

# Drying

## *general aspects*

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# Outline

## 1. MARKET GLOBALIZATION NEEDS AND DEMANDS

## 2. FOOD DRYING

- » An overview
- » Quality and safety of food
- » Impact on the production costs
- » Type of drying technologies
- » Impact of drying on product quality traits
- » Consumer perception of dried food quality
- » Changes in color
  - > *The enzymatic browning*
  - > *The non-enzymatic browning*
- » Chemical composition among species and cultivars
- » Energy efficiency
  - > *General aspects*
  - > *A quality by design approach*
- » Innovative drying technology
  - > The smart drying
  - > Vis/NIR spectroscopy

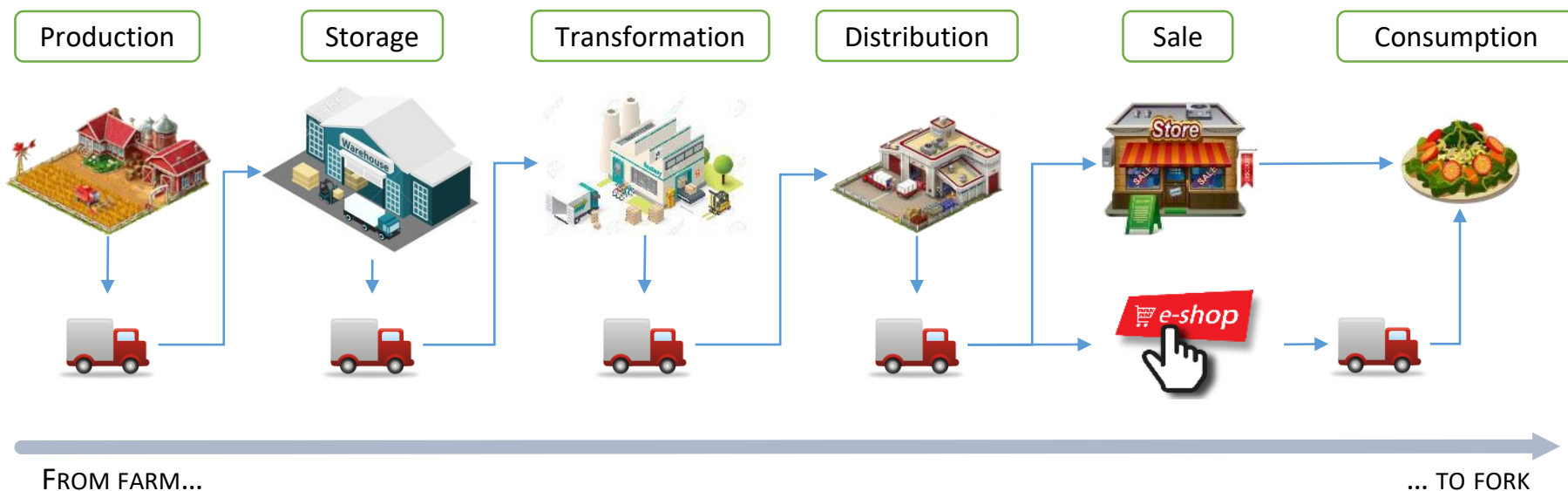
# Learning Outcomes

- » Enhance technical knowledge required to optimize process and technologies to organic raw materials of organic production and the factors that need to be taken into account
- » Develop knowledge and skills on food quality and safety and main criteria applied to organic produce
- » Implement modern sustainability concepts



## MARKET GLOBALIZATION NEEDS AND DEMANDS

Market globalization ensures constant availability of many foods regardless of their production date. Innovation in both products and processes across the entire agri-food chain yield foods with improved shelf-life, organoleptic quality, nutritional value, safety and healthfulness.





## FOOD DRYING – AN OVERVIEW

Drying may significantly extend the shelf-life and nutritional quality of fruit, vegetables, spices and herbs as well as meat and fish.



**FRUITS**



**VEGETABLES**



**SPICES AND HERBS**



**MEAT**



**FISH**



## FOOD DRYING – AN OVERVIEW

### DRYING OF FOOD CONSISTS OF THREE STEPS...



PRE-DRYING  
PROCESSING



DRYING



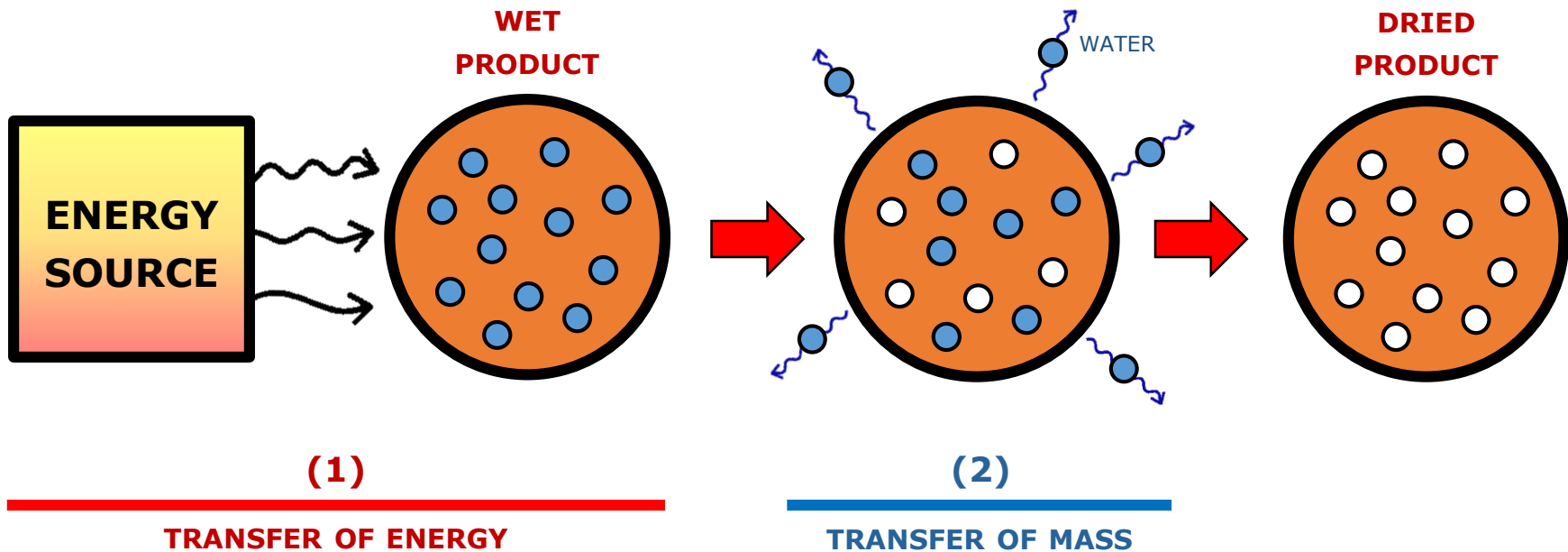
POST-DRYING  
HANDLING



## FOOD DRYING – AN OVERVIEW

Drying consists in two simultaneous processes

- (1) transfer of energy from an energy source to a wet solid
- (2) transfer of mass as water vapor

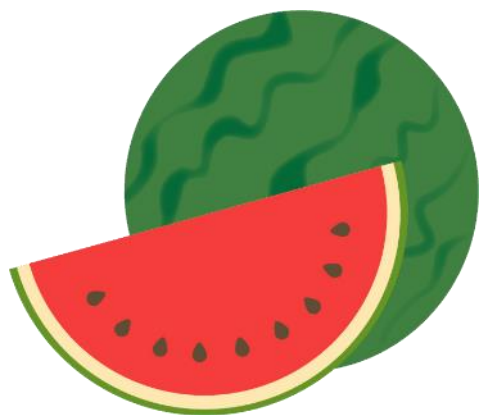


# Drying - general aspects



## FOOD DRYING – QUALITY AND SAFETY OF FOOD

Fruits and vegetables are rich in water



Watermelon

**93%**

water



Salad  
Greens  
Berries  
Tomatoes

Radishes  
Cauliflower  
Zucchini  
Peppers

**90%**

water



Acorn squash  
Butternut squash

**85%**

water



# Drying - general aspects

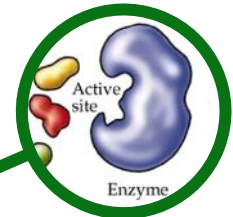


## FOOD DRYING – QUALITY AND SAFETY OF FOOD

Drying slows down deteriorative processes



**CHEMICAL REACTIONS**



**ENZYMATIC ACTIVITY**



**MICROBIAL GROWTH**



# Drying - general aspects



## FOOD DRYING – IMPACT ON THE PRODUCTION COSTS

Drying reduces storage and shipping costs

**WET  
PRODUCT**

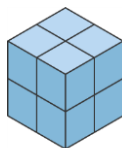


**VS**



**DRIED  
PRODUCT**

High size/volume



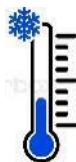
Low size/volume

High weight



Low weight

Must be stored at low temperature



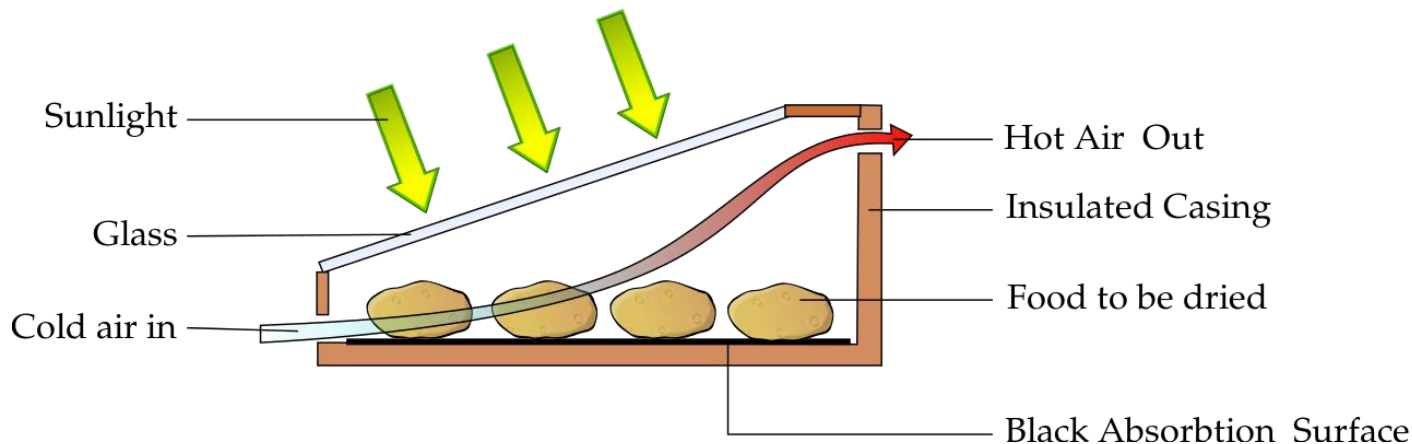
Can be stored at room temperature

# Drying - general aspects



## FOOD DRYING – TYPE OF DRYING TECHNOLOGIES

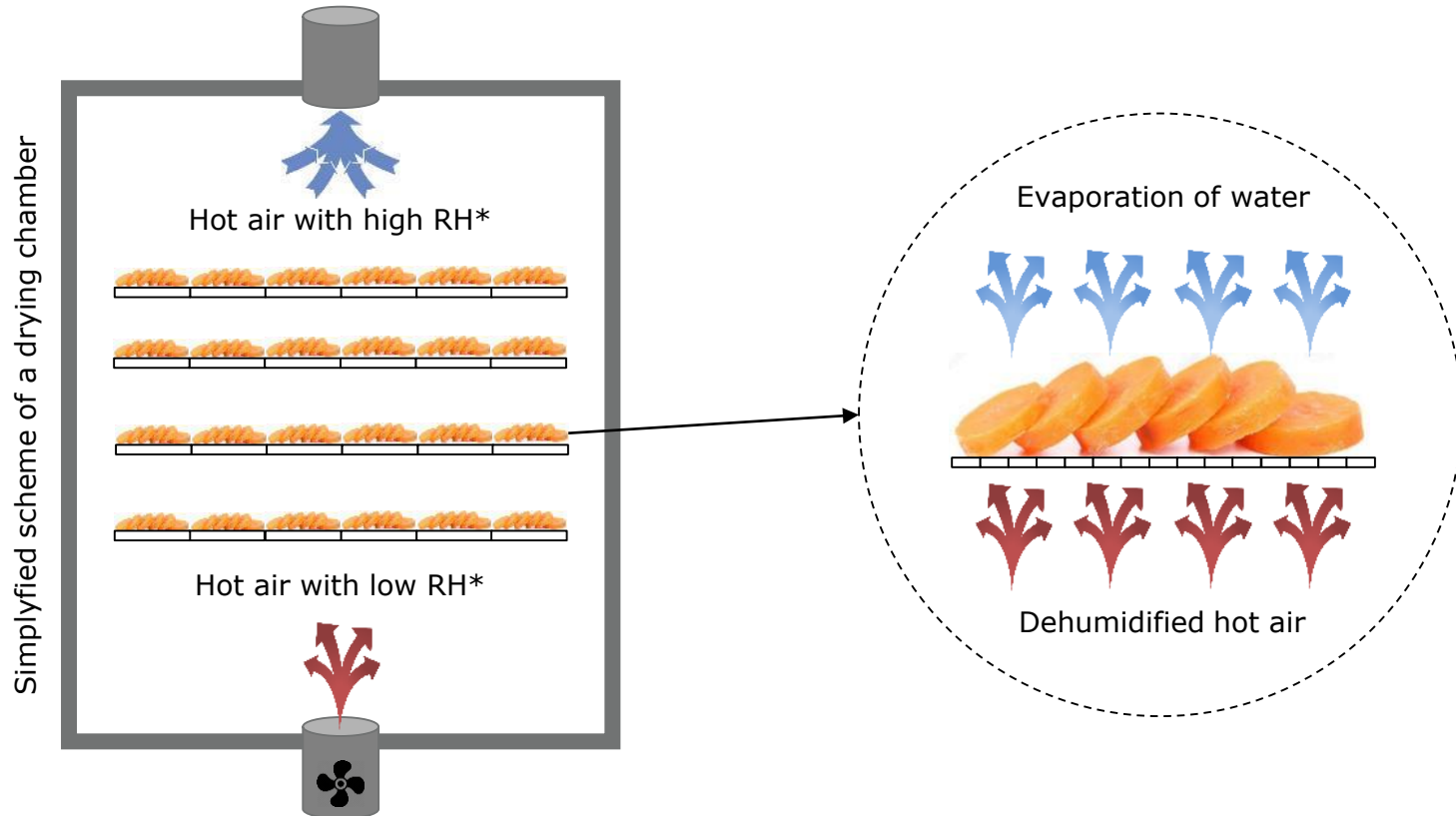
Sun drying is the oldest drying method





## FOOD DRYING – TYPE OF DRYING TECHNOLOGIES

Hot-air drying is the most used drying method



\*RH - relative humidity



## IMPACT OF DRYING ON PRODUCT QUALITY TRAITS

### PHYSICOCHEMICAL CHANGES

- » Moisture content and water activity
- » Shape and size
- » Firmness and texture
- » Pigments content
- » Enzymatic and non-enzymatic browning

### ORGANOLEPTIC CHANGES

- » Aspect
- » Odor
- » Taste
- » Texture

### NUTRITIONAL CHANGES

- » Vitamins content
- » Carotenoids content
- » Total polyphenolic content
- » Antioxidant capacity
- » ...





## CONSUMER PERCEPTION OF DRIED FOOD QUALITY



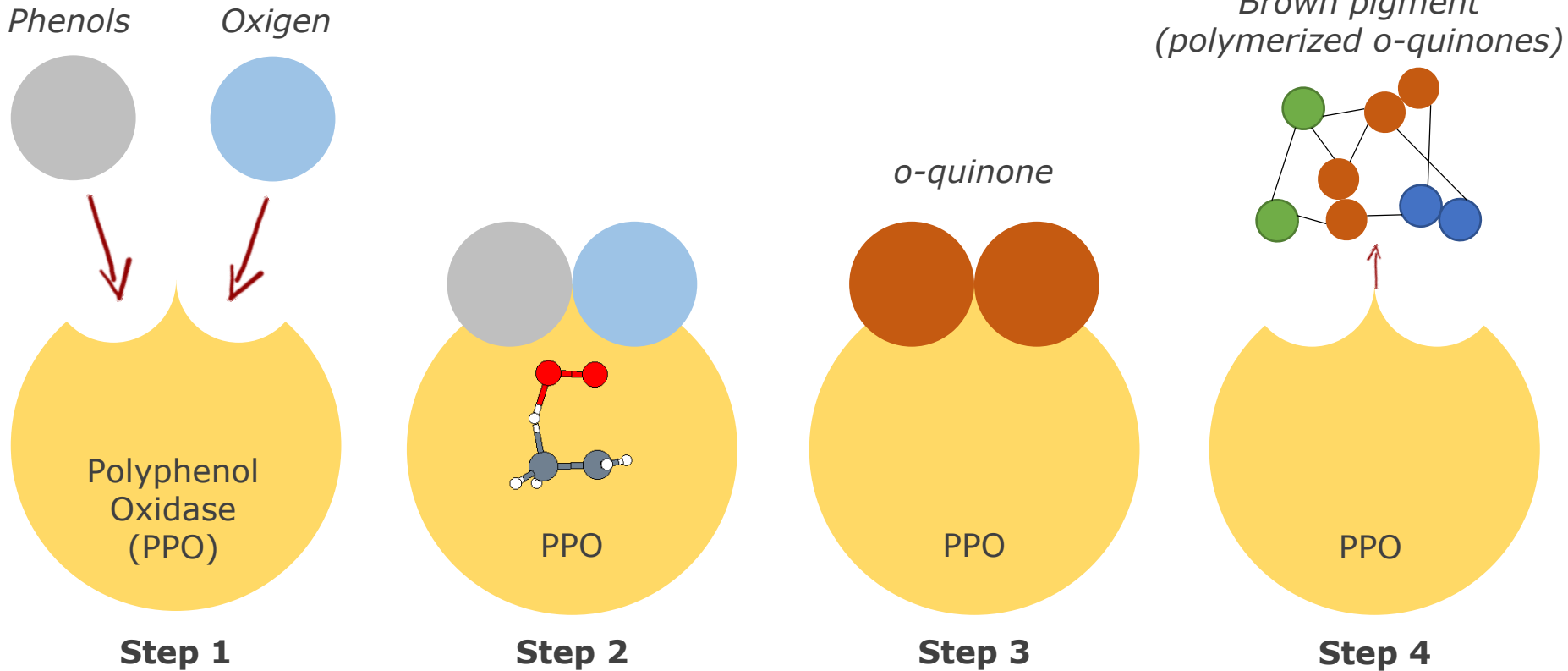
On the basis of color perception, consumer obtains critical but also biased information about quality of food by acquiring clues as to edibility as well as identity and intensity of flavor.



Consequently, dried strawberries have more chances to be bought because of more intense color in comparison with dried apples.



## CHANGES IN COLOR - THE ENZYMATIC BROWNING





## CHANGES IN COLOR - THE NON-ENZYMATIC BROWNING

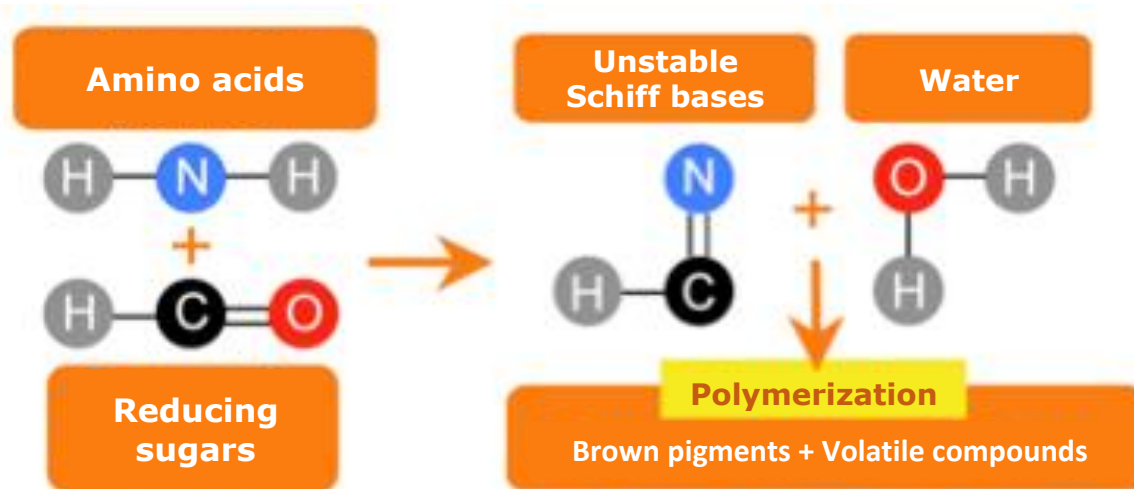
There are two types of non-enzymatic browning reactions:

- 1) Caramelization (a pyrolytic process of sugars)
- 2) Maillard reaction (a chemical reaction between amino acids and reducing sugars).

This reaction was first described by Louis Maillard in 1912.



Louis Camille Maillard







## CHEMICAL COMPOSITION AMONG SPECIES AND CULTIVARS

Species, cultivars and other agronomic variables (e.g. harvest date, soil type and water availability) severely affect chemical composition and functional property of fruits and vegetables.



BRAEBURN



COX



CAMEO



FUJI



GOLDEN DELICIOUS



GRANNY SMITH



JAZZ



PINK CRISP



RED DELICIOUS



ROYAL GALA

### LEGEND

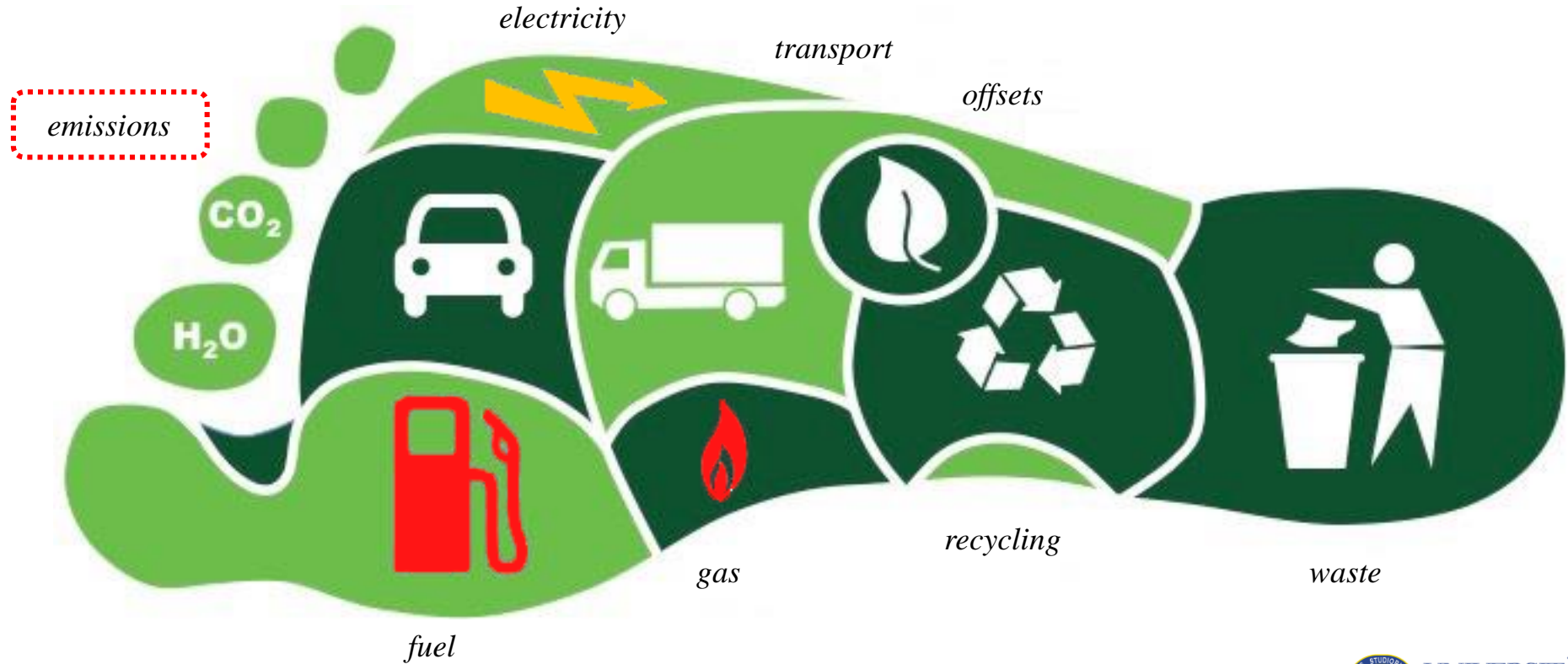
eating   
 baking   
 cooking

# Drying - general aspects



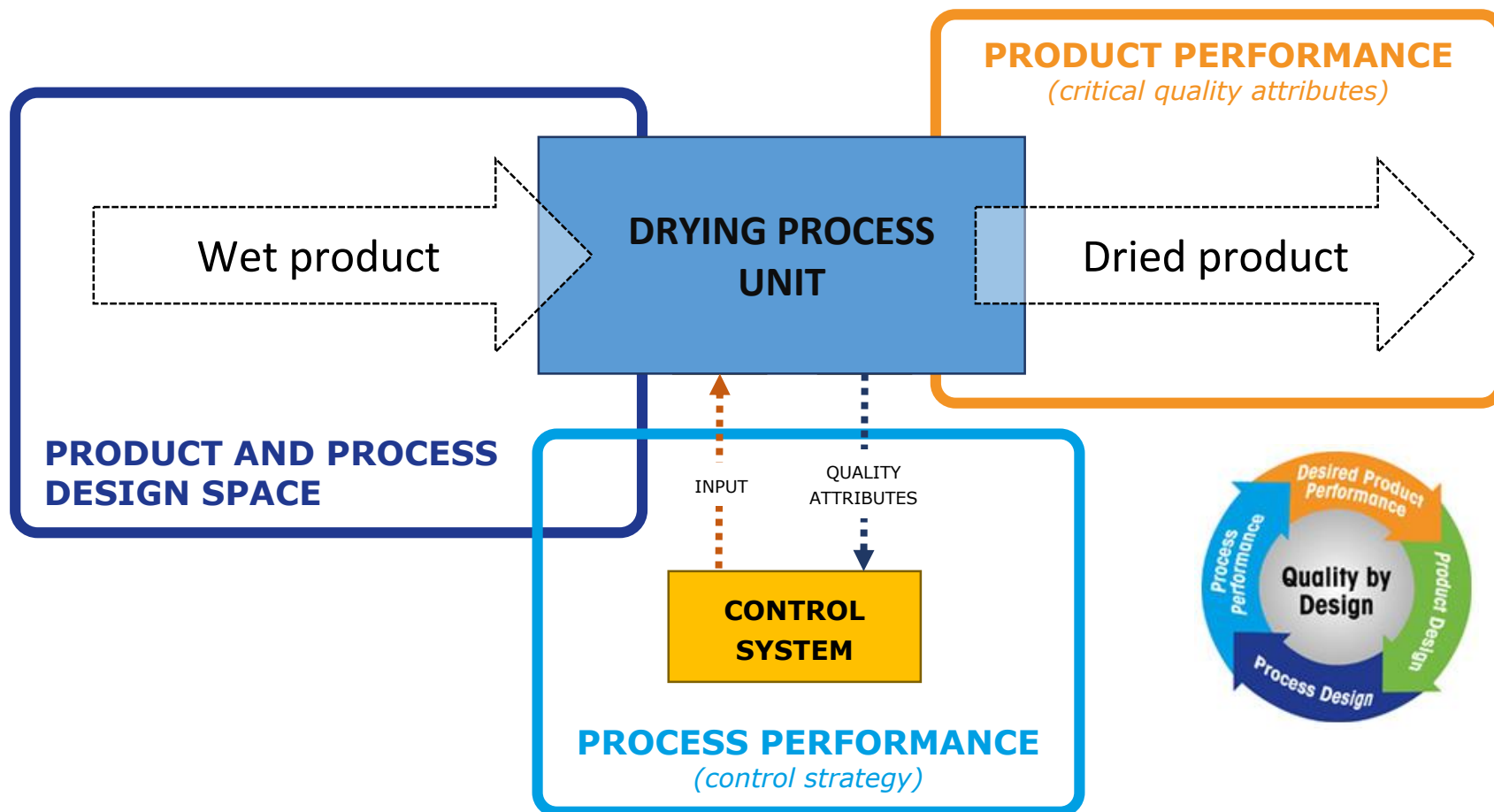
## ENERGY EFFICIENCY OF FOOD DRYING

Food drying is a highly energy-intensive operation which has an adverse effect on the environment (greenhouse gas emissions).



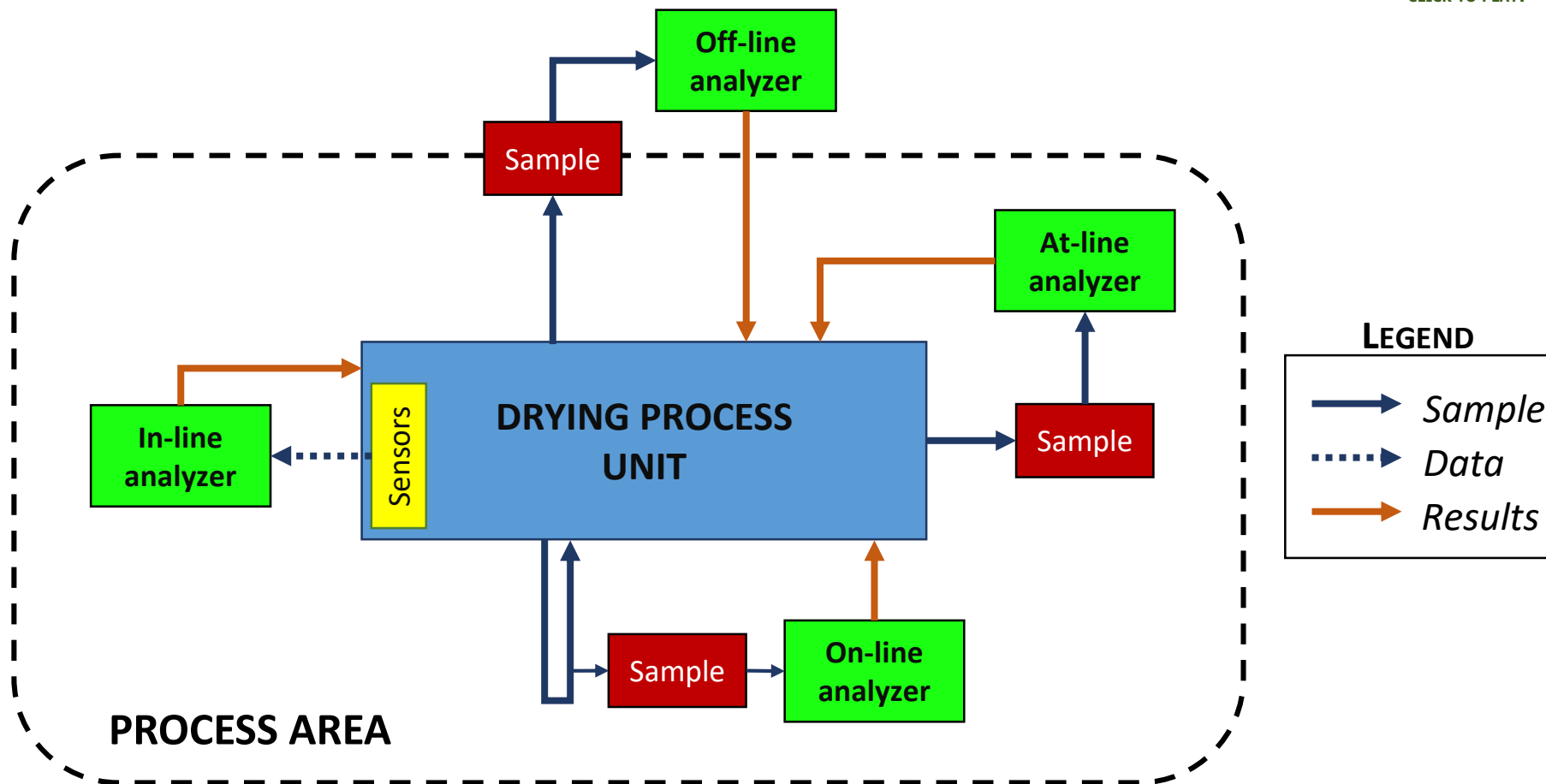


## DRYING EFFICIENCY – A QUALITY BY DESIGN APPROACH





## INNOVATIVE DRYING TECHNOLOGY - THE SMART DRYING





## INNOVATIVE DRYING TECHNOLOGY - THE SMART DRYING

### 1) Control systems for drying environment

- *pressure*
- *temperature*
- *air velocity*
- *humidity*

### 2) Biomimetic systems

- *odor-sensing system (electronic nose)*
- *taste-sensing system (electronic tongue)*

### 3) Computer vision technology

### 4) Microwave/dielectric spectroscopy

### 5) Visible and/or Near Infrared spectroscopy

- *single point*
- *multi/hyperspectral imaging*

### 6) Magnetic resonance imaging

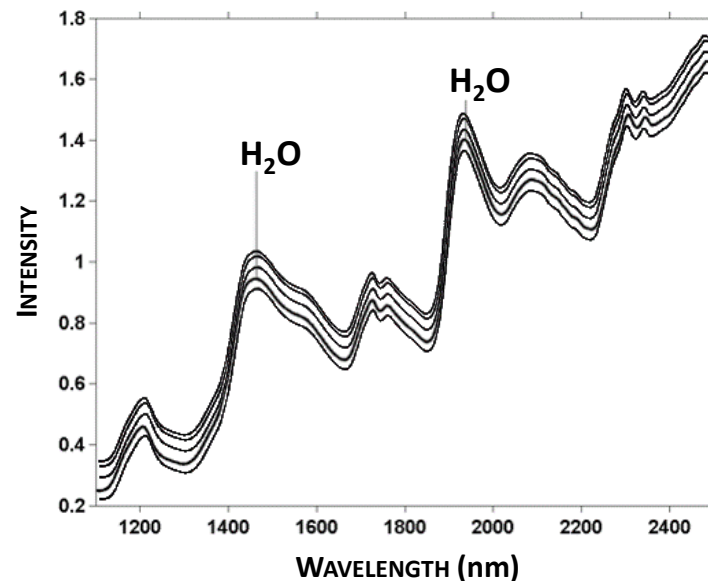
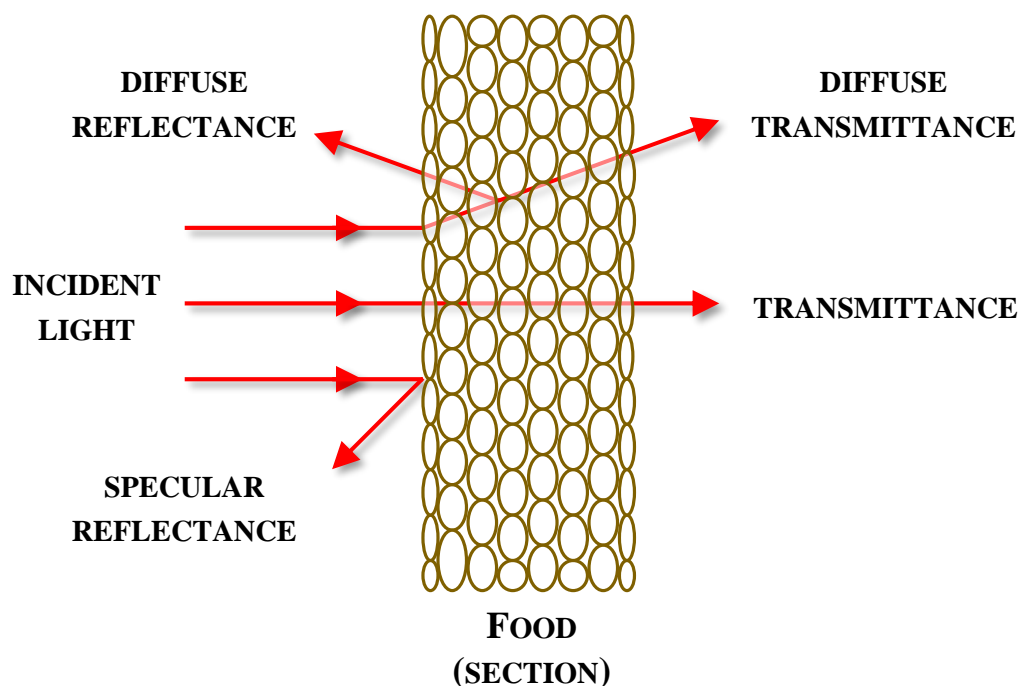
### 7) Ultrasound techniques

- ▶ Influence on the quality of the product
- ▶ Information about the progress of drying
- ▶ Smell and taste
- ▶ Size, shape and colour
- ▶ Chemical, physical and physicochemical characteristics
- ▶ Information about the progress of drying

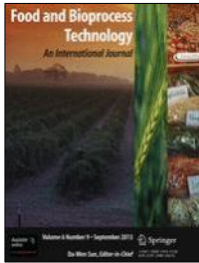


## INNOVATIVE DRYING TECHNOLOGY - Vis/NIR SPECTROSCOPY

Visible (Vis) / Near-infrared (NIR) spectroscopy is a form of non-invasive imaging that applies visible and near-infrared radiation to chemicals or biological subjects to measure differential absorption.



# References

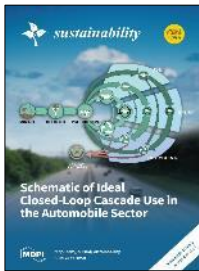


**2017**

**Journal:** Food and Bioprocess Technology

**Authors:** Moscetti R, Haff RP, Ferri S, Raponi F, Monarca D, Liang P, Massantini R

**Title:** Real-time monitoring of organic carrot (var. romance) during hot-air drying using Near-Infrared spectroscopy



**2017**

**Journal:** Sustainability

**Authors:** Raponi F, Moscetti R, Monarca D, Colantoni A, Massantini R

**Title:** Monitoring and optimization of drying fruits and vegetables process using computer vision: a review



**2017**

**Journal:** Journal of the Science of Food and Agriculture

**Authors:** Moscetti R, Sturm B, Crichton SOJ, Amjad W, Massantini R

**Title:** Postharvest monitoring of organic potato (cv. anuschka) during hot-air drying using vis/nir hyperspectral imaging



**2018**

**Journal:** Journal of Food Engineering

**Authors:** Moscetti R, Raponi F, Ferri S, Colantoni A, Monarca D, Massantini R

**Title:** Real-time monitoring of organic apple (var. Gala) during hot-air drying using Near-Infrared spectroscopy



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