



Research Lines Department of Agroindustry and Food Quality

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Researcher at the Andalusian Institute of Agricultural and Fisheries Research and Training (IFAPA)

Head Dept. of Agroindustry and Food Quality

Ljubljana (Slovenia)

April 20, 2023



Instituto Andaluz de Investigación
y Formación Agraria, Pesquera, Alimentaria
y de la Producción Ecológica
Consejería de Agricultura,
Pesca, Agua y Desarrollo Rural

Index

1 . IFAPA

2. Department of Agroindustry and Food Quality

2.1 Food Quality & Safety

2.2 Food Bioactives & Health

2.3 Stable Isotopes Applications/Collaborations

2.3.1 Food Trazability

2.3.2 Marine Ecosystems

2.3.3 Agroecosystems

2.3.4 Animal Trazability

Andalusian Institute of Agricultural and Fisheries Research and Training (IFAPA)



Index

1 . IFAPA

2. Department of Agroindustry and Food Quality

2.1 Food Quality & Safety

2.2 Food Bioactives & Health

2.3 Stable Isotopes Applications/Collaborations









2.3.1 Food Trazability

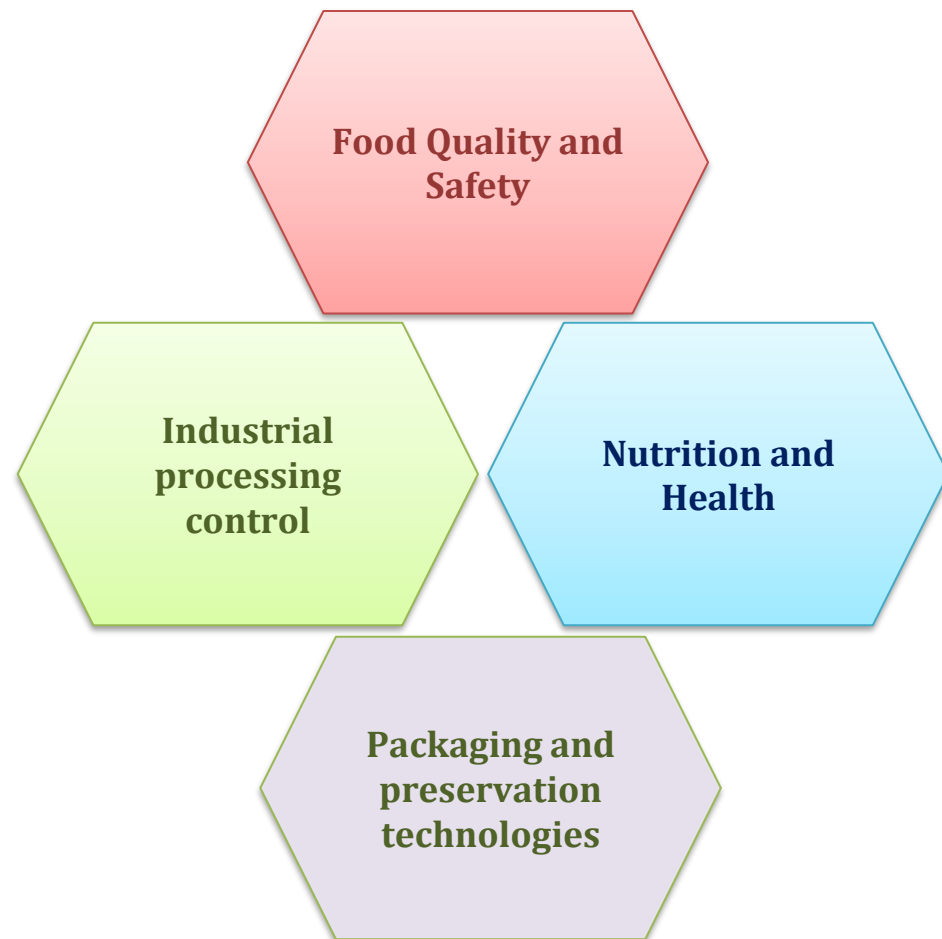
2.3.2 Marine Ecosystems

2.3.3 Agroecosystems

2.3.4 Animal Trazability

Departments at IFAPA

 <p>Acuicultura, Pesca y Medio Marino</p> <p>Acuicultura de Peces, Moluscos y otros - Ecosistemas marinos - Evaluación y Control de Pesquerías</p> <p>Más información</p>	 <p>Agroindustry and Food Quality</p> <p>Más información</p>	 <p>Economía de la Cadena Alimentaria</p> <p>Análisis de Sistema Agrarios - Desarrollo Rural - Estructuras Comerciales - Demanda y Consumo Agroalimentario</p> <p>Más información</p>	 <p>Ingeniería y Tecnología Agroalimentaria</p> <p>Cultivos Herbáceos - Leñosos - Horticultura - Floricultura - Ganadería</p> <p>Más información</p>
 <p>Mejora Vegetal y Biotecnología</p> <p>Biotecnología Aplicada a la Mejora del Cultivo - Cultivo de Tejidos - Nuevas variedades de Plantas Cultivadas - Mejora en cultivo de la fresa</p> <p>Más información</p>	 <p>Producción Agrícola y Ganadera</p> <p>Agronomía - Producción Ganadera - Transferencia y Formación Agraria</p> <p>Más información</p>	 <p>Protección Vegetal Sostenible</p> <p>Fitoparásitos - Virus - Hongos - Bacterias - Insectos-plaga - Nematodos - Plantas Espontáneas</p> <p>Más información</p>	 <p>Recursos Naturales y Forestales</p> <p>Agricultura y Ganadería Ecológica - Conservación y Sostenibilidad de los Medios Naturales de Producción: Suelo y Agua</p> <p>Más información</p>



IFAPA

VENTA DEL LLANO (Jaen)

Olive oil mill (industrial scale)



Junta de Andalucía



IFAPA

RANCHO DE LA MERCED (Cádiz)

Wine cellar



IFAPA ALAMEDA DEL OBISPO (Córdoba)



Index

1 . IFAPA

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2.1 Food Quality & Safety

2.2 Food Bioactives & Health

2.3 Stable Isotopes Applications/Collaborations

2.3.1 Food Trazability

2.3.2 Marine Ecosystems

2.3.3 Agroecosystems

2.3.4 Animal Trazability

Food Safety



Fermented Products

Biogenic amines



Fish

Biogenic amines

Total Volatile Basic Nitrogen



Beans (legumes)

Vicine/Convicine

Condensed tannins

Junta de Andalucía

Almonds

Amygdalin



Wines

Ethyl carbamate

Sulphites



Nuts & cereals

Mycotoxins



Diversification of production as a competitive strategy for wineries

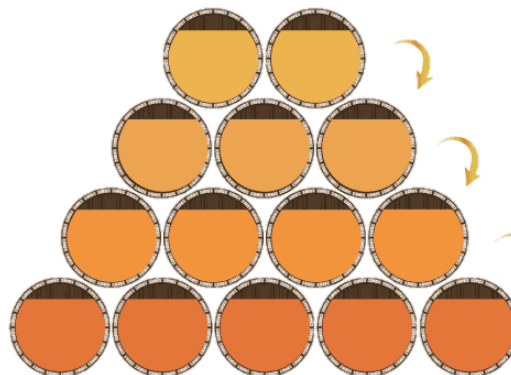


Appearance of new sparkling wines in Andalusia

↑↑↑ Added value



Rosé wines: an emerging market.
Attractive to new consumers



Study of brandy production process

Improve the
product
quality

Reduce
production
costs

Food Quality

Evaluating the profile of bioactives in food and examining how factors such as genetics, technology, processing, and storage modify them.



Pistachios



Chickpea



Mango



Purple carrot



Orange



Wines



Garlic and onion



Watermelon

🔗 Characterization of bioactive compounds in foods.



- 👁️ **Polyphenols & Sugars → Genetic Improvement**
- 👁️ **Characterization of healthy properties of varieties and link to new technological opportunities: canned foods, salads**
- 👁️ **Characterization of healthy properties of varieties and the effect of agronomic treatments**



🐞 Characterization of bioactive compounds in foods.



- ⊗ **Variety**
- ⊗ **Water stress**
- ⊗ **Farming System**

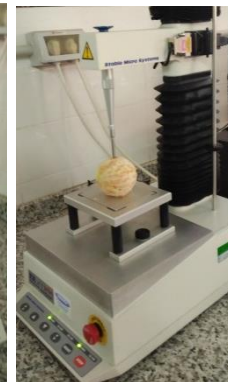


- 🐞 **Nitrogen reduction (fertilization)**
- 🐞 **Higher NaCl concentration water**



- ⊗ **Water stress**

🔗 Characterization of bioactive compounds in foods.



Antioxidants



Polyphenols

Black garlic & Black onion



0.50-1 €/kg



50-70 €/kg



T (70-80 °C)
HR 85-90%
20-45 days

Index

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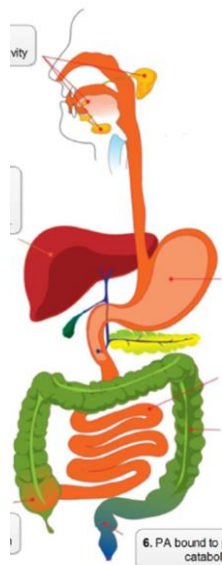
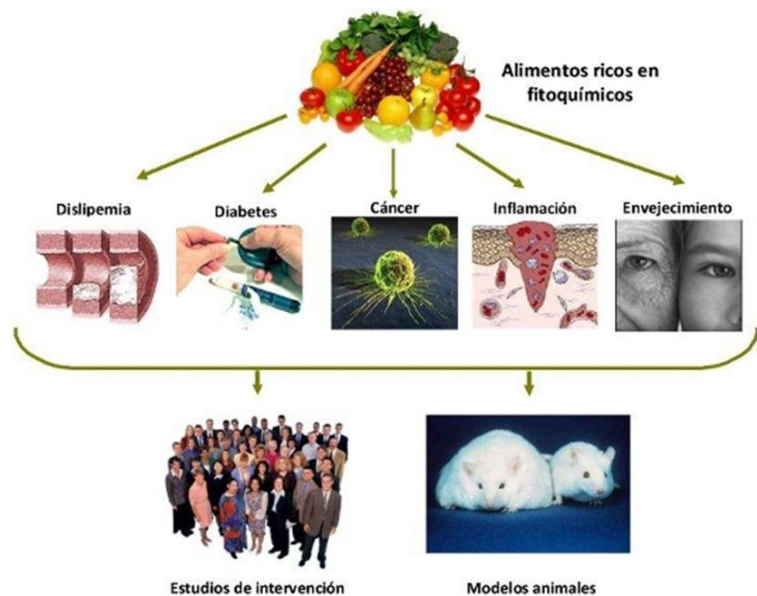
2.3.1 Food Trazability

2.3.2 Marine Ecosystems

2.3.3 Agroecosystems

2.3.4 Animal Trazability

Studies on bioavailability and health effects (humans and animal intervention studies).



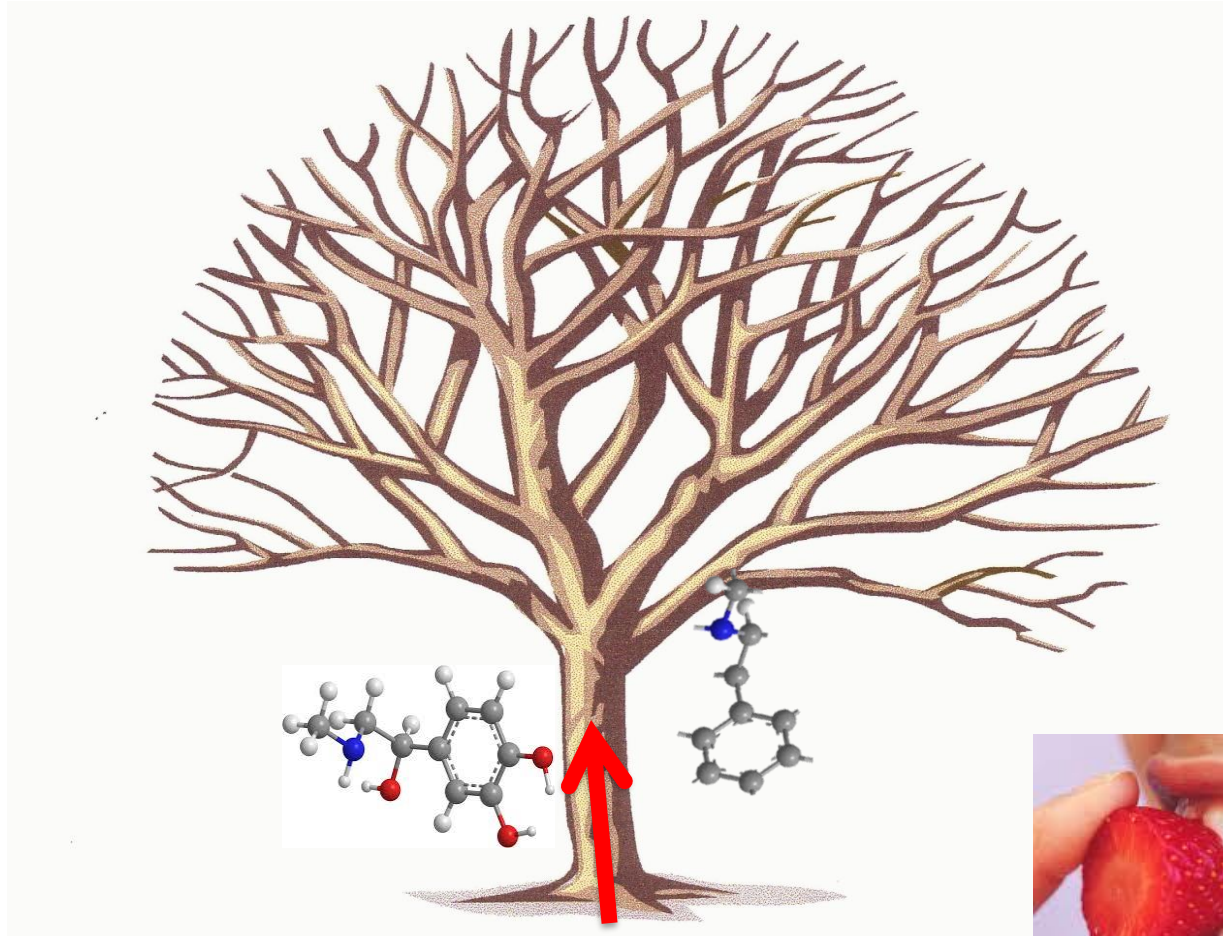
Life support.

The antioxidant power of pomegranate juice:

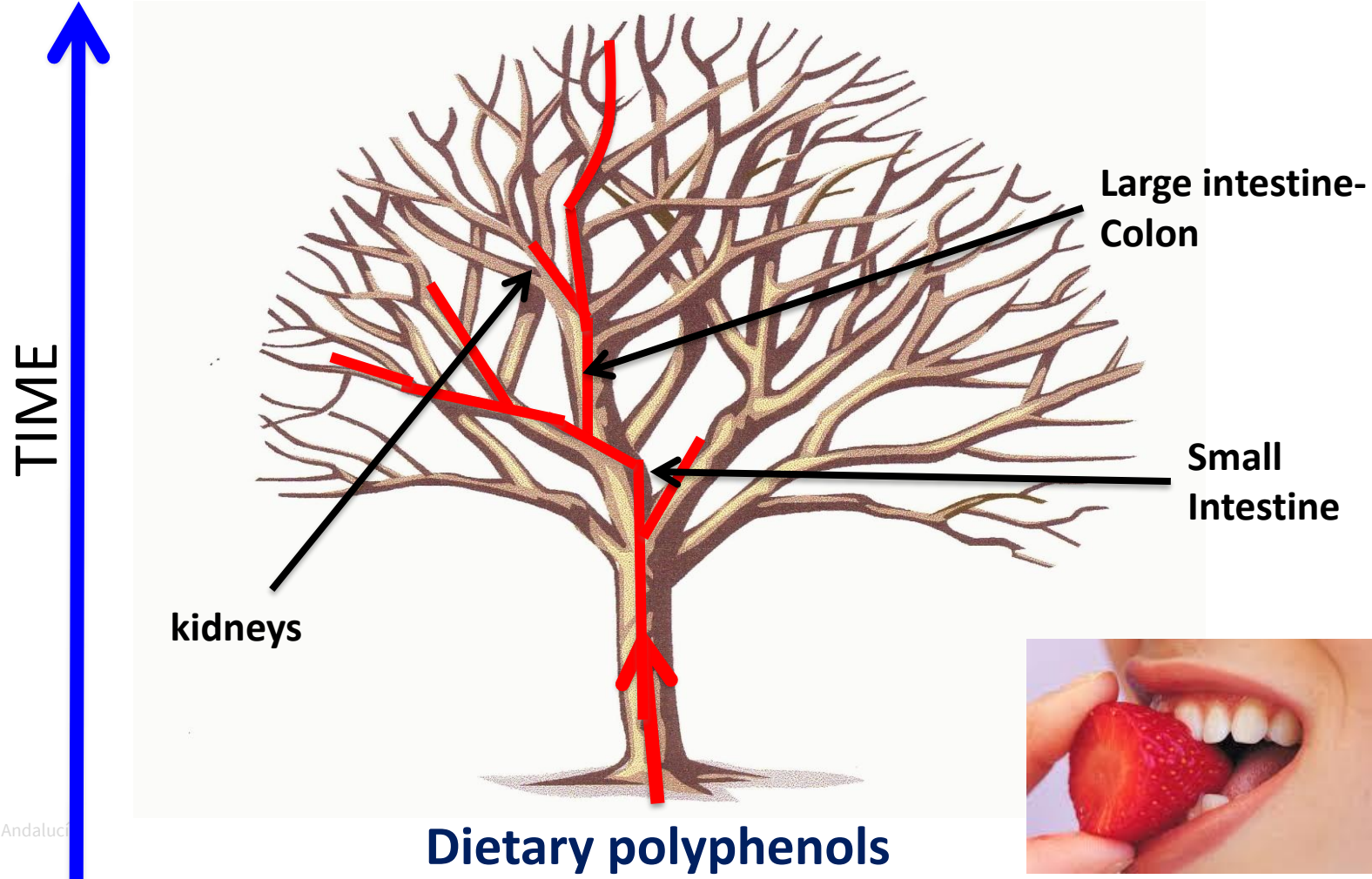


New foods: functional beverages (encapsulation).

How do they exert their protective effect?



How do they exert their protective effect?



How do they exert their protective effect?

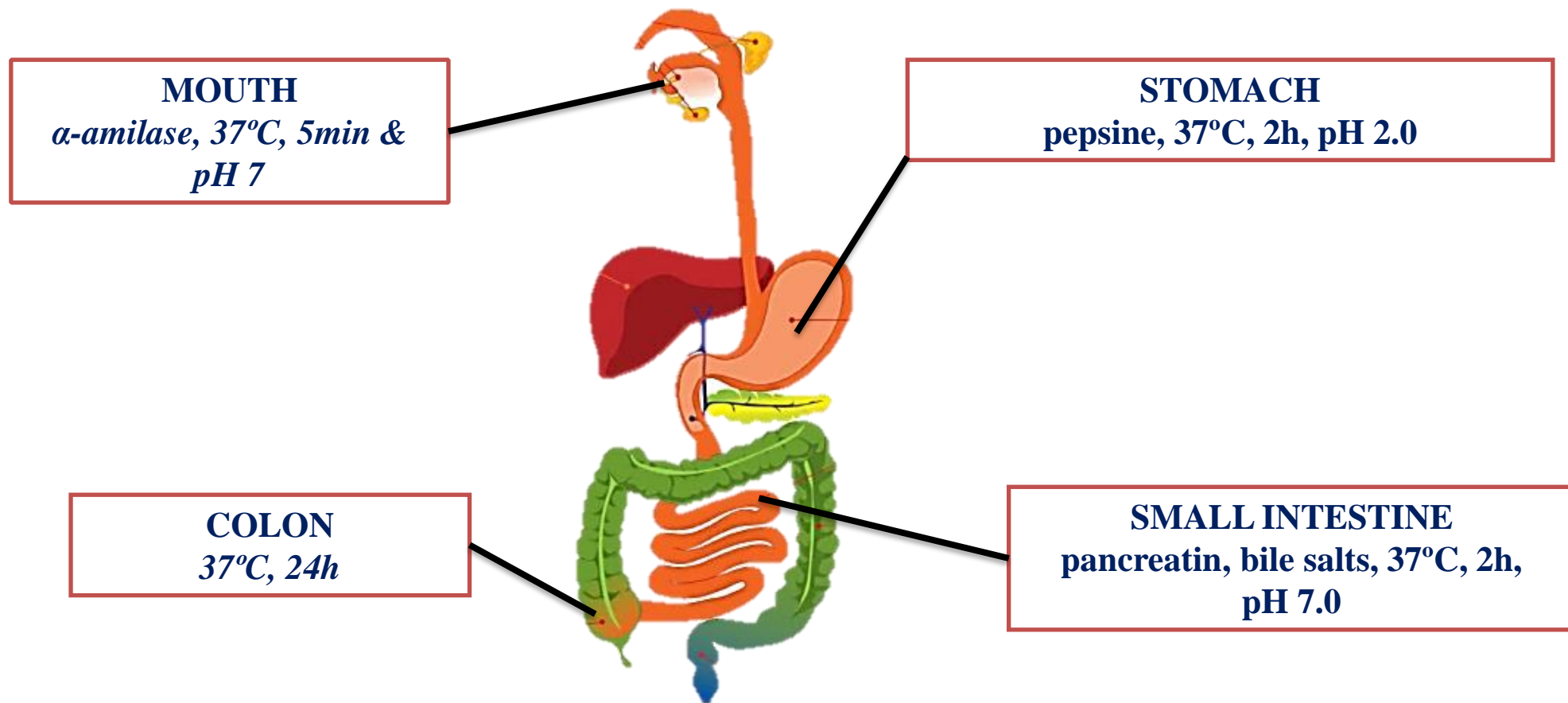
Conversion of antioxidants into metabolites by the body



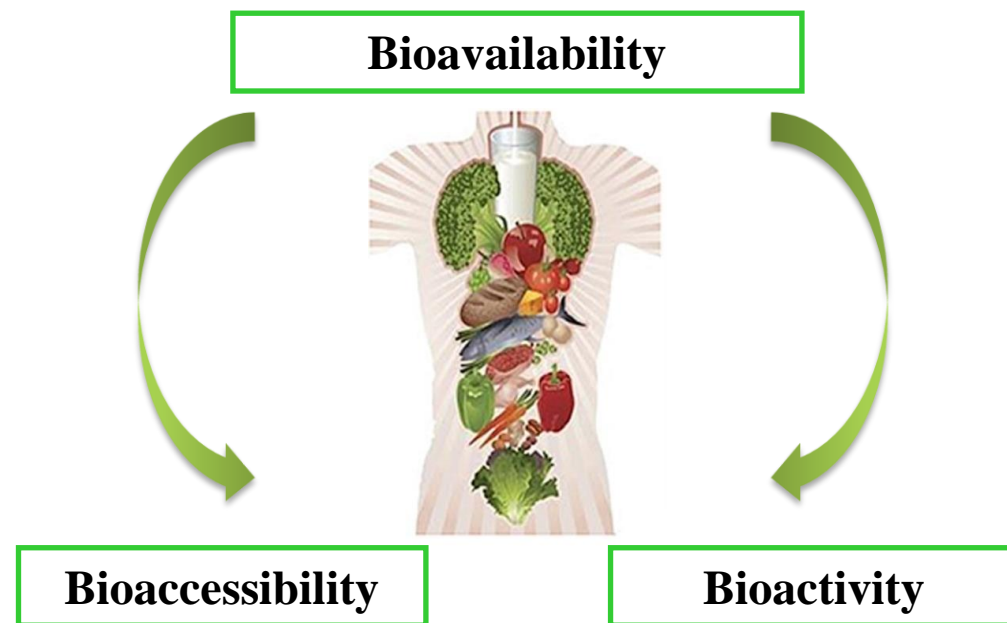
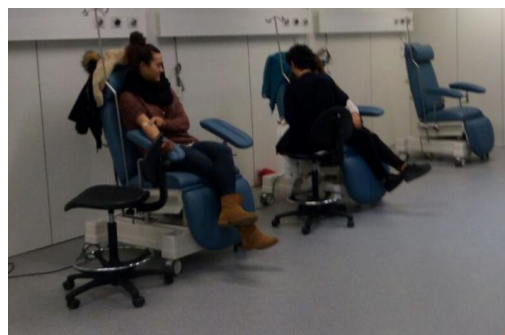
**Five years ago
($< 10\%$ metabolites)**

**Most of the metabolites come
from the action of the colonic
microbiota ($>90\%$)**

How do they exert their protective effect?



🔗 Studies on bioavailability and health effects



Studies on bioavailability and health effects

Studying the potential health benefits of consuming black garlic on cardiovascular risk parameters



Black Garlic

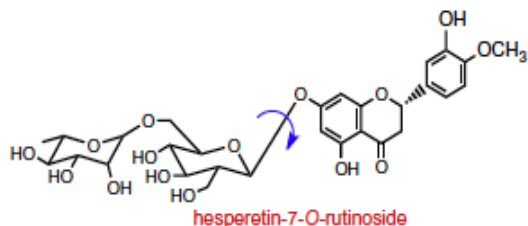


Hypercholesterolemic obese volunteers

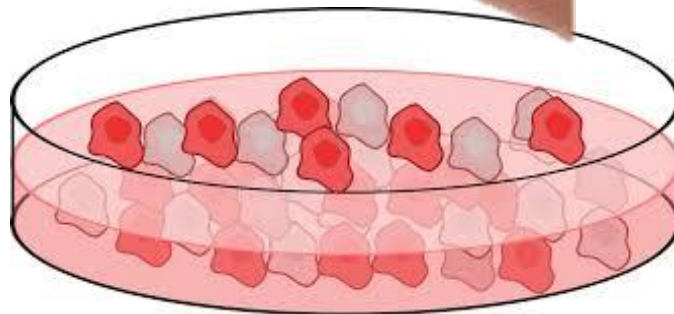
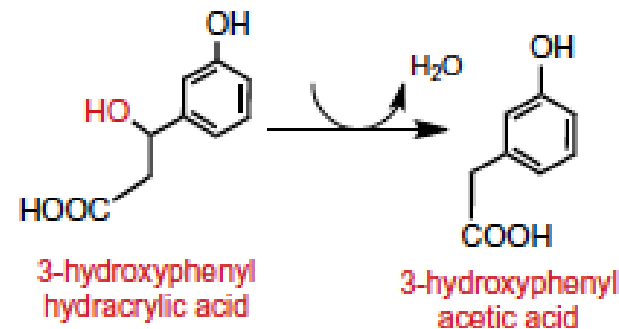
Effects on Cardiovascular Risk Parameters

- Cholesterol
- Blood pressure
- Lipidic profile
- Bioavailability

How do they exert their protective effect?



Wrong compounds



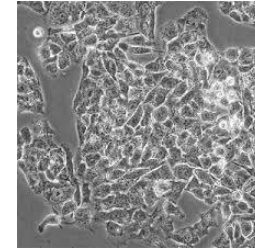
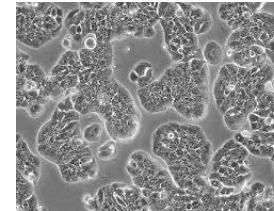
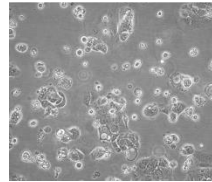
!!!PHYSIOLOGICAL
CONCENTRATIONS!!!

How do they exert their protective effect?

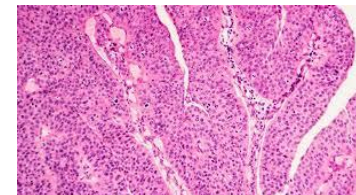
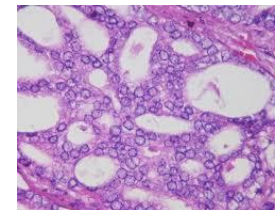
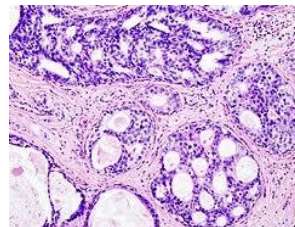
ASSESSMENT OF TRANSPORT AND METABOLISM/BIOACTIVITY



Intestine cancerous epithelial cells (Caco-2, HT29) and hepatic cancerous cells



Breast, bladder and prostate cancerous cells



Index

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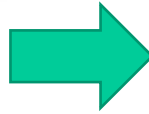
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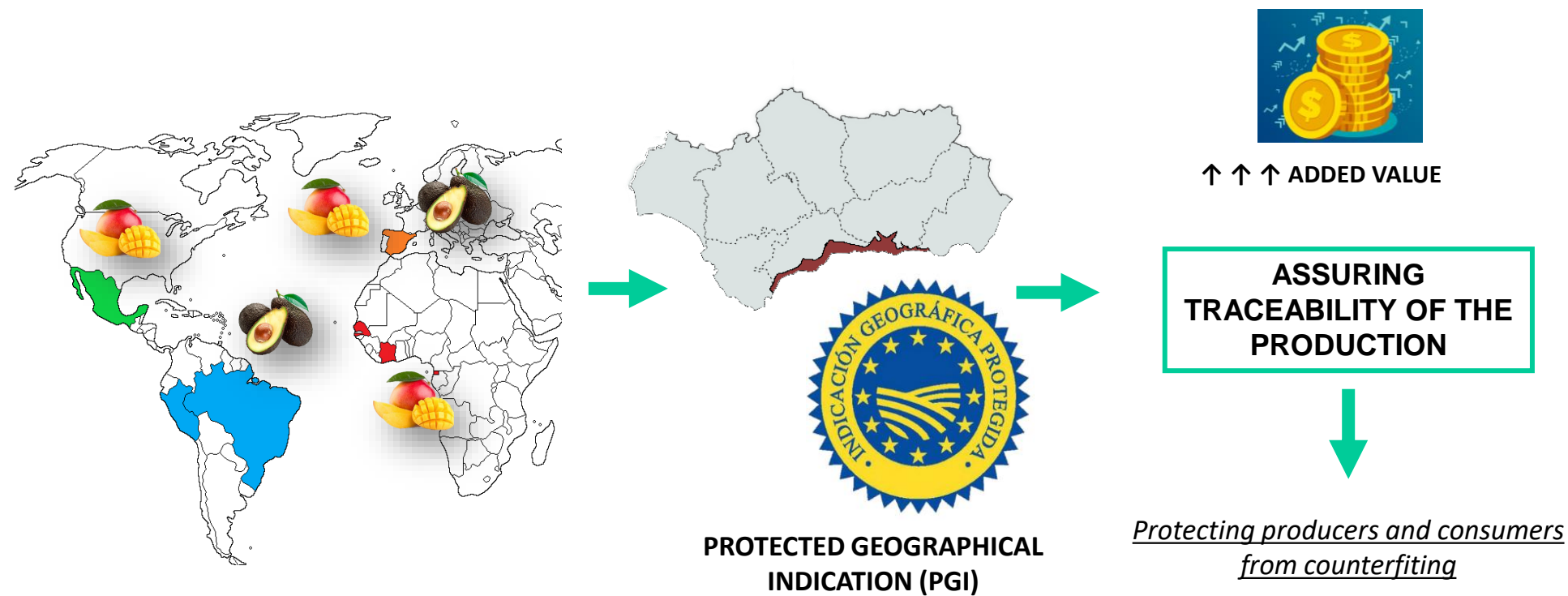
2.3.4 Animal Trazability

*Health promoting
properties*

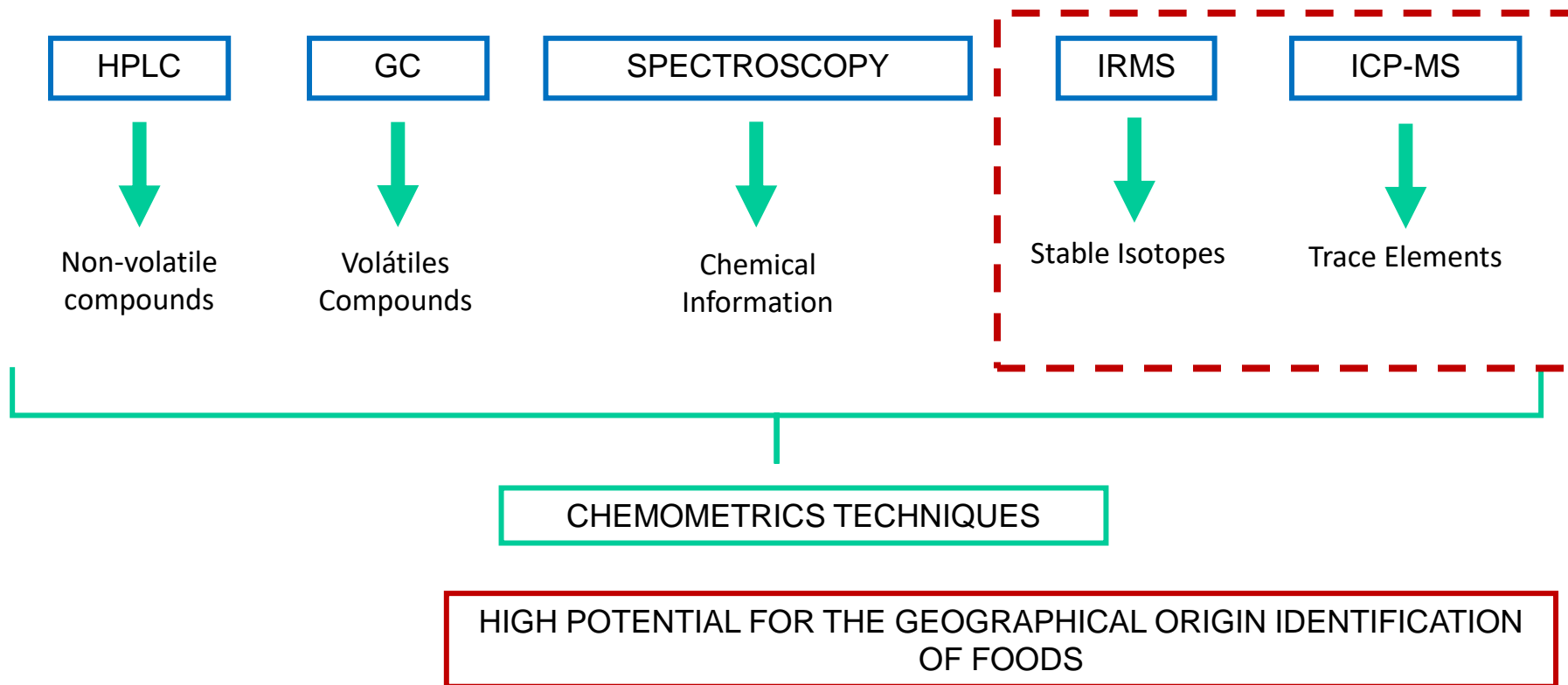


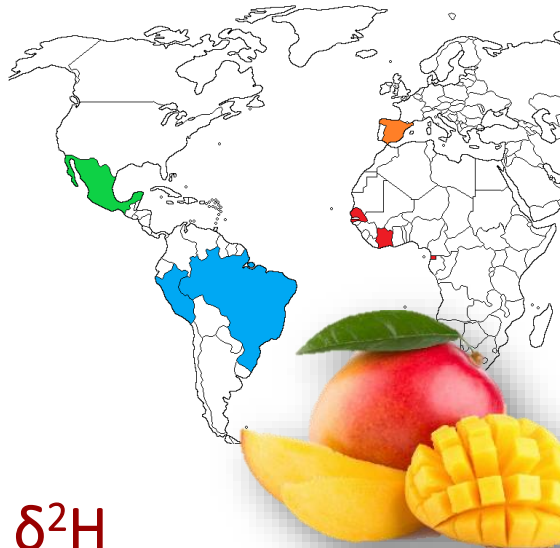
**STRATEGIC POSITION
FOR THE EXPORTS TO
THE EUROPEAN
MARKET VS OTHER
ORIGINS**



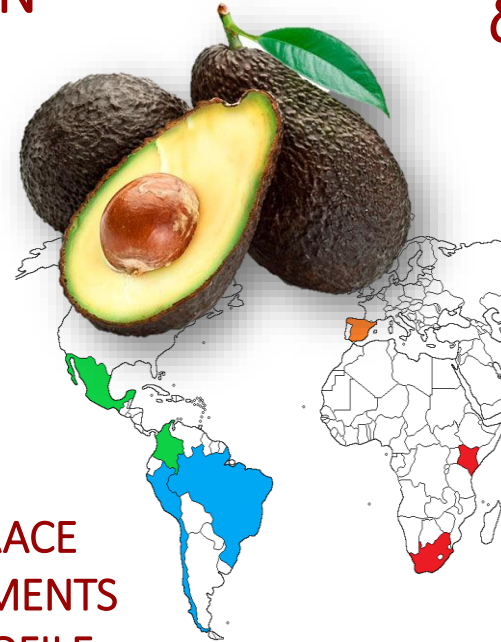


ANALYTICAL TECHNIQUES WIDELY USED WITH TRACEABILITY PURPOSES



$\delta^{18}\text{O}$  $\delta^2\text{H}$ $\delta^{15}\text{N}$

TRACE
ELEMENTS
PROFILE

 $\delta^{13}\text{C}$ $\delta^{34}\text{S}$ 



Sampling and Analysis



Junta de Andalucía

Consejería de Agricultura, Ganadería,
Pesca y Desarrollo Sostenible

INSTITUTO DE INVESTIGACIÓN
Y FORMACIÓN AGRARIA Y PESQUERA



Asociación Española
de Tropicales



Mango and Avocado Sampling +
Stable Isotopes Analysis



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Consejería de Agricultura, Ganadería,
Pesca y Desarrollo Sostenible

INSTITUTO DE INVESTIGACIÓN
Y FORMACIÓN AGRARIA Y PESQUERA

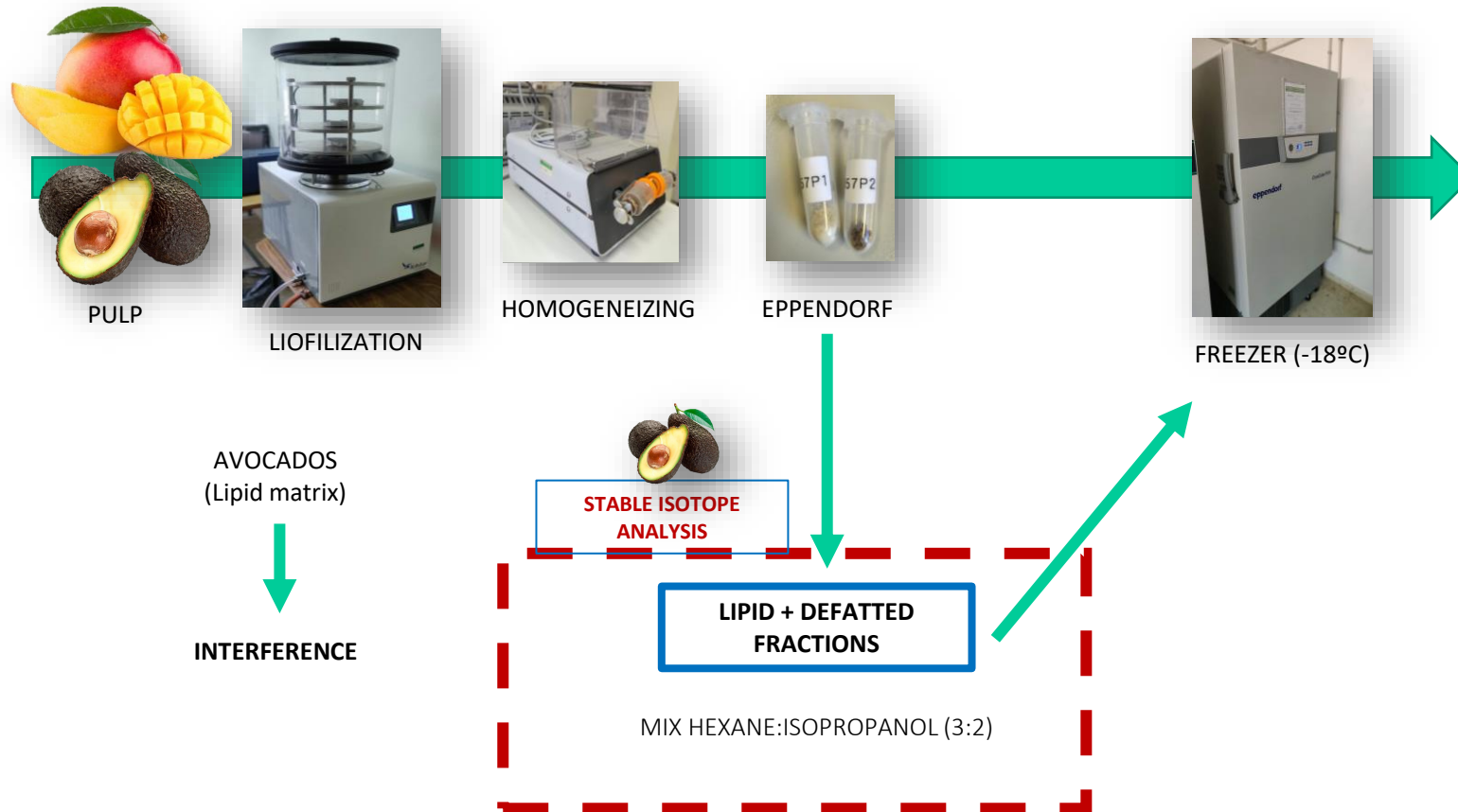


FONDAZIONE
EDMUND
MACH



Stable Isotopes + Trace Elements
Analysis

SAMPLE PREPARATION



STABLE ISOTOPES ANALYSIS



Weighing pulp



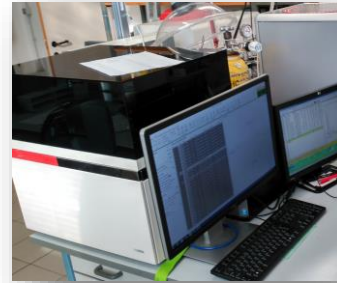
EA-IRMS

 $\delta^{13}\text{C}$, $\delta^{15}\text{N}$,
 $\delta^{34}\text{S}$ TC-IRMS
(FLASH) $\delta^2\text{H}$, $\delta^{18}\text{O}$

STABLE ISOTOPES ANALYSIS



Weighing pulp



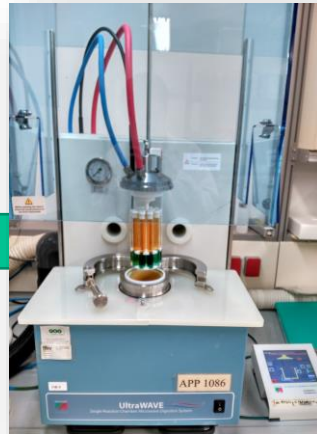
EA-IRMS



TC-IRMS

**DEFATTED
FRACTION** $\delta^{13}\text{C}_p$, $\delta^{15}\text{N}_p$,
 $\delta^{34}\text{S}_p$ **LIPID FRACTION** $\delta^{13}\text{C}_L$ $\delta^2\text{H}_p$, $\delta^{18}\text{O}_p$ $\delta^2\text{H}_L$ $\delta^{18}\text{O}_L$

TRACE ELEMENT PROFILE



Microwaves assisted
acid digestion



Element profile analysis
(ICP-MS)

53 elements

TRACEABILITY OF MANGO

CLASSIFICATION RESULTS

Mean overall BER	Class	Mean class Error
0.04 ± 0.01	Foreign	0.07 ± 0.02
	Spain	0.00 ± 0.00

→ STABLE ISOTOPES

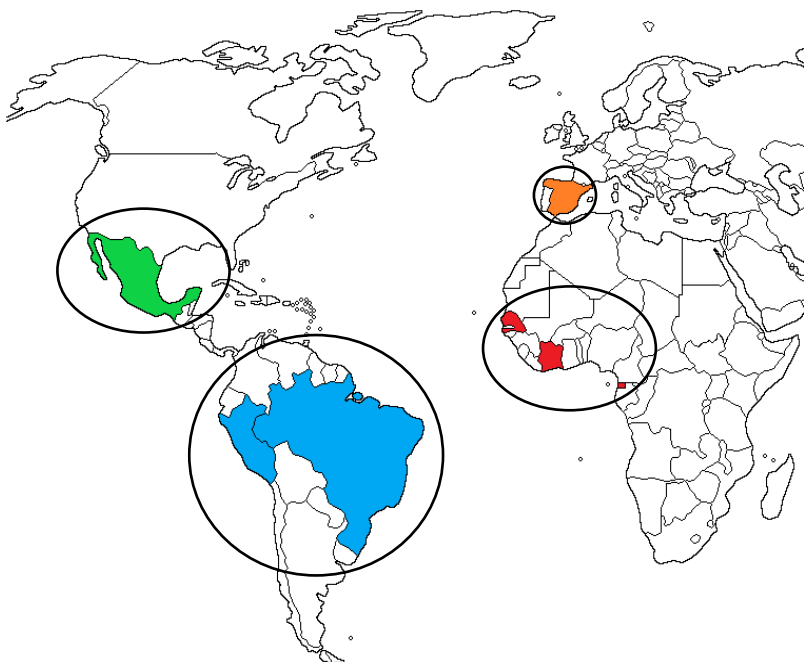
Mean overall BER	Class	Mean class Error
0.04 ± 0.01	Foreign	0.06 ± 0.00
	Spain	0.02 ± 0.00

→ MULTIELEMENTAL PROFILE

Mean overall BER	Class	Mean class Error
0.01 ± 0.00	Foreign	0.03 ± 0.00
	Spain	0.00 ± 0.00

→ STABLE ISOTOPES
+
MULTIELEMENTAL PROFILE

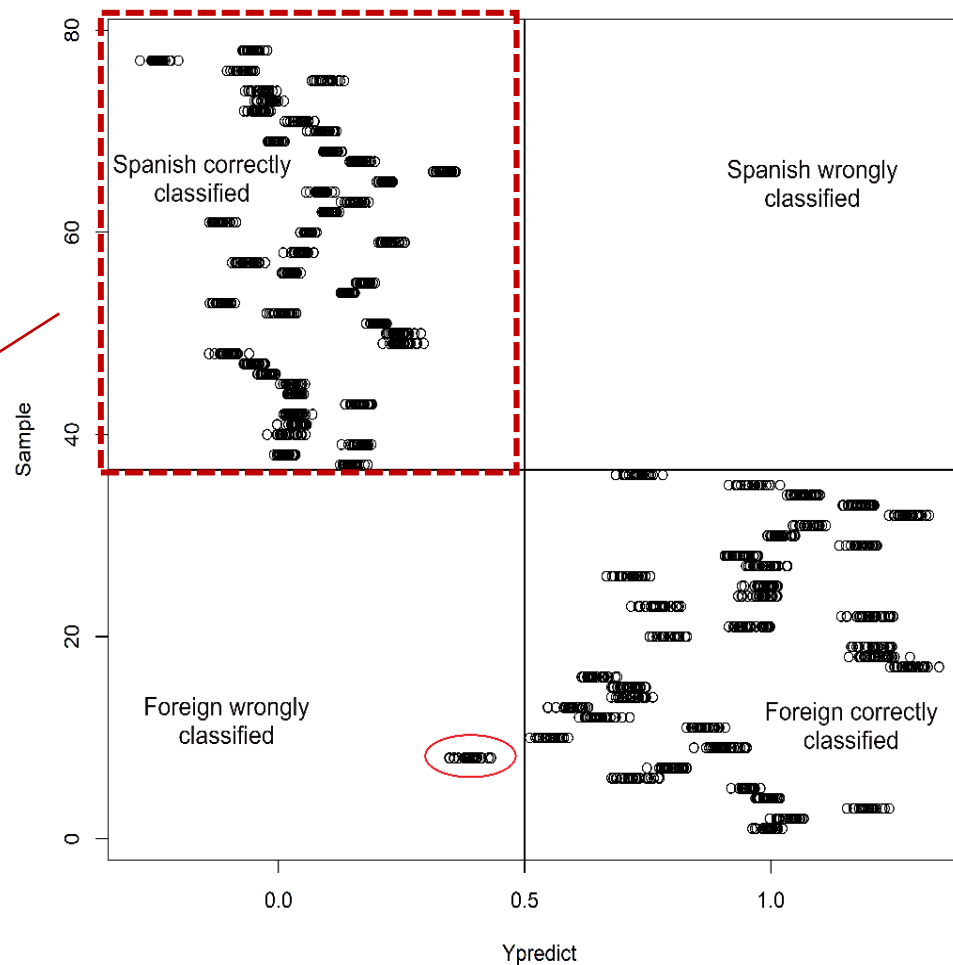
30 submodels PLS-DA (double cross-validation)



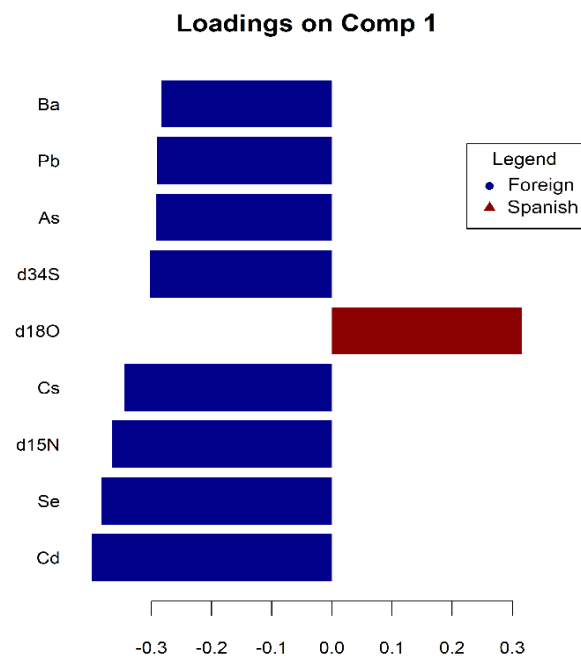
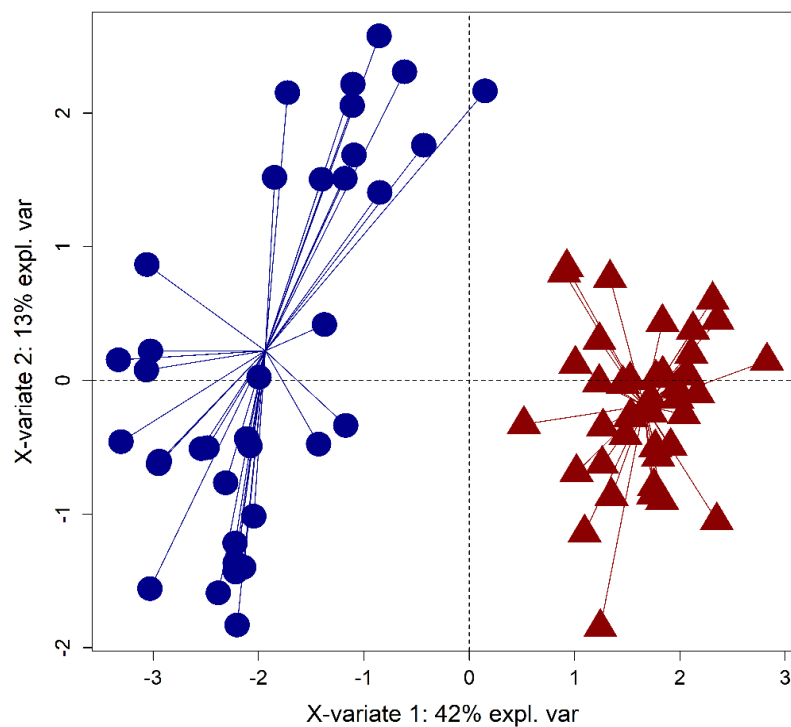
CLASSIFICATION RESULTS

STABLES ISOTOPES
+
MULTIELEMENTAL PROFILE

SENSITIVITY: 100 %



CLASSIFICATION RESULTS

**MARKERS
(CLASSIFICATION MODEL)**

**Cd, Se, Cs, As,
Pb and Ba**

**$\delta^{15}\text{N}$, $\delta^{18}\text{O}$ and
 $\delta^{34}\text{S}$**



Contents lists available at [ScienceDirect](http://www.sciencedirect.com)

Food Control

journal homepage: www.elsevier.com/locate/foodcont



Tracing the geographical origin of Spanish mango (*Mangifera indica* L.) using stable isotopes ratios and multi-element profiles

J.M. Muñoz-Redondo^{a,*,}, D. Bertoldi^b, A. Tonon^c, L. Ziller^c, F. Camin^{c,d}, J.M. Moreno-Rojas^{a,*}

^a Department of Food Science and Health, Andalusian Institute of Agricultural and Fisheries Research S/n., 14071, Córdoba, Spain

^b Department of Experimental and Technological Services, Technology Transfer Centre, Fondazione Edmund Mach, Via E. Mach 1, 38096, San Michele all'Adige, Italy

^c Department of Food Quality and Nutrition, Research and Innovation Centre, Fondazione Edmund Mach, Via E. Mach 1, 38096, San Michele all'Adige, Italy

^d Centre Agriculture Food Environment C3A, University of Trento, San Michele all'Adige, Trento, Italy



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Multi-element and stable isotopes characterization of commercial avocado fruit (*Persea americana* Mill) with origin authentication purposes

J.M. Muñoz-Redondo^a, D. Bertoldi^b, A. Tonon^c, L. Ziller^c, F. Camin^{c,d,e}, J.M. Moreno-Rojas^{a,*}

^a Department of Food Science and Health, Andalusian Institute of Agricultural and Fisheries Research and Training (IPAPA), Alameda del Obispo, Avda. Menéndez Pidal, s/n., 14071, Córdoba, Spain

^b Department of Experimental and Technological Services, Technology Transfer Centre, Fondazione Edmund Mach, Via E. Mach 1, 38096, San Michele all'Adige, Italy

^c Department of Food Quality and Nutrition, Research and Innovation Centre, Fondazione Edmund Mach, Via E. Mach 1, 38096, San Michele all'Adige, Italy

^d Centre Agriculture Food Environment C3A, University of Trento, San Michele all'Adige, Trento, Italy

^e International Atomic Energy Agency, Wagramer Strasse 5, Vienna A, 1400, Austria

“IRMS for the characterization and traceability of the carcass and products of the Iberian pig based on the diet”



DEHESA (Open field)

Acorn + grass

BELLOTA



FARMS

Feed

CEBO

DEHESA
Acorn + grass + feed
CEBO DE CAMPO



BELLOTA

80-100 Euro/Kg

CEBO DE CAMPO

25-35 Euro/Kg

CEBO

15-25 Euro/Kg

$\delta^{13}\text{C}$ FAT

FARMS
Feed
CEBO



DEHESA
BELLOTA



DEHESA
Acorn + grass + feed
CEBO DE CAMPO

$\delta^{15}\text{N}$ Protein

FARMS
Feed
CEBO



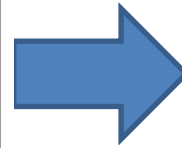
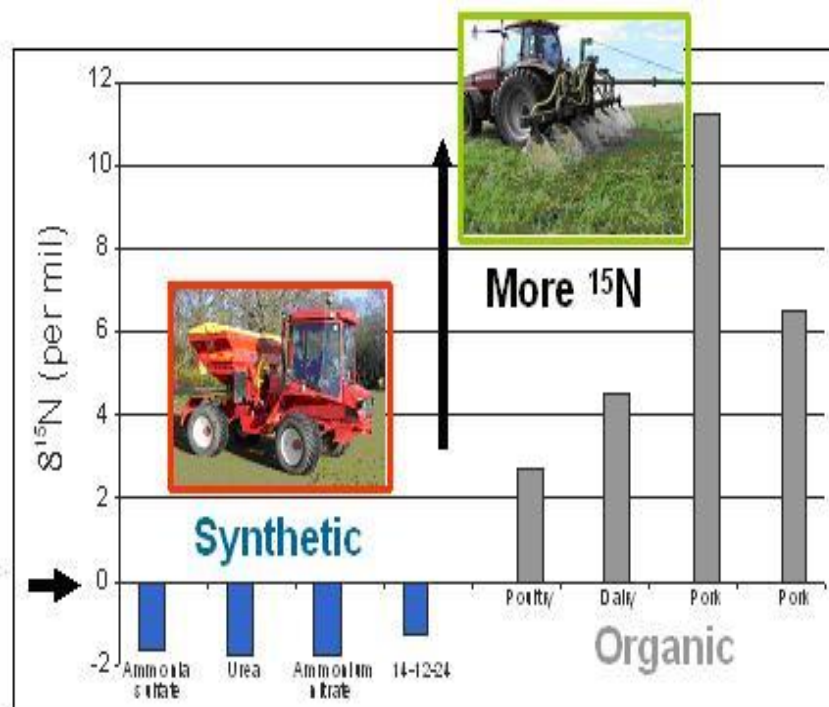
DEHESA
BELLOTA



DEHESA
Acorn + grass + feed
CEBO DE CAMPO

Using Nitrogen Stable Isotopes to Authenticate Organically and Conventionally Grown Vegetables: A New Tracking Framework

Fertilization Regime



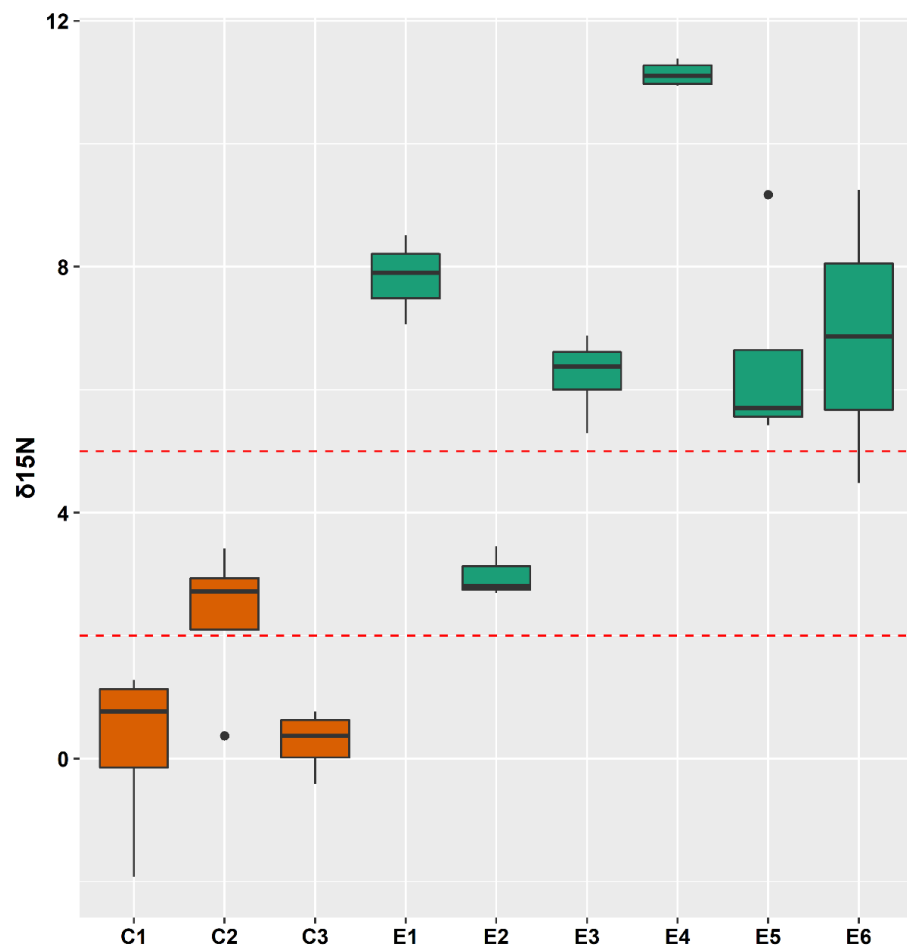
$\delta^{15}\text{N}$



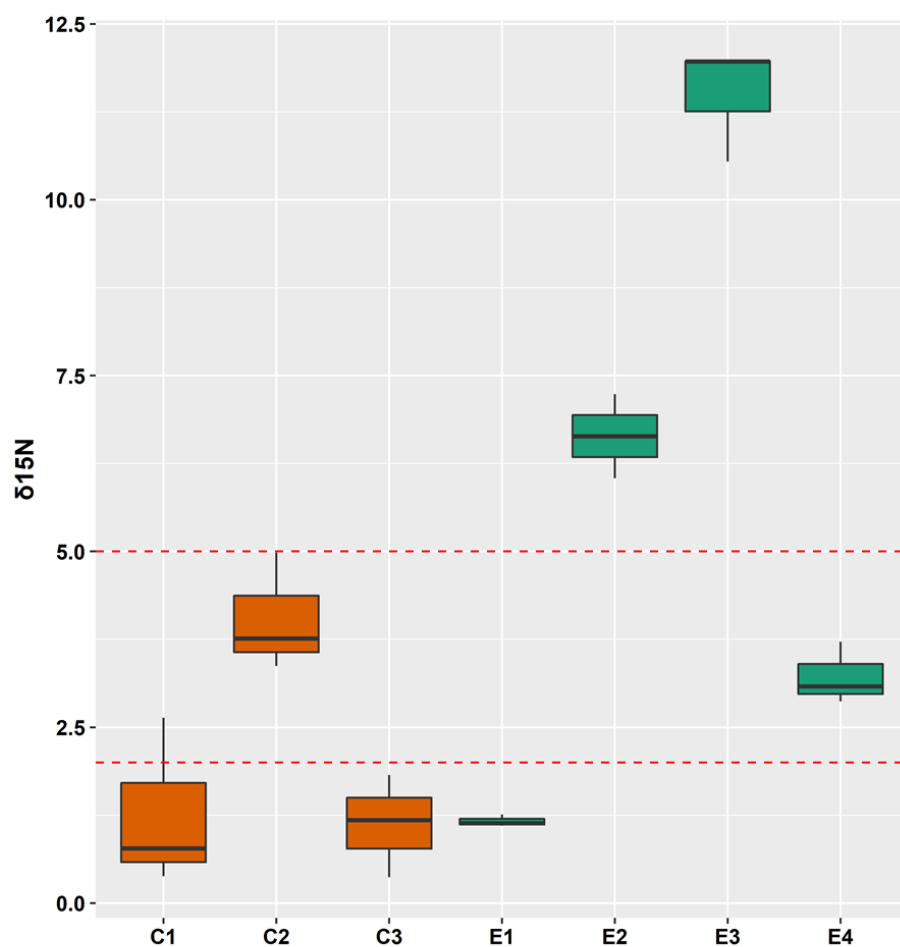
$\delta^{15}\text{N}$

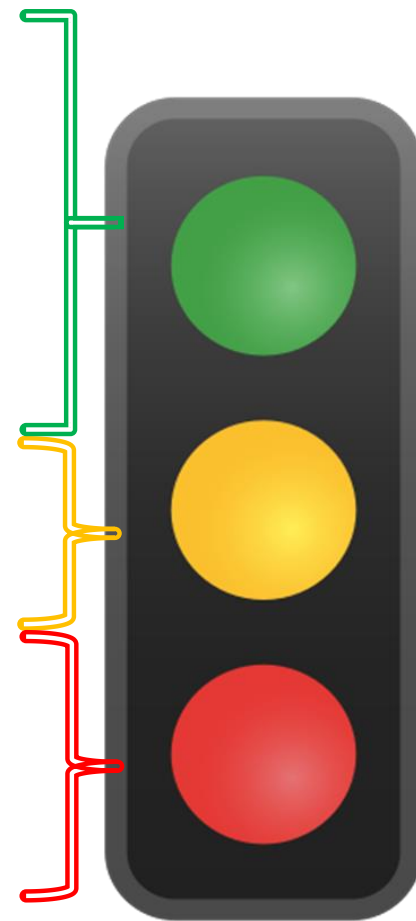
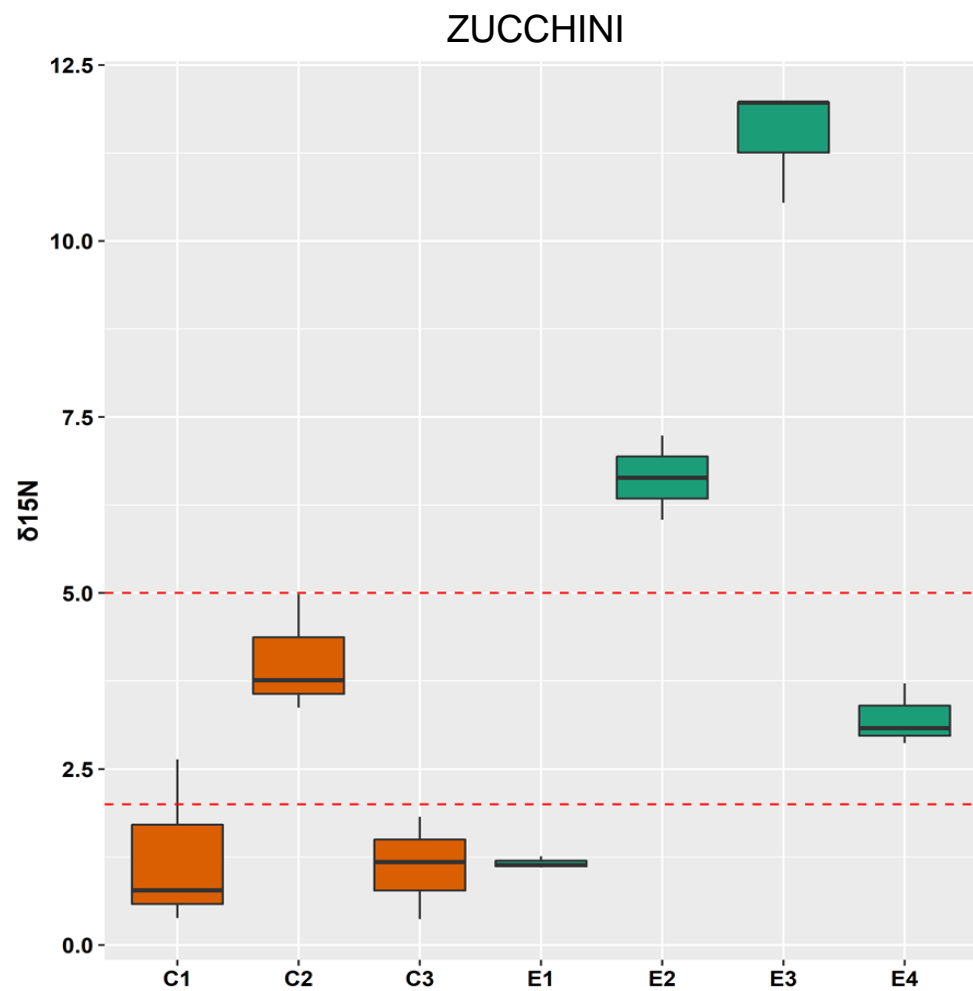


TOMATO




ZUCCHINI





*Article*

Using Nitrogen Stable Isotopes to Authenticate Organically and Conventionally Grown Vegetables: A New Tracking Framework

José Manuel Muñoz-Redondo *, José Carlos Montenegro and José Manuel Moreno-Rojas * 

Department of Agroindustry and Food Quality, Andalusian Institute of Agricultural and Fisheries Research and Training (IFAPA), Alameda del Obispo Avda, Menéndez Pidal s/n, 14004 Córdoba, Spain

* Correspondence: josem.munoz.redondo@gmail.com (J.M.M.-R.);
josem.moreno.rojas@juntadeandalucia.es (J.M.M.-R.)

Index

1 . IFAPA

2. Department of Agroindustry and Food Quality

2.1 Food Quality & Safety

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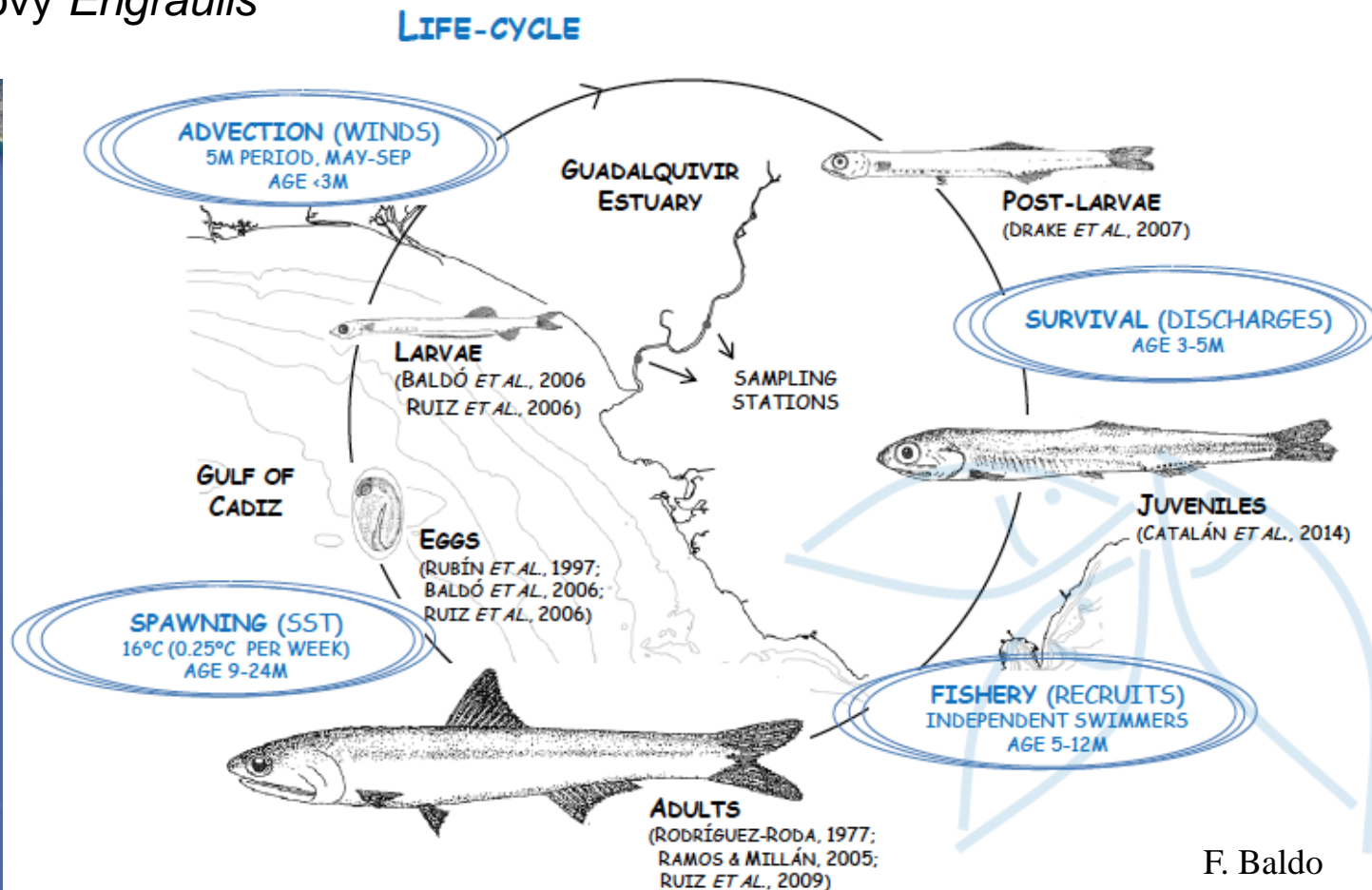
2.3.4 Animal Trazability

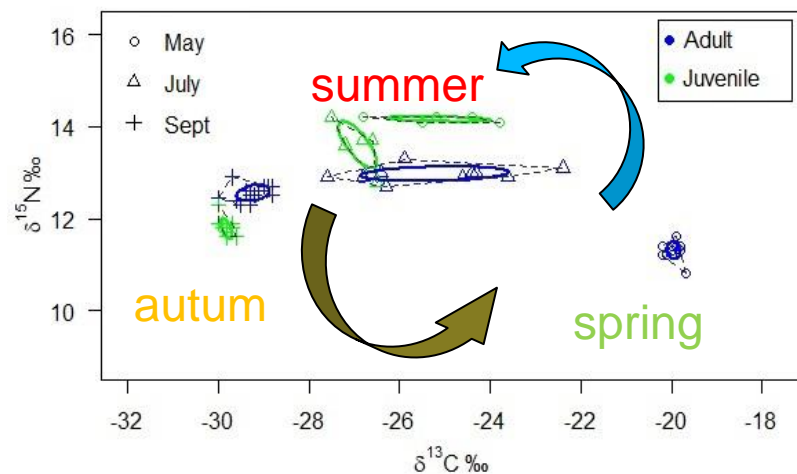
Coastal ecosystems of the Gulf of Cadiz...

Guadalquivir estuary...

Complex life cycle of the anchovy *Engraulis encrasicolus*

... very important for many commercial species (prawns, shrimps, sole, bream, bass,...) and pelagic species (anchovy and sardine)

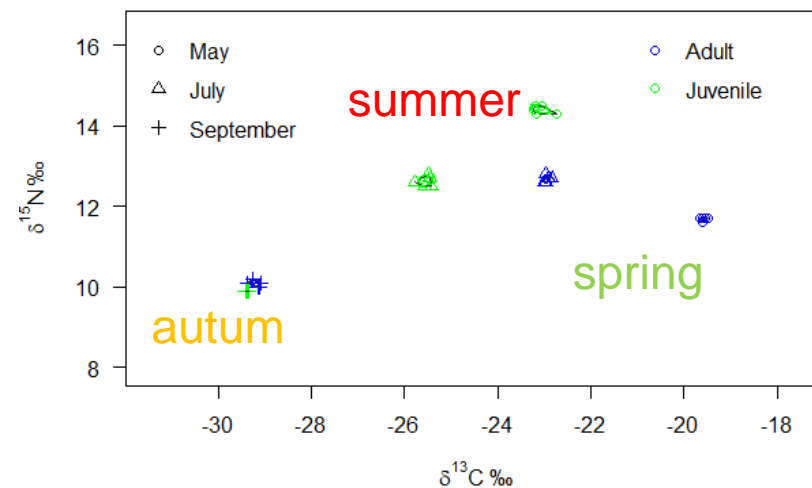
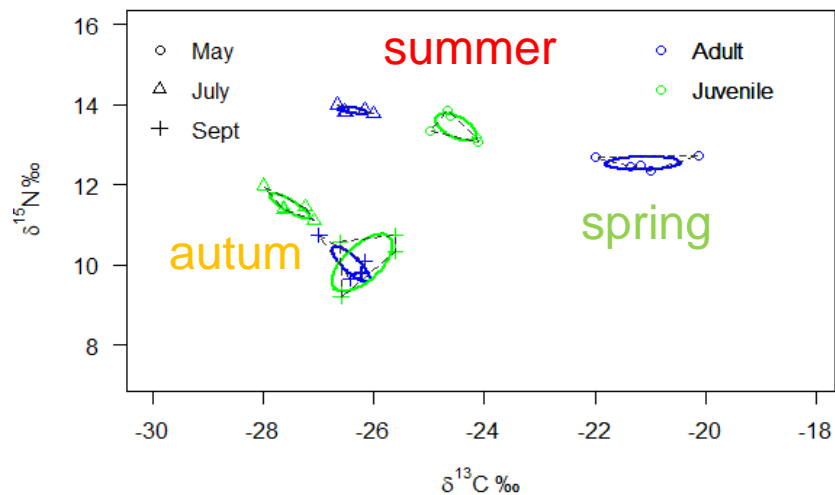


SIA-SIBER 2018 *Mesopodopsis slabberi*

Detection of seasonal changes in the primary carbon source (C) and trophic level (N) in their diet:

Spring => winter food in the Gulf of Cadiz

Summer-Autum => Guadalquivir estuary

SIA-SIBER 2020 *M.slabberi*SIA-SIBER 2019 *M.slabberi*

Index

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2.2 Food Bioactives & Health

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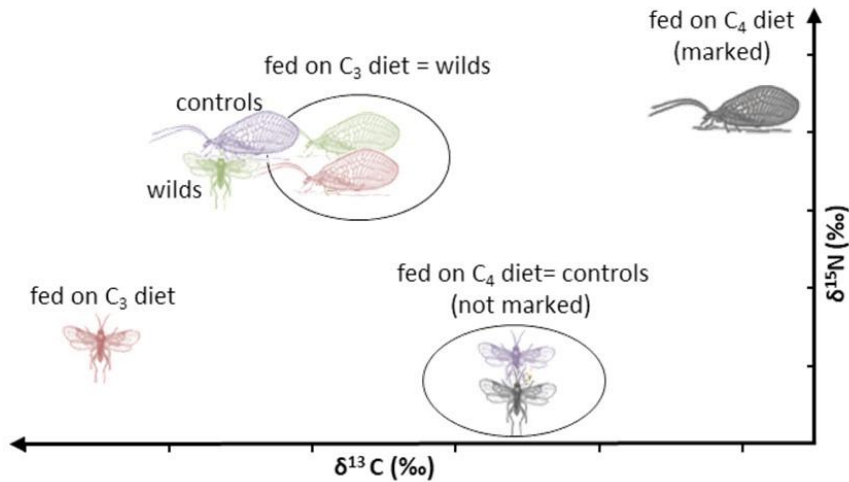
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2.3.4 Animal Trazability

Isotopic marking of natural enemies fed on C₄ honey for habitat management studies in agroecosystems



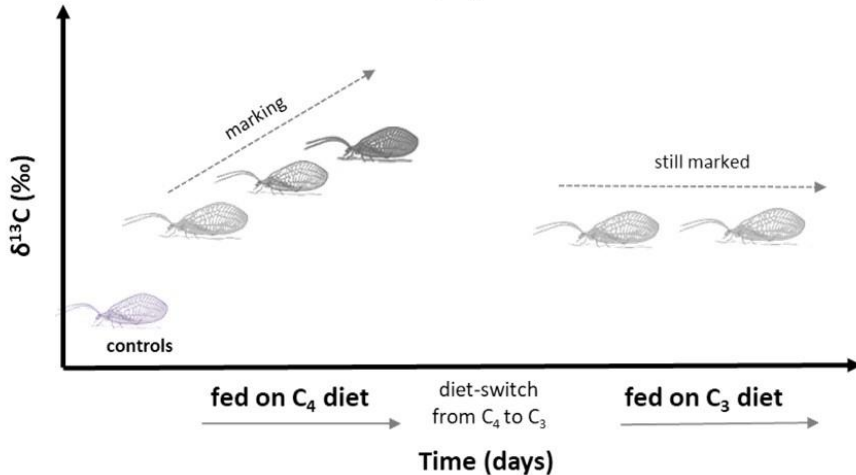
2 aphid predators
(green lacewing y parasitic wasp)

C₄ diet (sugar-cane)
C₃ diet (multi-flower honey)

Green lacewings fed on
C₄ vs C₃

➔ $\delta^{13}\text{C}$ ↑↑

Similar $\delta^{15}\text{N}$ values for both wild populations indicated both predators had similar prey, but different vegetal resources (different $\delta^{13}\text{C}$ values).



Sugarcane honey is a natural and reliable marker to track populations of green lacewings in the field

Index

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2.2 Food Bioactives & Health

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2.3.2 Marine Ecosystems

2.3.3 Agroecosystems

2.3.4 Animal Trazability

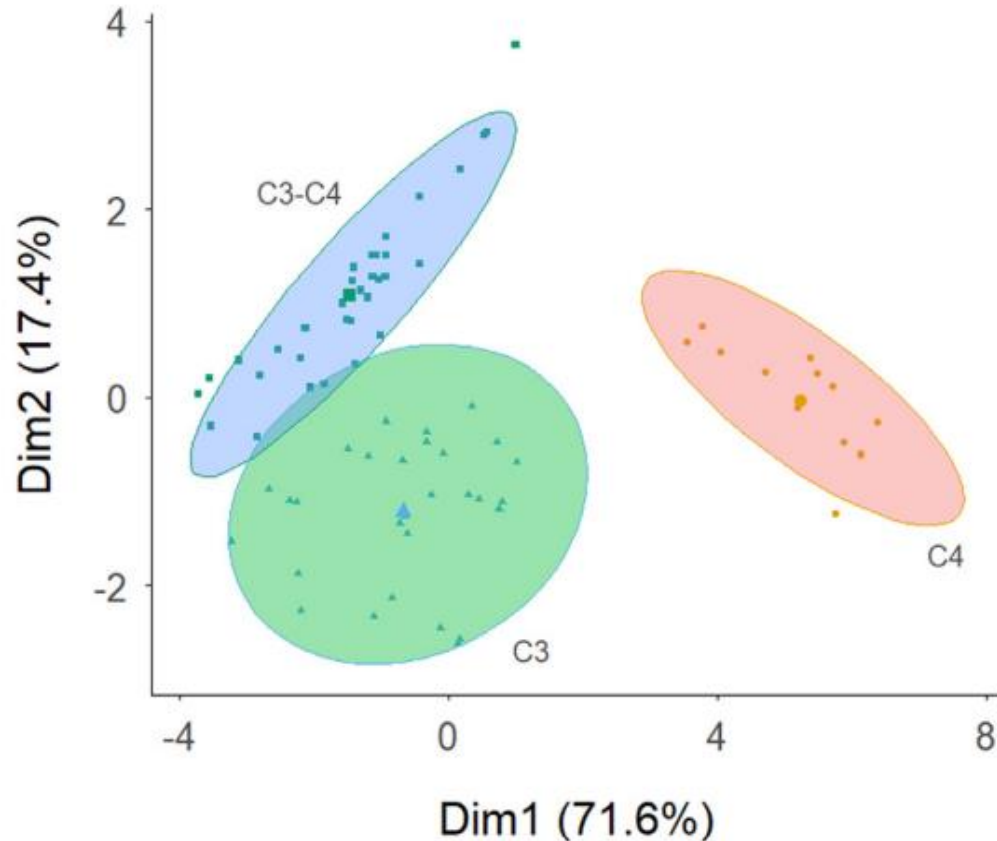
Effects of releases and supplementary feeding supplies in wild boar

- Genetic introgression
- New diseases



- Agglomeration of animals
- Diffusion of diseases between the same species or different species
- Greater reproductive potential

$\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of wild board cluster analysis revealed three different feeding groups.

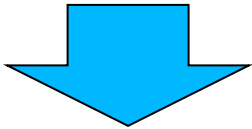


The results point towards different sustainable management strategies based on the following findings:

- ✓ Significant differences in isotopic values between farms
- ✓ Chronological changes in isotopic values within farms

MORE FOOD.... MORE INDIVIDUALS

- Lower juvenile mortality
- Females come into heat younger
- Even twice a year
- Population increase



Access to urban areas, zoonoses, ...



Thank you for your attention

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