

AGRICULTURAL PRODUCT DRYING TECHNOLOGY AND ITS APPLICATION



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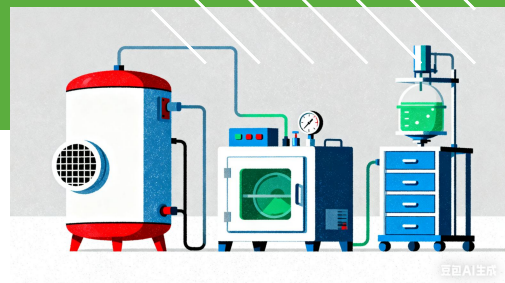
Part 03

Principles, Methods and Applications of Various Drying Equipment

PART.01



Overview of Drying Technologies



1. Definition of Drying and Dehydration



■ Drying

- The process of **evaporating moisture** from products under **natural or controlled conditions**.

■ Methods

- **Natural drying** and **artificial drying**.

■ Dehydration

- The process of **evaporating moisture** under **controlled conditions** to **minimize quality loss**.

■ Dehydrated products

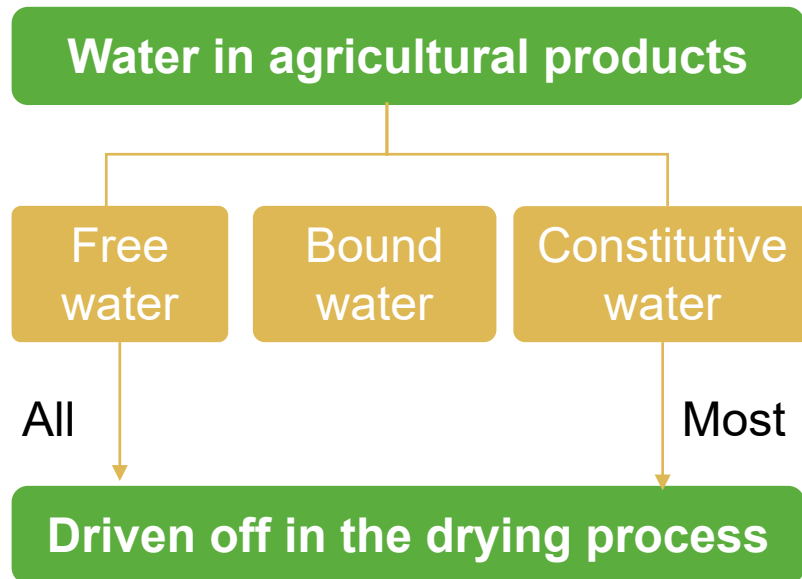
- **Durable, storable**, and able to **rehydrate** close to their **original state**.



■ Agricultural product drying

- The process of **evaporating moisture** from **agricultural products** under **natural or controlled conditions**.

2. Forms of Water in Agricultural Products



■ Free water

- Located in the **tissues** in a **free state**; **evaporates easily** during drying.

■ Bound water

- **Linked to biological macromolecules** (proteins, polysaccharides, etc.) through **hydrogen bonds** and **van der Waals forces**.
- **Lower free energy** than free water.
- **Tightly bound**, making **evaporation difficult**.

■ Constitutive water

- Firmly bound to **non-water components** by **chemical or physical forces**; usually **not removed** during drying.

3. Water Activity and Preservation

Three Categories



Monolayer Water
(Primarily Bound Water)



Multilayer Water
(Primarily Bound Water)



**Free and Gel-Associated
Water**

3. Water Activity and Preservation

Zone I - Monolayer Water (Primarily Bound Water)

■ Definition & Existence

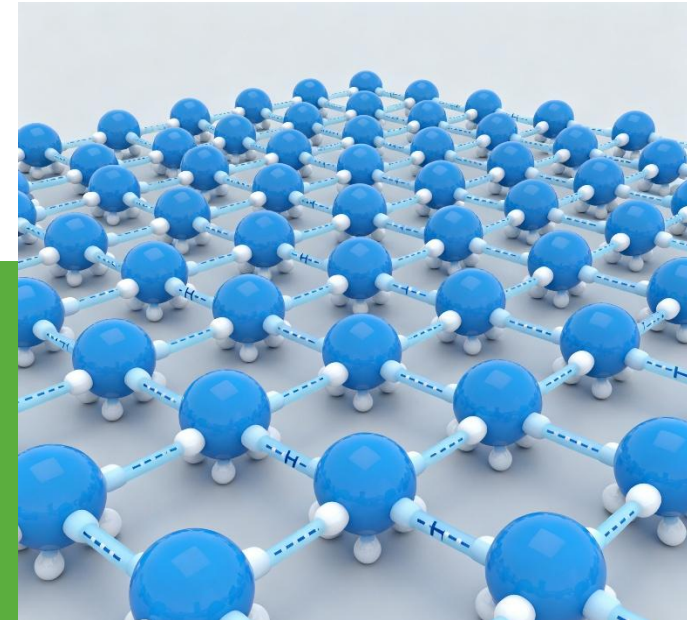
- Exists as a **single molecular layer** attached to solute surfaces and is the **most strongly bound**.

■ Water Activity

- Water activity **0 - 0.25**.

■ Characteristics & Removal

- **Tightly bound to chemical components** such as sugars, carbohydrates, and cellulose → **an integral part of the material**.
- **Extremely difficult to remove through drying**.



3. Water Activity and Preservation

Zone II - Multilayer Water (Primarily Bound Water)

■ Definition & Existence

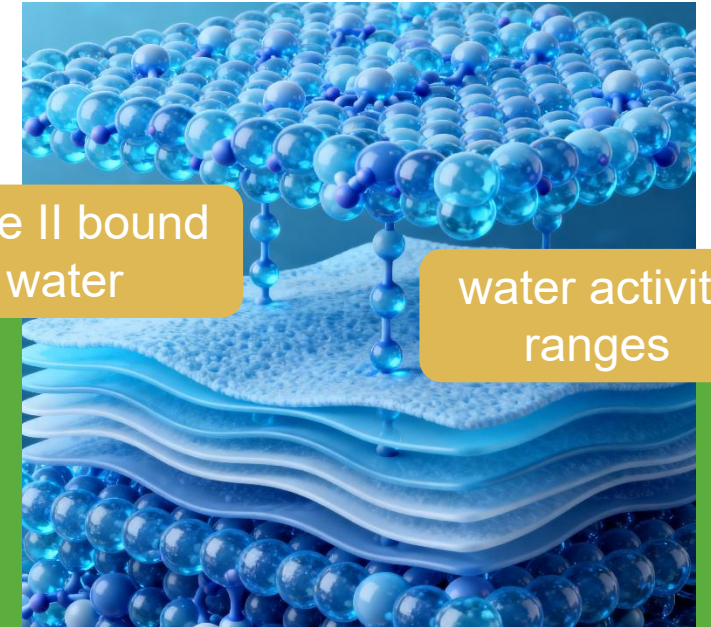
- Multilayer Water (Primarily bound water) **forms hydrogen bonds** with **neighboring water molecules** and **with chemical components** in the product.

■ Activity & Mobility

- **Mobility is limited.**
- **Water activity 0.25 - 0.8.**

■ Proportion

- Usually <5% of total water content.



3. Water Activity and Preservation

Zone III - Free and Gel-Associated Water

Composition

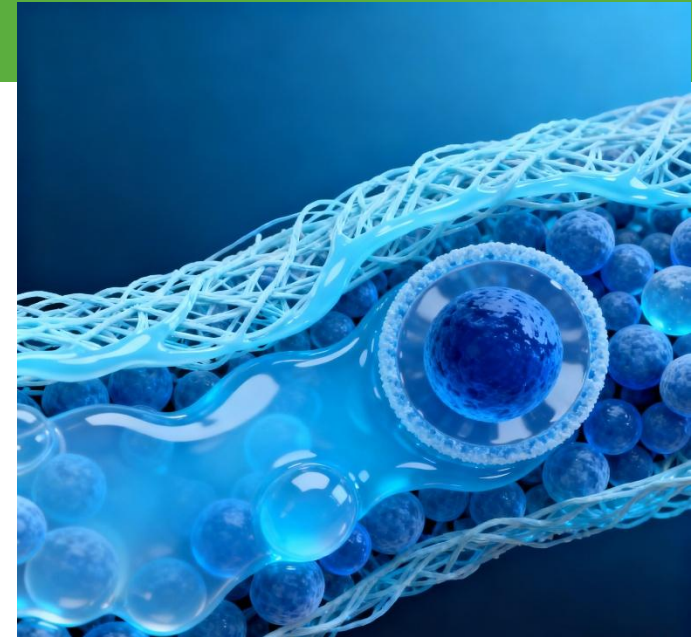
- Includes water within tissues, interstitial spaces, intracellular water, and gel-bound water.

■ Activity & Mobility

- Mobility somewhat restricted.
- Water activity 0.8 - 0.99.

■ Proportion

- Typically **>95% of total water** → represents the free water fraction.



3. Water Activity and Preservation

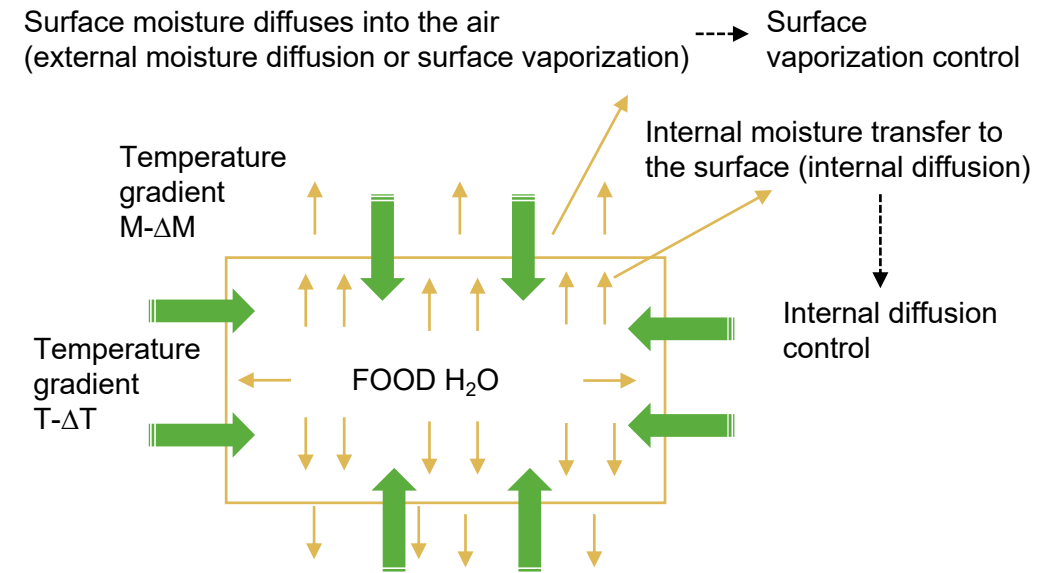
Drying Mechanism

■ Evaporation Sites

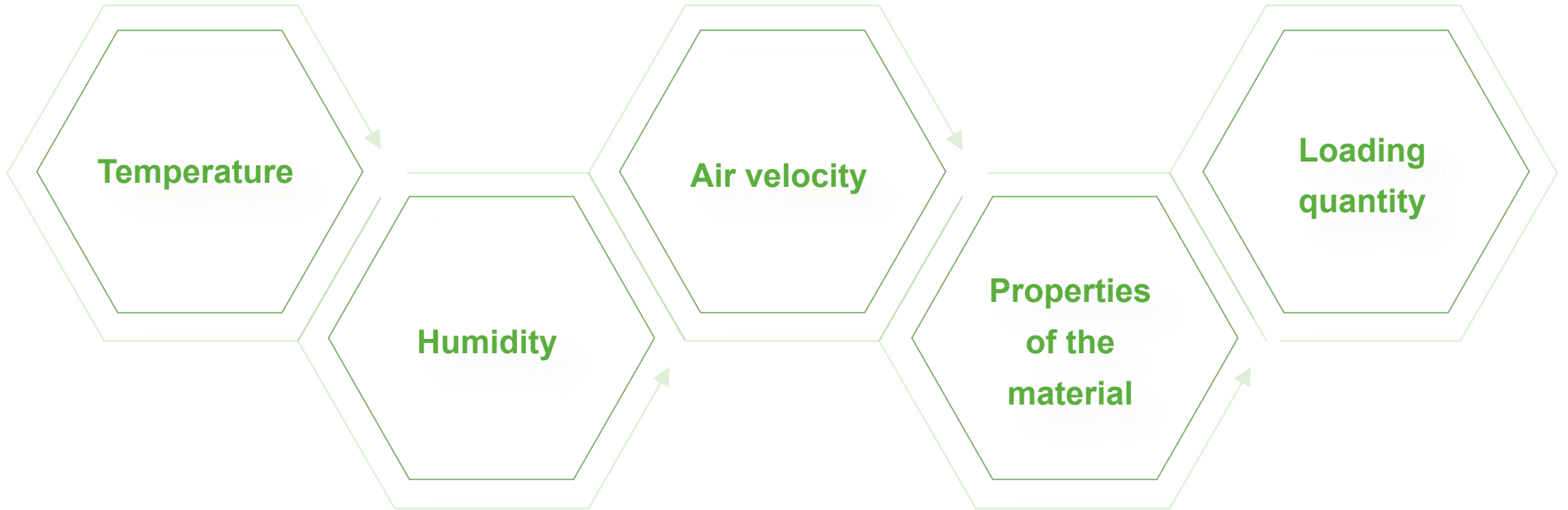
- Water evaporates not only from the surface but also from within the product.

■ Internal Water Transfer

- Internal water requires transfer to the surface before vaporization.



4. Factors Affecting Drying



4. Factors Affecting Drying

Humidity of the Drying Medium

Core Drying Medium

Air is the primary **drying medium**.

Direct Influence on Efficiency

Drying efficiency is closely related to **air humidity**.

Impact of High Humidity

High humidity reduces the evaporation rate from the material surface, **making drying more difficult**.

4. Factors Affecting Drying

Temperature of the Drying Medium

01

Acceleration of Drying

- Higher temperatures increase the drying rate.

02

Negative Effects on High - Moisture Products

- Excessively high temperatures → cracking.
 - Excessively high temperatures → leakage of internal contents (e.g., sugars) or bursting.
- ➔ Negatively affects the product's commercial and sensory value.

03

Thermal Reactions Reducing Quality

- High temperatures → caramelization / gelatinization of organic matter → Flavour deterioration → Reduction in commodity value.

4. Factors Affecting Drying

Air Velocity of the Drying Medium

■ Key Action

- Increases velocity (e.g., good ventilation).

■ Mechanism

- Enhances convective heat and mass transfer.

■ Final Effect

- Removes moisture faster, accelerates drying.



4. Factors Affecting Drying

Type and Condition of Raw Materials



Different materials and their physical states directly affect drying rate and required drying time.



4. Factors Affecting Drying

Loading Quantity of Raw Materials

Larger loading volumes extend the required drying time.



5. Effect of Drying on Product Quality

Physical Changes

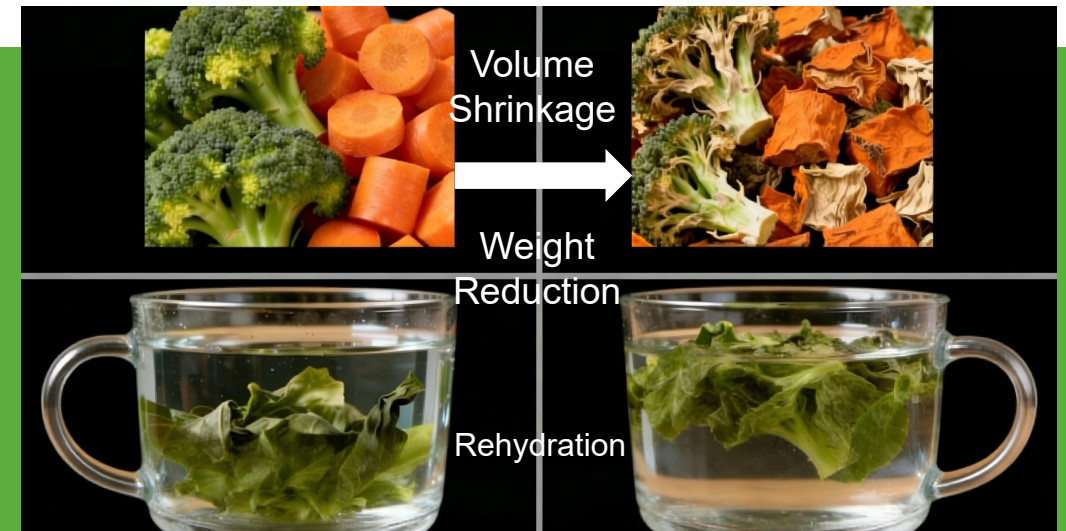
■ Drying process induces a series of physical changes

- Volume shrinkage.
- Weight reduction.
- Changes in dimensions and shape.

■ Solubility, including rehydration capacity, is also affected.

■ Outcome Example

- Some dehydrated vegetables **significantly reduce in volume and weight** and may **not fully regain their original plumpness** upon rehydration.



5. Effect of Drying on Product Quality

Chemical Changes

■ Loss of Active Components

- Heat-sensitive compounds:
 - Chlorophyll, anthocyanins, carotenoids → **degrade under high temperature drying** → **color darkening**(e.g., dried vegetables turning **brown/black**).
- Bioactive compounds:
 - **Fructose, glucose, and certain functional bioactive compounds may lose activity** during drying.



Chlorophyll, anthocyanins, and carotenoids remain intact



Reduced retention of fructose and glucose



Decomposition of heat-sensitive compounds



Loss of functional bioactive compounds activity

■ Compound Decomposition

- **Drying triggers decomposition of sugars and functional compounds.**

5. Effect of Drying on Product Quality

Biochemical Changes

■ Microbial and Cellular Reactions

- **Key Threshold:**
 - Moisture content drops to around **6%** → microbial activity inhibited.
- **Specific Manifestations:**
 - **Seeds may not germinate after drying**, facilitating storage.
 - **Rehydration** → microbial activity resumes → **seeds germinate more readily**.

Seeds with moisture content above 6%



Strong microbial activity, prone to germination

Moisture content below 6% after drying



Microbial activity inhibited, facilitating storage

5. Effect of Drying on Product Quality

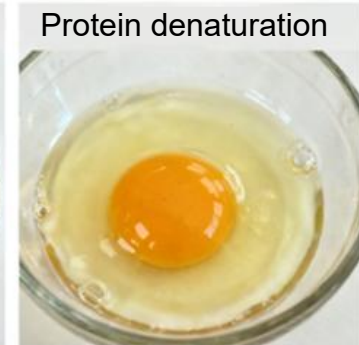
Biochemical Changes

■ Irreversible Reactions

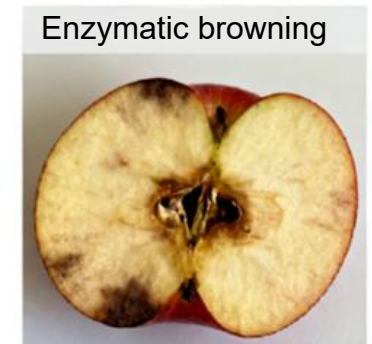
- **Main Types:**
 - Lipid oxidation.
 - Protein denaturation.
 - Enzymatic browning.
 - Maillard reaction.
 - Caramelization.
 - Oxidation / inactivation of vitamins (A, B, C).
- **Core Impact:**
 - Impact overall product quality.



Lipid oxidation: color change in oils



Protein denaturation: egg coagulation



Enzymatic browning: browning of sliced apples



Vitamin oxidation: rupture of vitamin C tablets

6. Objectives of Agricultural Product Drying

1

Extending Shelf Life

Approach: Reduce the **moisture content** and **water activity** of agricultural products.

Specific Effect:

- Inhibits **microbial growth** and **reproduction**.
- Inactivates **enzyme activity**.
- Minimizes **undesirable chemical reactions**.
- Ensures **food safety** and **preservation**.

2

Facilitating Storage and Transportation

Core Action: Remove **moisture** from food products.

Key Value:

- **Reduced volume + reduced weight**.
- → **Lower storage costs**.
- → **Lower transportation costs**.

3

Meeting Processing Requirements

Basic Position:

- An **indispensable step** in the processing of certain **foods** (e.g., **bread, biscuits, tea**).

Dual Functions:

- **Basic Function:** Remove **moisture** from food.
- **Quality Function:** Develop characteristic **color, aroma, and flavor**.
 - > e.g., **caramelized color** of bread; **unique aroma** of shiitake mushrooms.
- **Additional Value:** Play an important role in the development of new food products.

7. Degree of Food Drying

■ Definition and General Moisture Requirements

- **Degree of drying** = moisture content expressed as % of water in total mass.
- Most dried products require **moisture < 15%**.
- **Excess moisture** → promotes **bacterial growth + mold**.

■ Standards Vary by Food Type

- **Dried longan & lychee** ≤ 25%.
- **Raisins** ≤ 20%.
- **Persimmons** ≤ 35%.
- Goal: balance **taste + product value**.

■ Moisture Standards Across Food Types

- Other foods have defined moisture standards: **meat, bread, flour, pasta, candy, biscuits, milk powder, potato chips**.

Moisture decreases → Water activity decreases → Product stability increases.



8. Wide Applications and Challenges of Drying

Wide Applications

■ Agriculture

- Reduces the **volume of products** + lowers **storage and transportation costs**.

■ Food Industry

- **Preservation + enhanced quality** → **flavor + aroma + color**.
- **Examples** → **caramelized bread crust** + **aromatic shiitake mushrooms** + **processed tea leaves**.

■ Chemical Industry

- Drying prevents **urea** from **absorbing moisture** and **losing nitrogen**.

■ Pharmaceutical Industry

- Ensures **moisture control** and protects **tablets** from **degradation**.

■ Other Sectors

- Paper manufacturing.
- Wood processing.
- Mineral industries.

8. Wide Applications and Challenges of Drying

Challenges

■ High Energy Consumption

- In developed countries, drying processes **account for about 12% of total industrial energy consumption.**
- **Second only to the paper industry**, consuming large amounts of coal and electricity.

■ Affect Product Quality

- Excessive heat or **prolonged exposure** can **damage colour, flavour, texture, and nutrients.**

■ Environmental Challenges

- **High energy demand** → pressure on the **environment.**
- **Energy efficiency** → key focus in the development of **drying technology.**