

Chapter 2: Characteristics of Foods

Water in Foods

Water is one of the major components of foods and directly influences their structure, texture, chemical and microbiological stability, as well as their technological value.

Its content, and especially its availability, determines the rate of enzymatic reactions, oxidation, microbial growth, and the shelf life of food products.

In the agri-food industry, controlling water is therefore essential to ensure quality, food safety, and product stability.

1. Water Activity (a_w)

In a food product, not all water is free: part of it is physically or chemically bound to components such as proteins, carbohydrates, or mineral salts.

Thus, food stability depends more on available water than on total water content.

Water activity (a_w) is an indicator that measures the water truly available for chemical reactions and microbial growth.

Water activity (a_w) is defined as the ratio between the partial vapor pressure of water in the food and that of pure water at the same temperature.

It ranges between 0 and 1:

- A value close to 1 means a large amount of available water (e.g., fresh milk).
- A low value indicates little available water (e.g., dried fruits).

A high a_w value promotes microbial growth, enzymatic reactions, and chemical deterioration.

Conversely, low water activity improves preservation, which is the principle used in drying, salting, or sugar addition.

Example:

Fresh meat spoils quickly because of its high a_w , whereas dried dates can be stored for a long time.

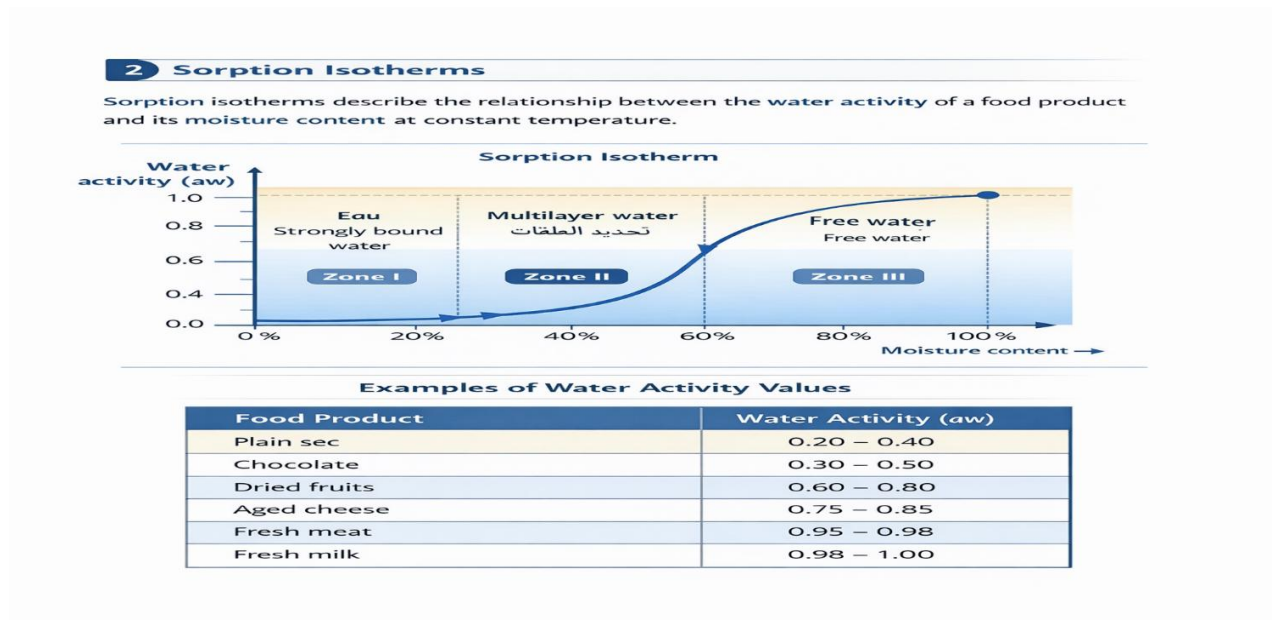
2. Sorption Isotherms

Sorption isotherms are curves that show the relationship between the water content of a food and the relative humidity of the surrounding air at constant temperature.

They are used to understand how a food absorbs or loses water during storage.

These curves generally present three zones: strongly bound water, multilayer water, and free water.

Analyzing these curves is essential for designing drying processes, selecting packaging materials, and estimating shelf life.



Each food has its own adsorption curve, since its ability to retain water depends on its composition: protein, starch, sugar, lipid, and fiber content.

For example, for a crispy biscuit:

1. Experimental measurement

Biscuit samples are placed in environments with controlled relative humidity (e.g., 30%, 50%, 70%) at constant temperature (e.g., 25°C).

2. Curve construction

The water content of each sample is measured until equilibrium with the surrounding humidity is reached.

These data points are used to plot the adsorption curve specific to the biscuit.

3. Usefulness

- Predict how the biscuit will react under different storage conditions (loss of crispness if a_w increases).
- Determine the optimal moisture content to ensure stability and quality.

Industrial application:

Biscuits rapidly absorb ambient moisture; therefore, moisture-barrier packaging is essential.

3. States of Water in Foods

Depending on its interaction with the food matrix, water can exist in different forms that influence product stability.

Strongly Bound Water

This water is adsorbed onto macromolecules and has very low water activity.

It practically does not participate in chemical or microbiological reactions.

It contributes to structural stability and is generally non-freezable.

Weakly Bound or Free Water

This water is more mobile and acts as a solvent for biochemical reactions.

It promotes microbial growth and food spoilage.

Its quantity depends on pH, chemical composition, and temperature.

4. Technological Importance

Controlling water is essential in food technology to extend shelf life and maintain quality.

The main methods used are:

- **Drying:** removal of water (e.g., milk powder).
- **Freezing:** immobilization of water in the form of ice.
- **Addition of salt or sugar:** reduction of available water.

Final objective: microbiological stability, improved texture, and food safety.

Sorption isotherms also help predict changes in texture (softening, hardening) and sensory quality during storage.

They therefore constitute a fundamental tool for food formulation, packaging, and preservation.

Vegetable Fats and Oils

Vegetable fats and oils are important components of foods. They provide energy, improve texture, and contribute to the technological properties of food products.

For example, oil in a cake improves softness, while butter adds flavor and texture.

1. Physico-Chemical Properties of Lipids

Lipids have specific characteristics that influence their behavior in foods.

Insolubility in Water

Lipids do not dissolve in water, which allows the formation of emulsions.

Definition:

An emulsion is a stable mixture of water and fat formed with the help of an emulsifying agent.

Example:

Mayonnaise is an oil–water emulsion stabilized by egg yolk.

Melting Point

The melting point is the temperature at which a fat becomes liquid.

Some fats melt easily, which influences food texture.

Example:

Chocolate melts in the mouth due to cocoa butter.

Plasticity of Lipids

Plasticity means that fat can be molded or spread without breaking.

This property is important in biscuits, puff pastries, chocolate, and other products requiring proper texture.

2. Factors Influencing Texture and Melting

- Temperature strongly affects lipids: cooling and heating modify their crystalline structure.
- Storage conditions also play a role: heat, light, and storage time can alter their stability.

Example:

An oil exposed to heat oxidizes more rapidly.

3. Main Characteristics of Edible Fats and Oils

Edible fats and oils come from plant and animal sources and are used in various food applications. They are essential ingredients due to their nutritional, functional, and technological properties.

- **Vegetable fats** are generally extracted from oilseeds and fruits. They are widely used to produce table oils, frying fats, margarines, and emulsifiable fats.
- **Animal fats** come from animal adipose tissue and have specific characteristics depending on their origin. Ruminant fats are generally more unsaturated than those from other animals.
Tallow, obtained from beef and mutton fat, is mainly used in soap production.
Whale and fish fats, rich in unsaturated fatty acids, must undergo hydrogenation before being used in human food, especially for margarine production and frying.

4. Factors Affecting Lipid Oxidation

Lipid oxidation is a process that leads to rancidity, deteriorating the sensory and nutritional quality of foods. This process is influenced by several factors that can accelerate or slow lipid degradation.

Factors promoting oxidation include:

- A high initial peroxide level, a key indicator of degradation.
- The presence of pro-oxidants such as certain metals (iron, copper), myoglobin heme, or the enzyme lipoxygenase.
- Low activity of natural antioxidants, such as tocopherols (vitamin E) and certain amino acids.
- Water activity, which influences the catalytic action of metals and competitive oxidation reactions between oxidizable substances.

5. Prevention of Lipid Oxidation

Lipid oxidation is a chemical reaction that degrades fats and oils, leading to rancidity, loss of nutritional value, and alteration of sensory properties. This reaction occurs when oxygen in the air reacts with unsaturated fatty acids, forming free radicals — highly reactive molecules that initiate chain oxidation reactions in lipids.

To preserve lipid-containing foods, it is essential to prevent oxidation. The methods and substances used can be grouped into three main categories:

Type I Antioxidants

Directly neutralize free radicals before they attack lipids.
Examples: propyl gallate, BHA, BHT, wood smoke.

Type II Antioxidants

Prevent the formation of free radicals by binding to metals that catalyze oxidation.
Examples: EDTA, citric acid, cysteine.

Protective Methods

- Reduce exposure to oxygen (vacuum packaging or modified atmosphere packaging).
- Protect foods from light.

These methods slow oxidation and help maintain nutritional and sensory quality.