Drying

*general aspects*

Roberto Moscetti*, Flavio Raponi, Serena Ferri, Riccardo Massantini**

Affiliation: Department of Innovation in Biology, Agri-food and Forest systems, University of Tuscia, Viterbo (Italy)

*corresponding author: rmoscetti@unitus.it

** scientific responsible: massanti@unitus.it
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
Drying - general aspects

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.

Module: Sustainable processing for organic food products
Drying - general aspects

**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.
Drying - general aspects

FOOD DRYING – AN OVERVIEW

DRYING OF FOOD CONSISTS OF THREE STEPS...

1. PRE-DRYING PROCESSING
2. DRYING
3. POST-DRYING HANDLING

Module: Sustainable processing for organic food products
Drying - general aspects

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: 90% water
- 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
Drying - general aspects

Food Drying – Impact on the Production Costs
Drying reduces storage and shipping costs

**Wet Product**
- High size/volume
- High weight
- Must be stored at low temperature

**Dried Product**
- Low size/volume
- Low weight
- Can be stored at room temperature
Drying - general aspects

FOOD DRYING – TYPE OF DRYING TECHNOLOGIES
Sun drying is the oldest drying method

Example of sun-dried tomato in south of Italy
Drying - general aspects

FOOD DRYING – TYPE OF DRYING TECHNOLOGIES
Hot-air drying is the most used drying method

Evaporation of water

Dehumidified hot air

Hot air with high RH*

Hot air with low RH*

Simplyfied scheme of a drying chamber

*RH - relative humidity

Module: Sustainable processing for organic food products
Drying - general aspects

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
» ...

Module: Sustainable processing for organic food products
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.
Drying - general aspects

CHANGES IN COLOR - THE ENZYMATIC BROWNING

1. Phenols + Oxigen → Polyphenol Oxidase (PPO)
2. PPO → o-quinone
3. o-quinone → Brown pigment (polymerized o-quinones)

Step 1
Step 2
Step 3
Step 4
Drying - general aspects

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
Drying - general aspects

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.

LEGEND
- eating
- baking
- cooking

Module: Sustainable processing for organic food products
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 - general aspects

Drying Process Unit

Product and Process Design Space

Wet product → Drying Process Unit → Dried product

Quality Attributes

Input attributes

Control System

Process Performance (control strategy)

Product Performance (critical quality attributes)

Module: Sustainable processing for organic food products
Drying - general aspects

INNOVATIVE DRYING TECHNOLOGY - THE SMART DRYING

Legend:
- Sample
- Data
- Results

PROCESS AREA

Module: Sustainable processing for organic food products
Drying - general aspects

INNOVATIVE DRYING TECHNOLOGY - THE SMART DRYING

1) Control systems for drying environment
   - pressure
   - temperature
   - air velocity
   - humidity

   ▶ Influence on the quality of the product
   ▶ Information about the progress of drying

2) Biomimetic systems
   - odor-sensing system (electronic nose)
   - taste-sensing system (electronic tongue)

   ▶ Smell and taste

3) Computer vision technology

4) Microwave/dielectric spectroscopy

5) Visible and/or Near Infrared spectroscopy
   - single point
   - multi/hyperspectral imaging

   ▶ Chemical, physical and physicochemical characteristics
   ▶ Information about the progress of drying

6) Magnetic resonance imaging

7) Ultrasound techniques

Module: Sustainable processing for organic food products
Drying - general aspects

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.

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