoplasts at ripening**

- **Difficult gene manipulation**

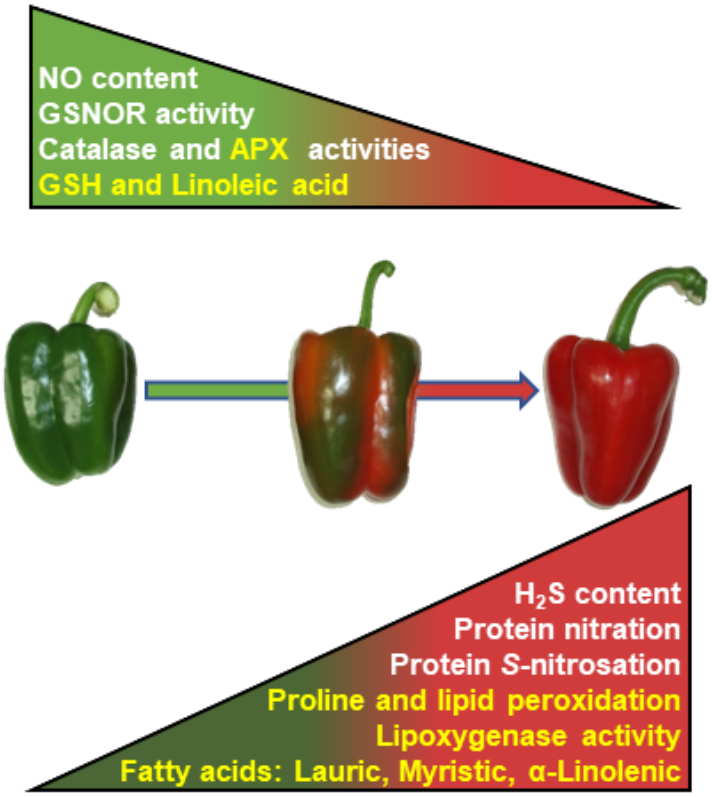
Sweet pepper ripening

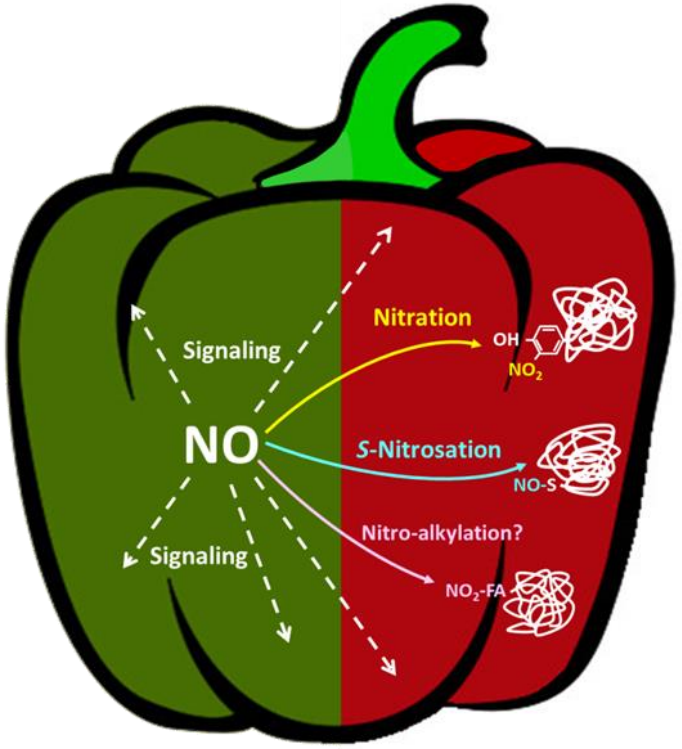


- Intense metabolism
- Emission of volatile organic compounds (respiration)
- Chlorophyll breakdown
- Synthesis of new pigments (carotenes, xanthophylls, anthocians)
- Formation of pectins
- Protein synthesis
- Taste alteration (acidity, pH and astringency)
- Changes in total soluble reducing equivalents ROS
- Alteration of oxidative metabolism
- **ASCORBATE AS REDOX BUFFER**

(Palma et al. 2015; Rodríguez-Ruiz et al. 2017)

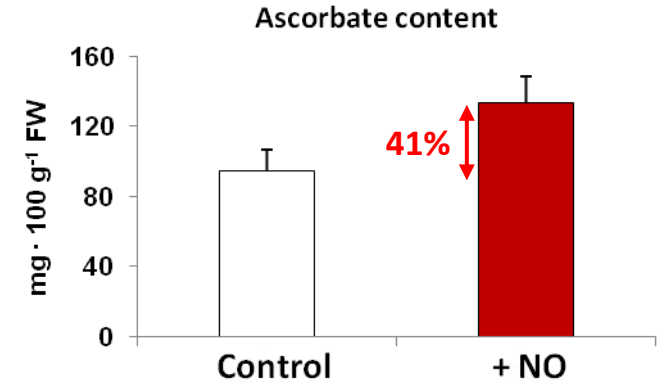
Global view of NO and antioxidative metabolism during ripening of sweet pepper fruits

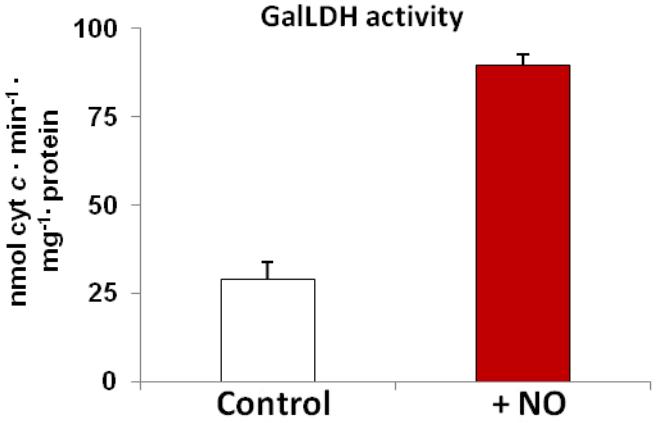


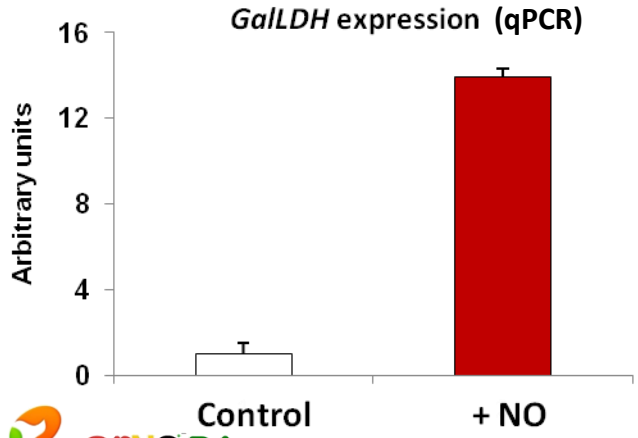


Palma et al. (2019) J. Exp. Bot. 70: 4405–4417
González-Gordo et al. (2019) J. Exp. Bot. 70: 4557–4570

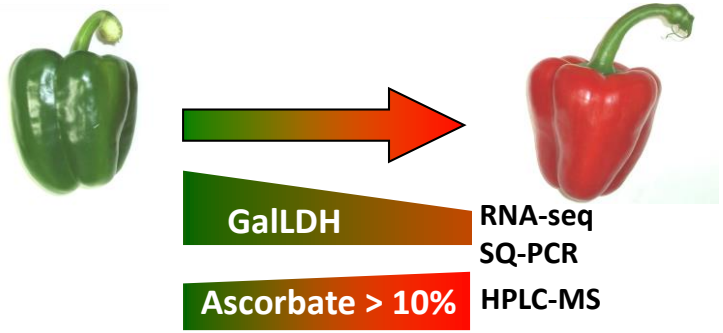
NO delays ripening of sweet pepper fruits and increases their ascorbate content



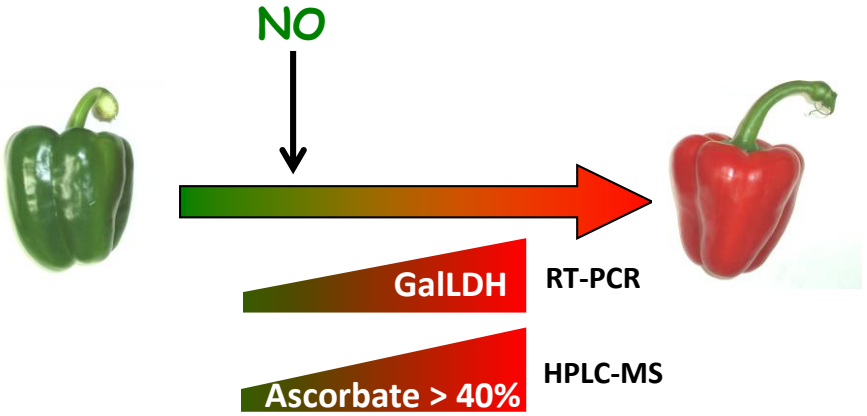




Natural conditions



NO treatment

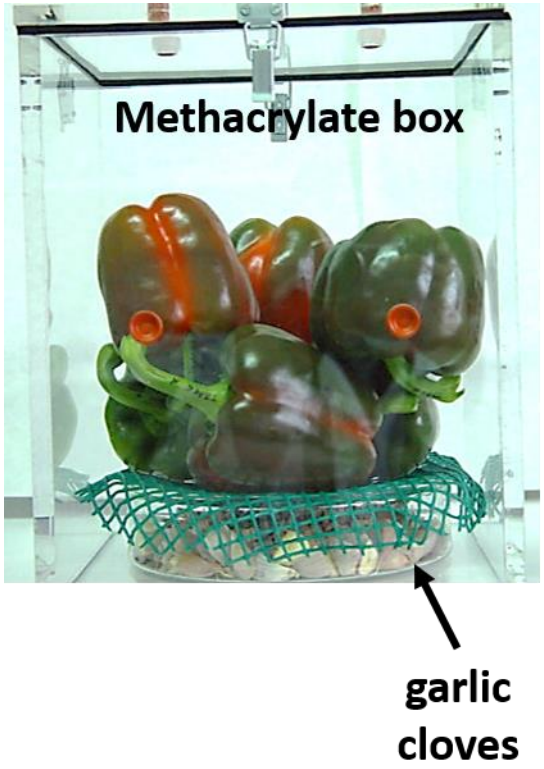


Chaki, Álvarez de Morales et al. (2015) Ann. Bot. 116: 637-647
Rodríguez-Ruiz et al. (2017) *Redox Biol*. 12: 171-181

Experimental design

Incubation of pepper fruits in the presence of garlic cloves

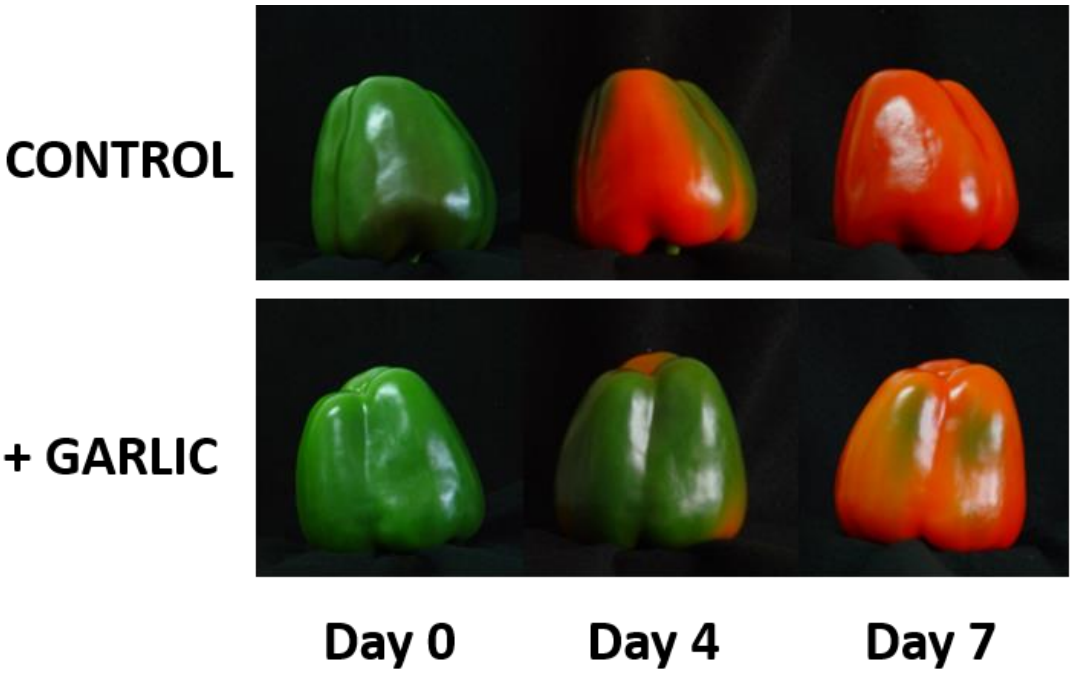
- **1 hour**
- **2 weeks at 6 ºC and room temperature**



Analyses

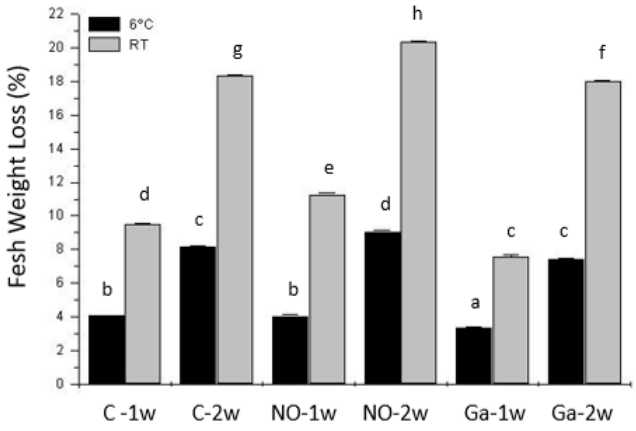
- **Ascorbate (HPLC-MS)**
- **Glutathione (GSH and GSSG) (HPLC-MS)**
- **Carotenoids**
- **β-carotene**
- **Total phenolics**
- **Flavonoids**
- **Lipid peroxidation (oxidative stress marker)**

Phenotype of sweet pepper fruits at day 4 and 7 after the incubation with garlic cloves and further storage at room temperature.

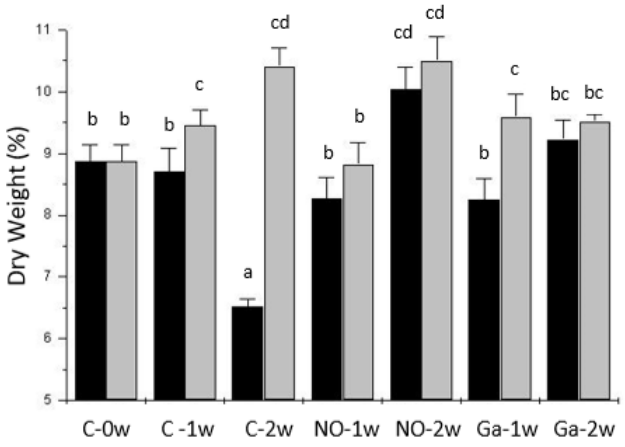


Effect of NO and garlic on fresh weight, dry weight and Brix of sweet pepper fruits at different times and storage conditions.

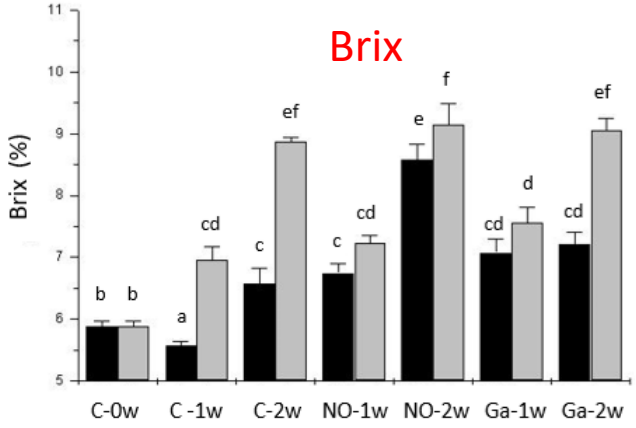
Fresh weight



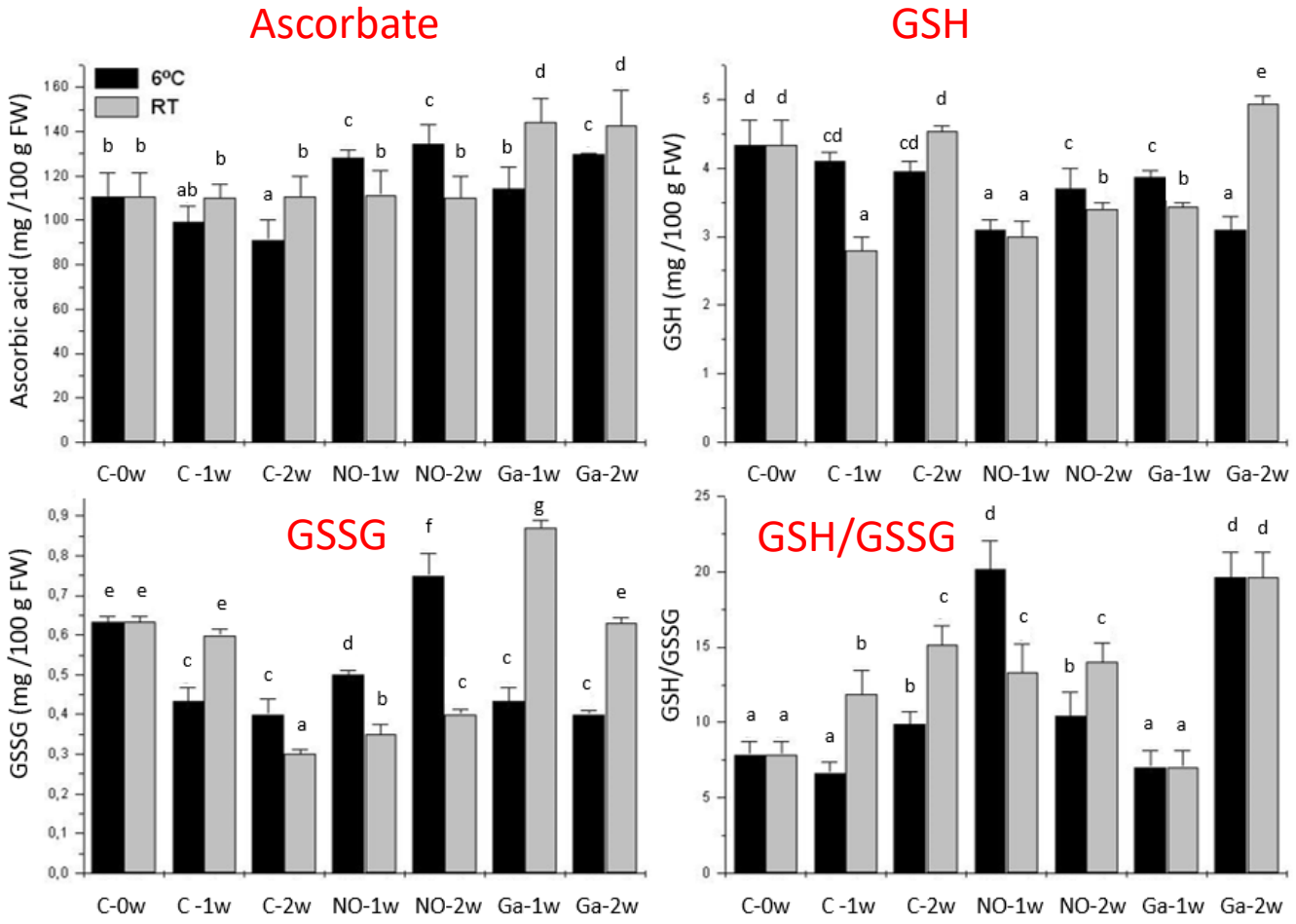
Dry weight



Brix

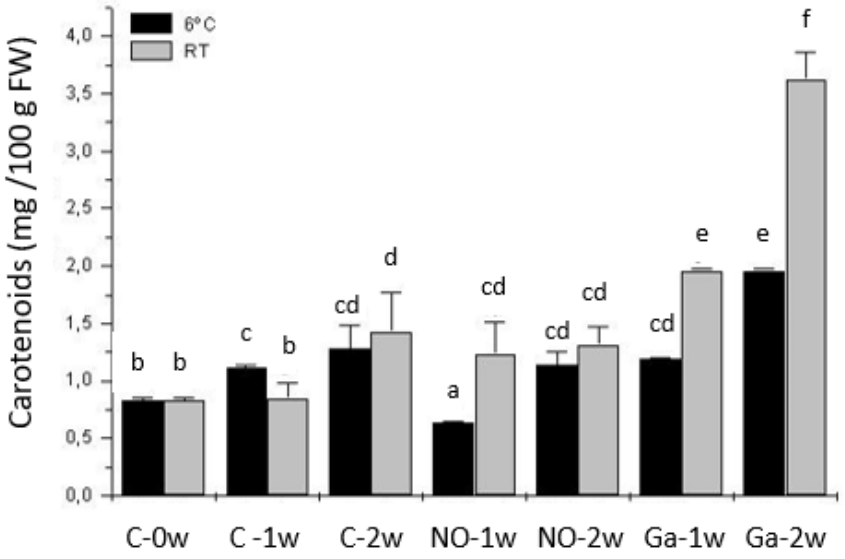


Effect of NO and garlic on ascorbate and glutathione contents in sweet pepper fruits at different times and storage conditions.

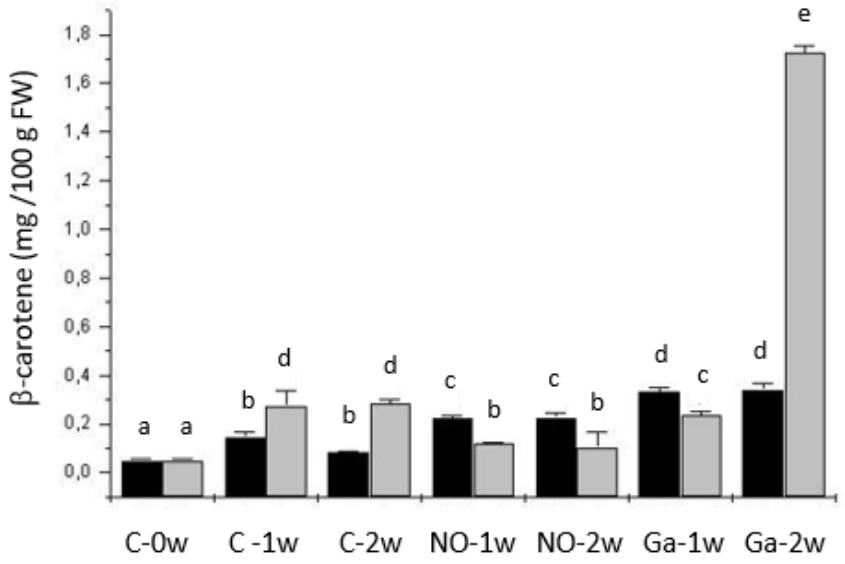


Effect of NO and garlic on carotenoids and β-carotene contents in sweet pepper fruits at different times and storage conditions.

Carotenoids

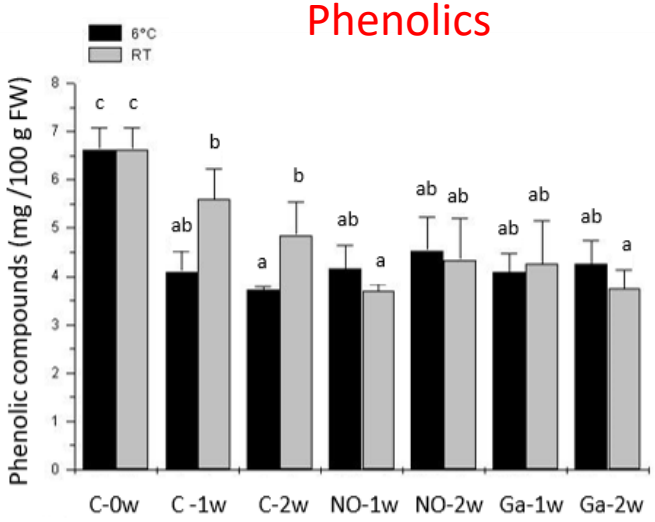


β-carotene

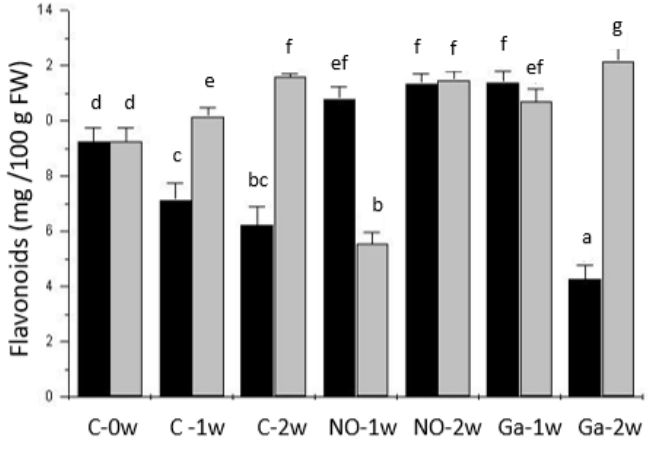


Effect of NO and garlic on phenolic compounds and flavonoid contents and lipid peroxidation level (MDA) in sweet pepper fruits at different times and storage conditions.

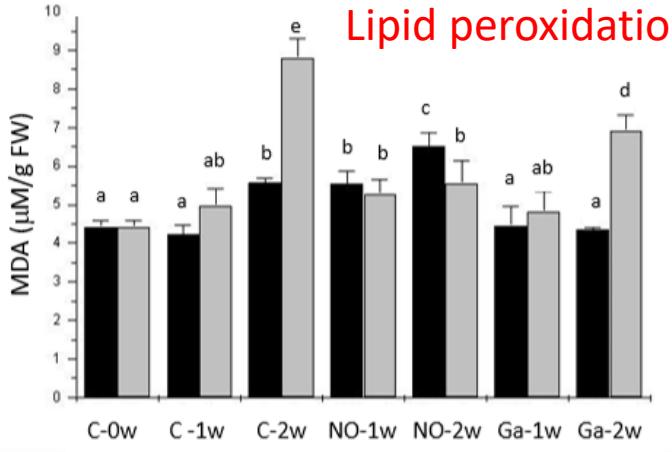
Phenolics



Flavonoids



Lipid peroxidation



CONCLUSIONS

1. Garlic preparations mostly exerted similar effects as NO in sweet pepper fruits, delaying ripening and increasing some commercial traits such as ascorbate, glutathione and flavonoids.

2. This strategy allows improving the added value of sweet pepper fruits, a vegetable with a high economical yield in the Mediterranean area.

3. To our knowledge, this is the first report on the direct influence of garlic on the metabolism and nutritional properties of a crop fruit. These results suggest that this experimental design could be up-scaled for agro-biotechnological purposes with the circular economy being promoted.

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