Strategies for functional food production

- Improve the content or profile
- Increase bioavailability
- Increase or modulate bioactivity

Interventions to increase the content

- Genetics
- Agronomics
- Livestock
- Fish farming
- Technological
- Biotechnological
- Formulation and presentation

Livestock and Fish Farming

- Milk
- Meat
- Eggs
- Fish

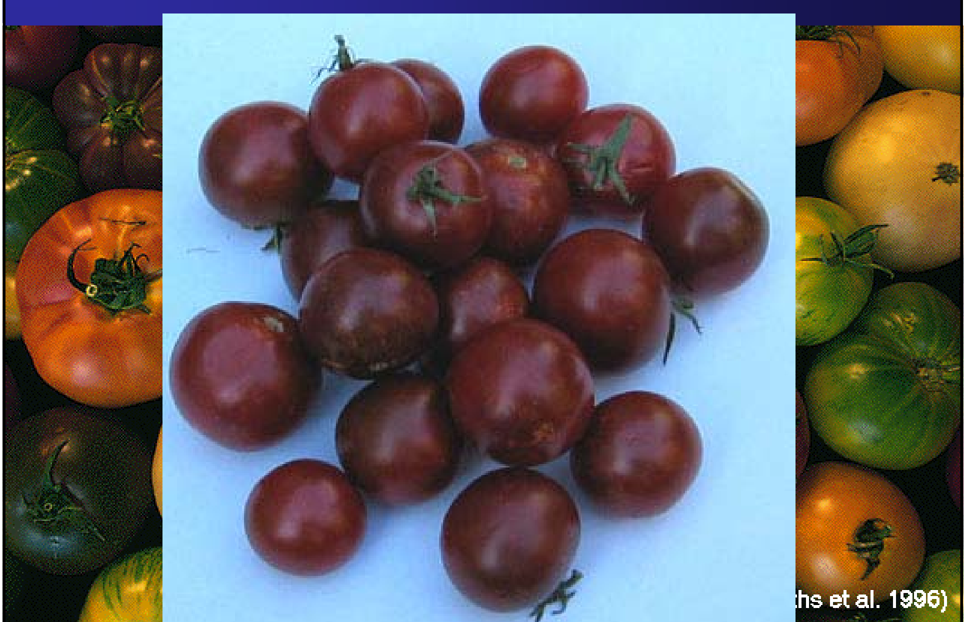
- Lipids
- Proteins
- Metabolites (carotenoids, etc.)

Factors affecting the plant bioactive compounds content

- 1-Internal (genetic)
- 2-Agronomic (environmental)
- 3-Postharvest treatments
- 4-Technological treatments
- 5-Biotechnological treatments

1) Genetic factors

- Flavonoid content
- Flavonoid quality
- Polyphenol oxidases



Phenolic content of different tomato types (mg/100g f.w.)

	HCA	Flavonols	Flavanones	total
cherry	170.97	1042.41	729.86	1943.24
cluster	31.02	12.94	42.4	86.36
Specialities	5.76	13.48	2.68	21.92
Marmande	9.34	80.19	47.13	136.66
medium	12.95	21.05	37.27	71.27
large GB	23.83	20.48	44.81	89.12
Large beef	7.39	18.71	15.72	41.82

2- Agronomic factors

- Irrigation
- Soil (nutrients)
- Temperature
- Irradiation (sun)
- Pests

Irrigation

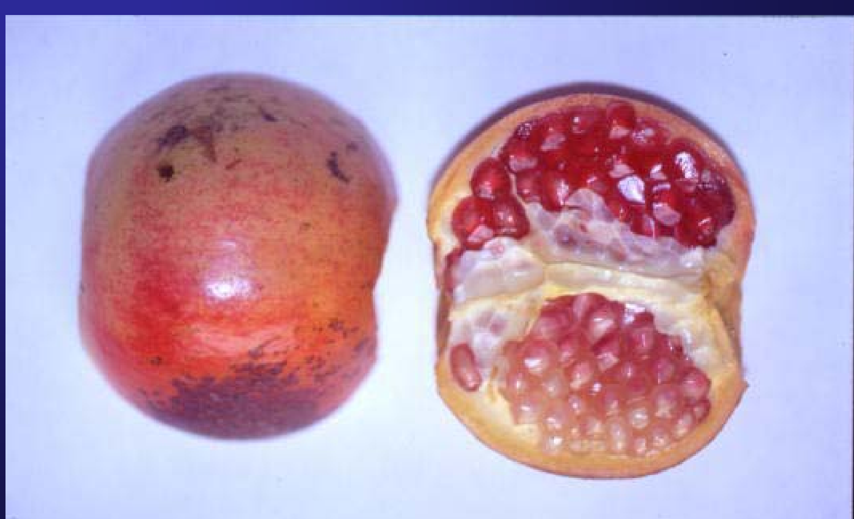
- Water quality
- Water quantity

Soil (nutrients)

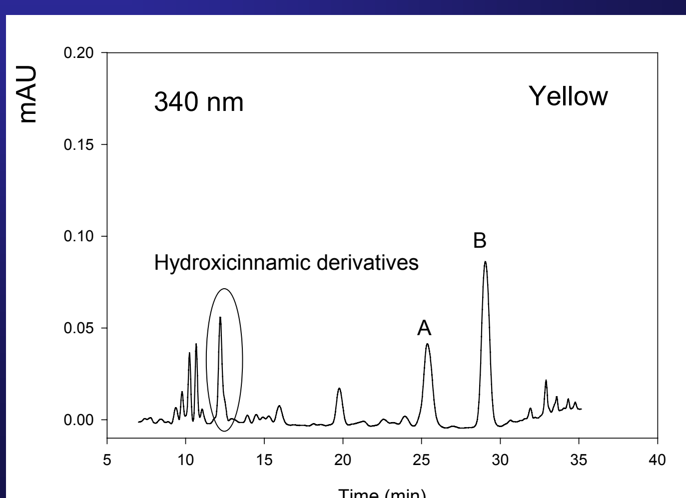
- Sulfur nutrients
- 15-30 kg/Hect   (2-3 fold increase in glucosinolates)
- 50-90 kf/Hect   (nutritional imbalance, the effects are lost)

Temperature

Sun irradiation



Sweet Pepper flavonoids California type (Cv Luzon)

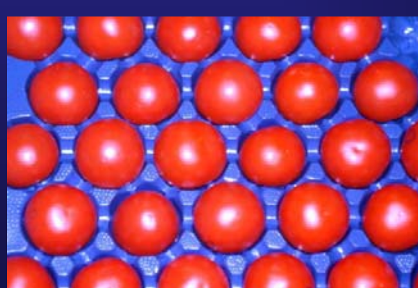


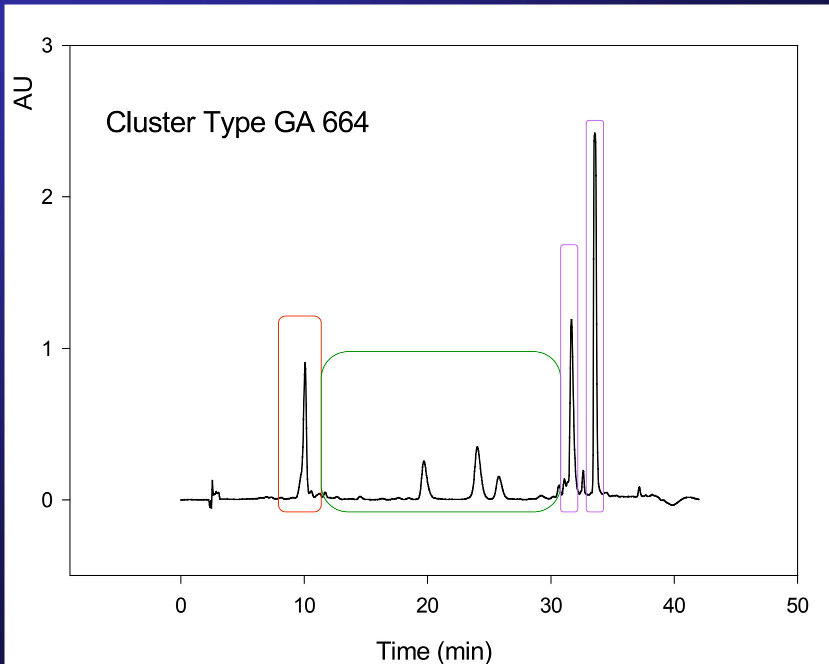
Phenolic content (mg/100 g f.w.)

	HCA	Flavonoids
California		
– *Aifos*	0.181	1.976
Lamuyo		
– *Duque*	1.008	5.033
Dulce Italiano		
– *Italico*	0.584	7.702

Tomato flavonoids

- Greenhouse
- Out doors 2-10 times more flavonoids





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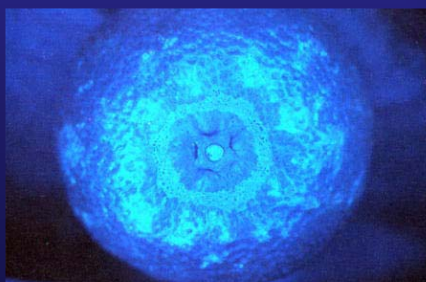
Pests

- Phytoalexins

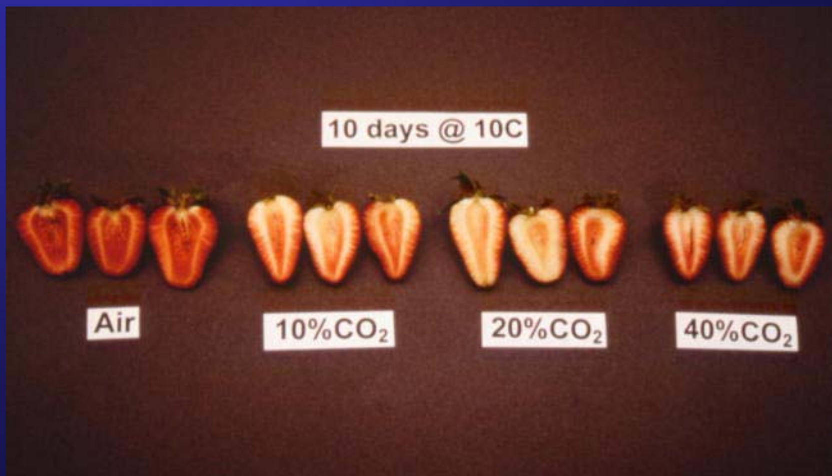


3- Postharvest factors

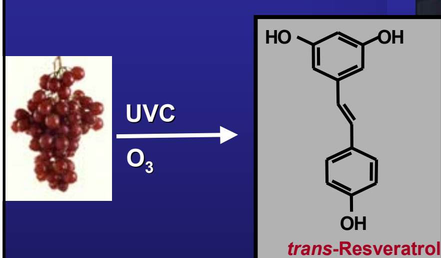
Storage Conditions
- **Temperature**
- **Atmosphere**
- **Plant Hormones**

Technological treatments
- – **Cutting**
- – **Irradiations**

3- Factores Postrecolección



Improve profile



HPLC Analysis

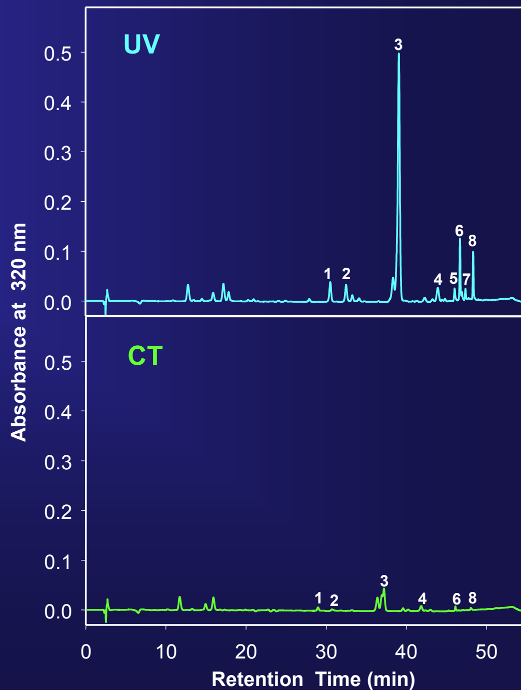
Irradiation conditions:

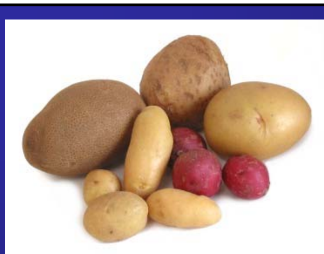
- 510 W
- 60 seconds
- 40 cm

Peaks:

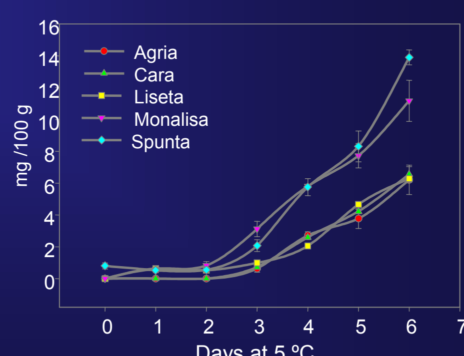
1. Piceid
2. Piceatannol
3. Resveratrol

4-8. Viniferins





Induce flavonoid biosynthesis



Tudela, J.A., Cantos, E., Espín, J.C., Tomás-Barberán, F.A., Gil, M.I. 2002. Induction of antioxidant flavonols biosynthesis in fresh-cut potatoes. Effect of domestic cooking. J. Agric. Food Chem. 50: 5925-5931.

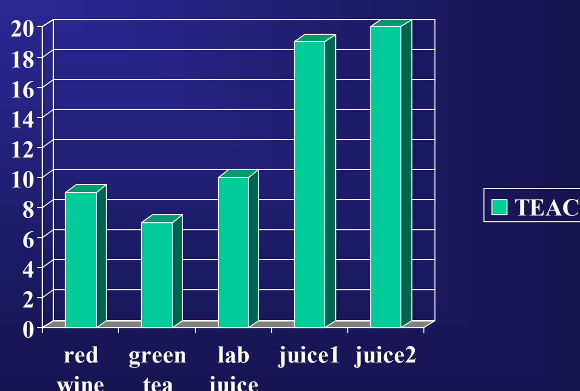
4. Effect of Processing

- Tissue disruption
- Thermal treatments
- Fermentation
- Freezing
- Drying
- Addition of other ingredients

Processing and bioavailability

Juice preparation

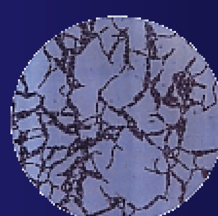
Antioxidant activity of pomegranate juice



ENZYMATIC TREATMENT - SUPERIOR

Biotechnological treatments

- Use microorganisms
- Use Animal Cells
- Use enzymes



- Improve bioavailability
- Improve biological activity

CONVERSION OF PHENOLIC-RUTINOSIDES TO PHENOLIC-GLUCOSIDES

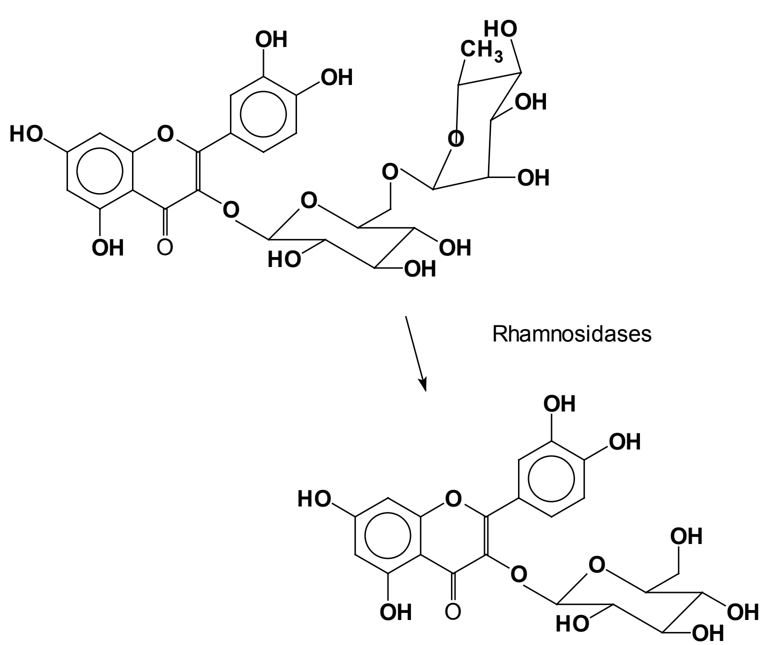
Background:

- Rhamnosidases from *Aspergillus aculeatus* can convert, in model solutions, phenolic-rutinosides to their phenolic-glucosides counterparts.
- Phenolic-rutinosides are less bioavailable than their phenolic-glucosides counterparts.

Question: Is possible to convert phenolic-rutinosides to phenolic-glucosides in juices?

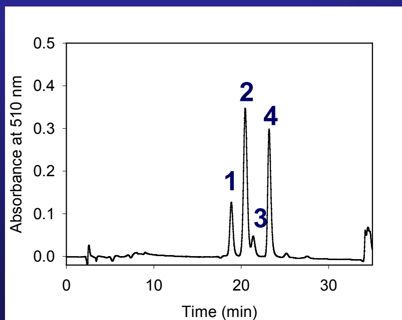
Enzyme: Rhamnosidases from *A. aculeatus* ‘A and B’ (provided by Leo de Graaf’s group, WAU).

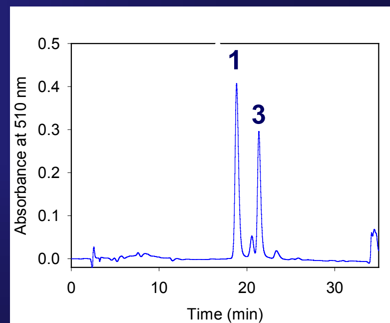
Juices: Black currant and orange (commercial and fresh).



CONVERSION OF PHENOLIC-RUTINOSIDES TO PHENOLIC-GLUCOSIDES

Black currant (R-A, 2 μg/mL)





1 = Delphinidin-3-glucoside
2 = Delphinidin-3-rutinoside
3 = Cyanidin-3-glucoside
4 = Cyanidin-3-rutinoside

Conversion: 2 → 1 and 4 → 3

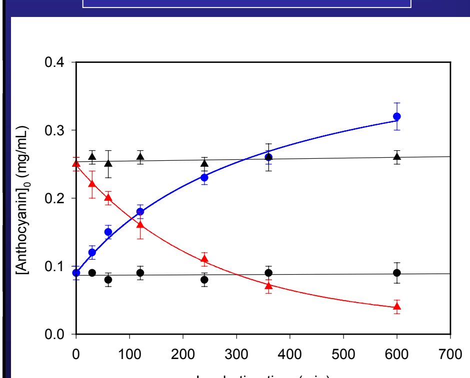
CONVERSION OF PHENOLIC-RUTINOSIDES TO PHENOLIC-GLUCOSIDES

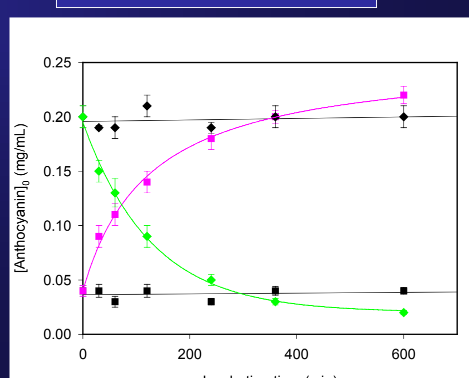
Kinetics

Black currant (R-A, 2 μg/mL)

- CONTROL Dpn-3-glucoside
- R-A, Dpn-3-glucoside
- CONTROL Dpn-3-rut
- R-A, Dpn-3-rut

- CONTROL Cyn-3-glucoside
- R-A, Cyn-3-glucoside
- CONTROL Cyn-3-rut
- R-A, Cyn-3-rut

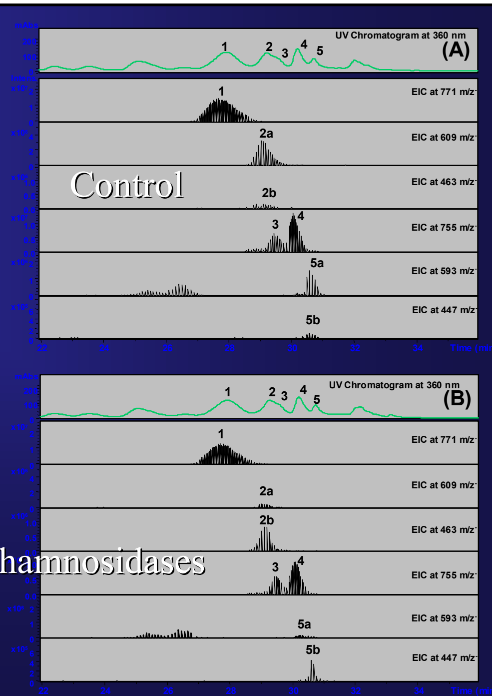


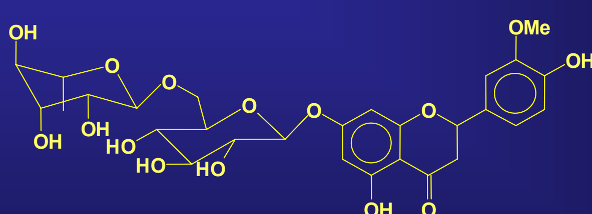


Green Tea

Hplc MS-MS

- 1 Q-glc-rha-glc
- 2 Q-glc + Q-glc-rha
- 4 K-glc-rha-glc
- 5 K-glc + K-glc-rha

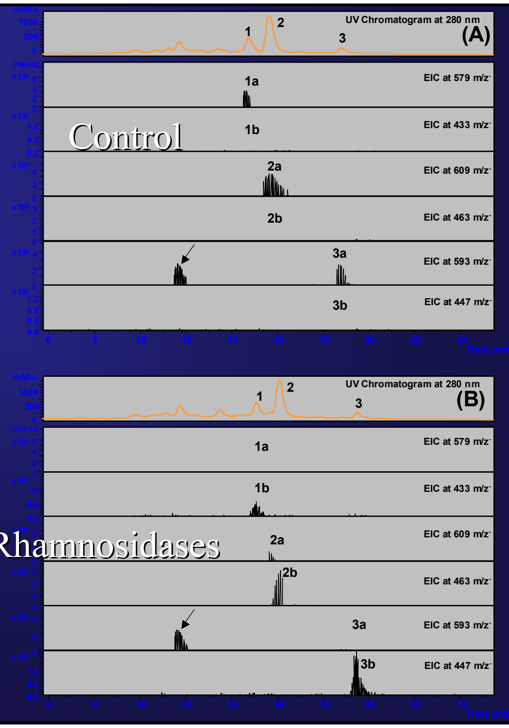




Citrus

Hplc MS-MS

- 1 N-glc-rha + N-glc
- 2 H-glc-rha + H-glc
- 3 D-glc-rha + D-glc



BIOAVAILABILITY IN VIVO

CSIC

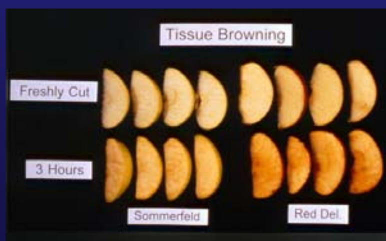
Gary Williamson et al., Nestlé Research Centre

16 healthy volunteers

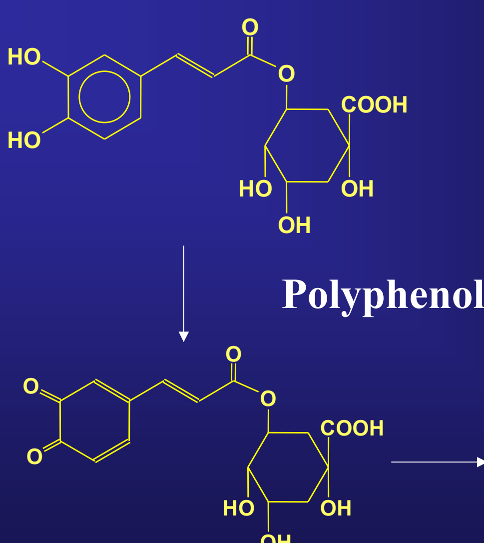
5.4-fold higher bioavailability for hesperetin-glucoside

Bioavailability of hesperidin can be modulated by the enzymatic conversion to the glucoside.

Enzymatic browning



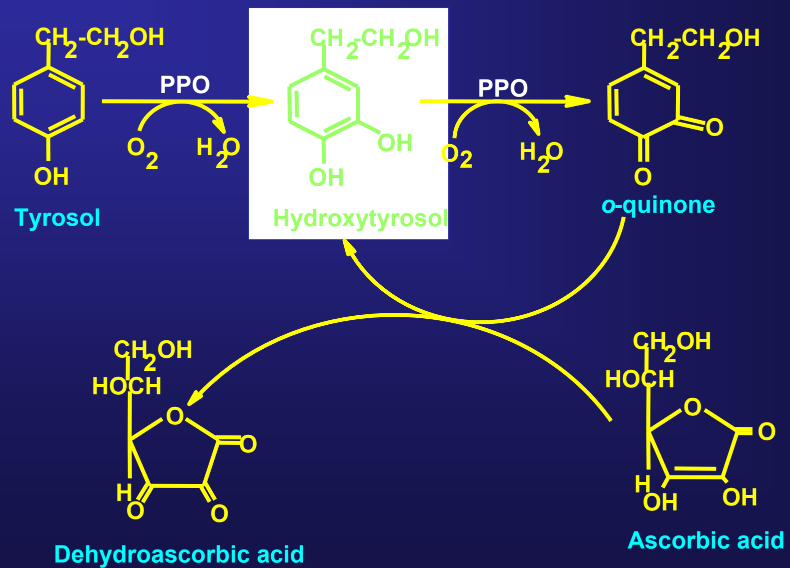
Enzymatic Browning



Polyphenol oxidase (PPO)

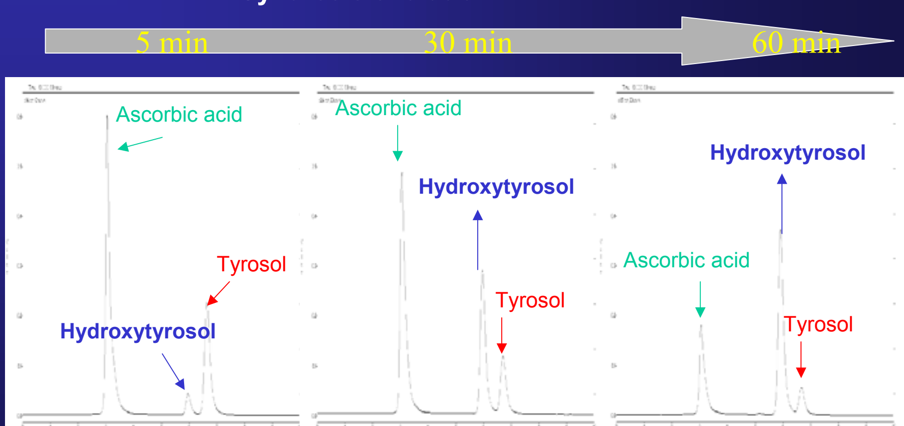
Brown Polymers

Enzymatic synthesis of hydroxytyrosol using tyrosinase as biocatalist



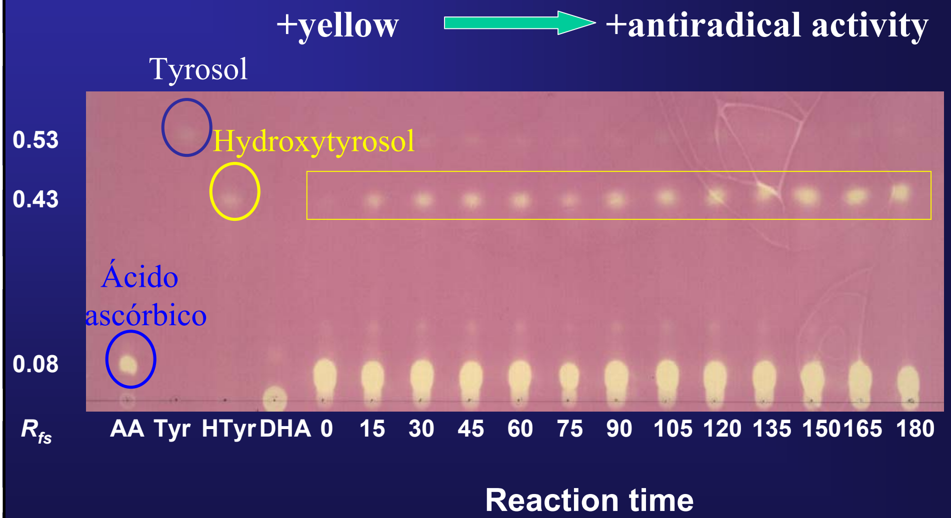
HPLC follow-up of the reaction

Synthesis evolution



Process modelling → **PATENT**

TLC-DPPH Follow-up of hydroxytryrosol formation



Enzymatic synthesis of piceatannol