Tishk International University
Faculty of Applied Sciences
Nutrition and Dietetics Department
Principles of Food Science

Water and Its Role in Food Science

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Outlines

- Previous Lecture
- An Overview about Water
- Water Properties
- Water Activity
- Functions of Water
- Application of Water

Learning Outcome

Understand how water's properties affect food.

Analyze how water activity helps keep food fresh and safe.

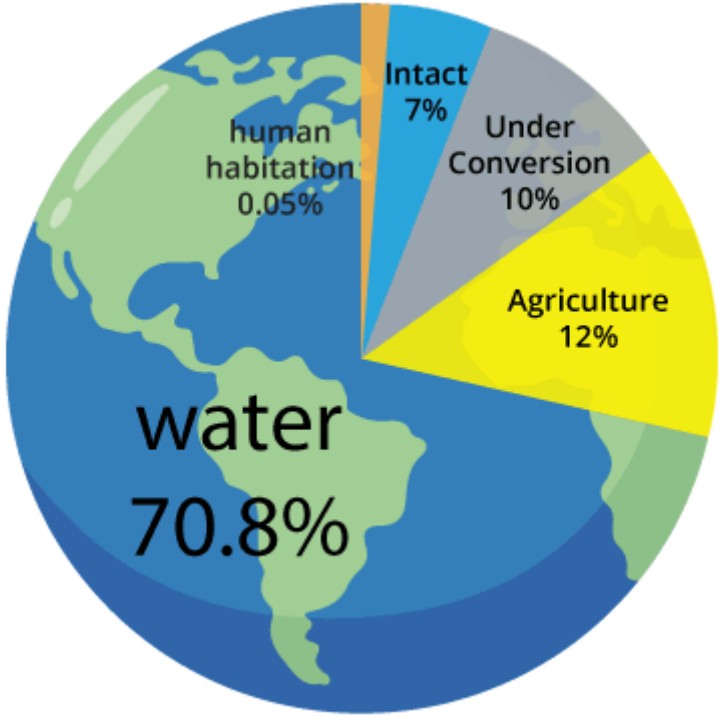
Evaluate ways to use water effectively in food processing.

Water: a substance composed of the chemical elements hydrogen and oxygen and existing in gaseous, liquid, and solid states.

Water is a vital substance that sustains life on Earth.

It's a clear, tasteless, and odorless liquid that covers about **70%** of Earth's surface.

It is essential for all known forms of life, despite not providing food energy or organic micronutrients.



Sources of water

Well

Rain

Stream

River

Tap

Lake

Sources of Water

1. Natural Sources

- **Surface Water**: Rivers, lakes, and streams.
- **Groundwater**: Wells and springs.
- **Rainwater**: Directly collected or used to replenish surface and groundwater.

2. Food Sources

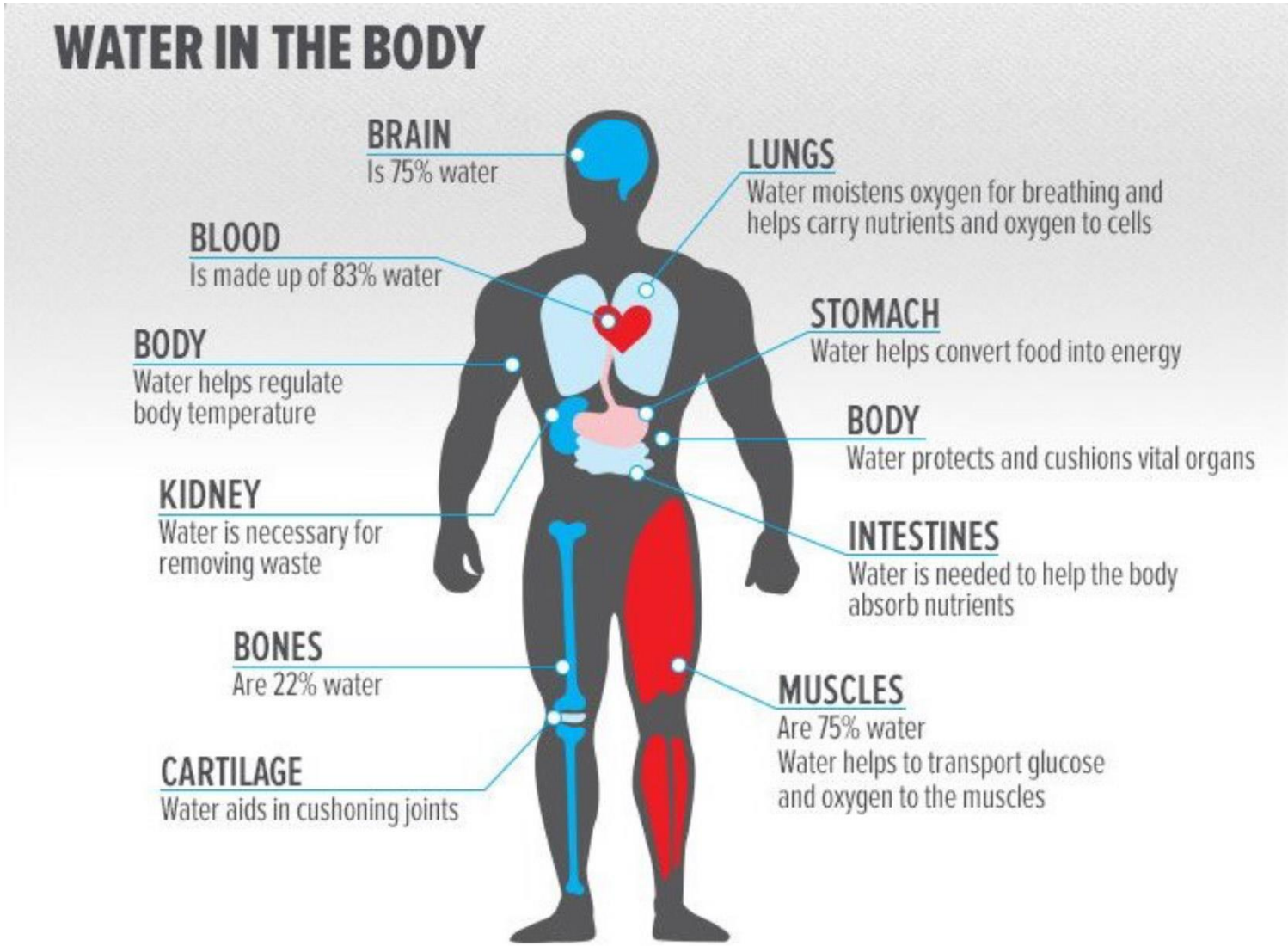
- **Fruits**: High-water content examples include watermelon, oranges, and strawberries.
- **Vegetables**: Cucumbers, lettuce, celery, and tomatoes.
- **Other Foods**: Soups, broths, and dairy products like milk and yogurt.

3. Beverages

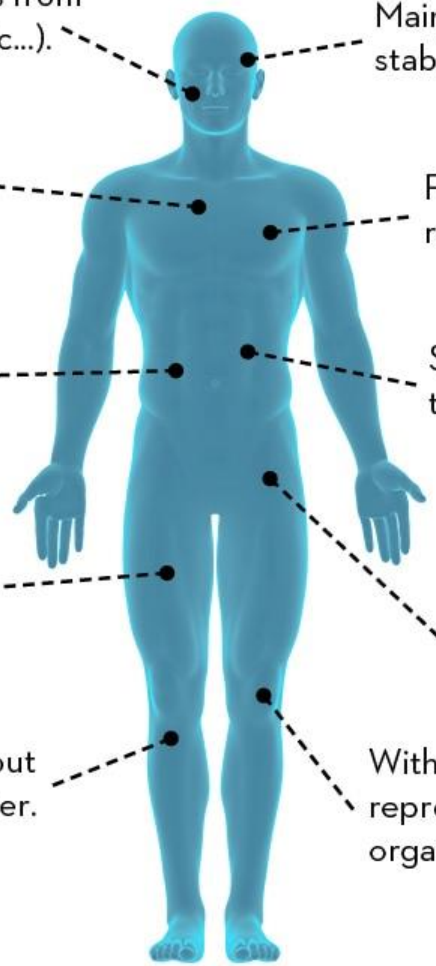
- **Water**: Tap, bottled, or mineral water.
- **Other Drinks**: Juices, teas, coffee, and non-alcoholic beverages.

4. Metabolic Water

- Water produced internally by the body during the metabolism of carbohydrates, proteins, and fats.


WATER IN THE BODY
BRAIN
Is 75% water
LUNGS
Water moistens oxygen for breathing and helps carry nutrients and oxygen to cells
BLOOD
Is made up of 83% water
STOMACH
Water helps convert food into energy
BODY
Water helps regulate body temperature
BODY
Water protects and cushions vital organs
KIDNEY
Water is necessary for removing waste
INTESTINES
Water is needed to help the body absorb nutrients
BONES
Are 22% water
MUSCLES
Are 75% water
Water helps to transport glucose and oxygen to the muscles
CARTILAGE
Water aids in cushoning joints

WATER NEEDS



Keeps mucosal membranes from drying out (eyes, mouth, etc...).

Maintains optimal and stable heating & cooling.

Comprises at least $^{3}/_{4}$ of total body mass & substance.

Facilitates blood flow, cellular reproduction, movement & life itself.

Maintains optimal digestive function & elimination.

Supports the efficient removal of toxins & waste from internal organs.

Permits the Absorption of life-essential nutrients & energy.

Primary conduit for delivering all body fluids, molecular messages and especially oxygen delivery.

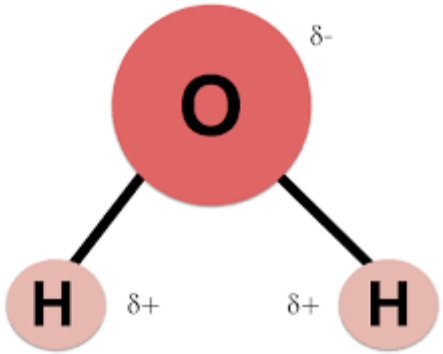
The body can survive for weeks without food, but only a few days without water.

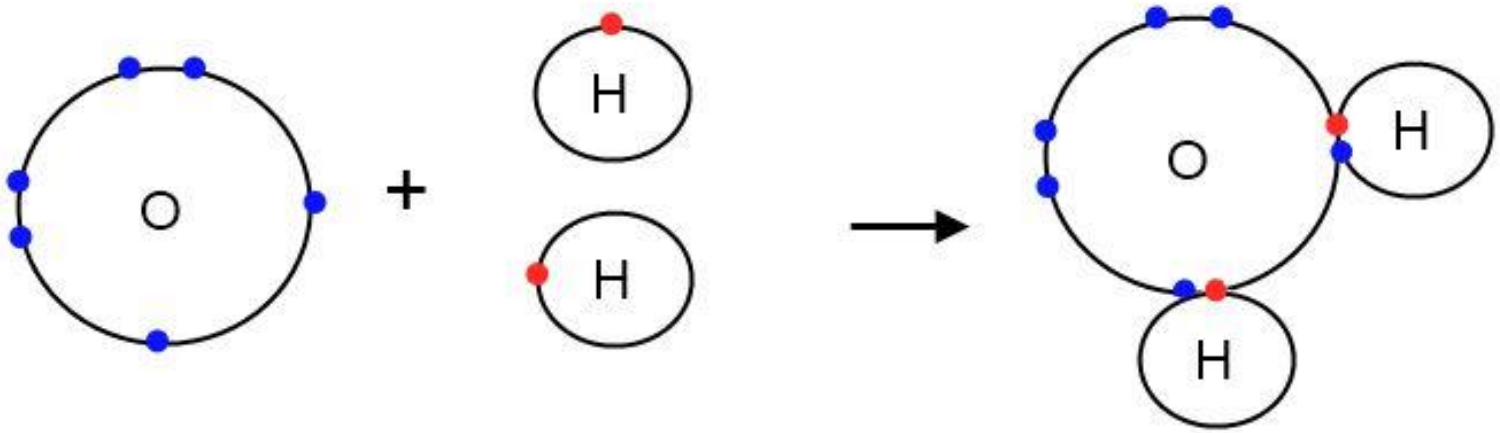
Without water, cells cannot grow, reproduce or survive, and the entire organism dies.

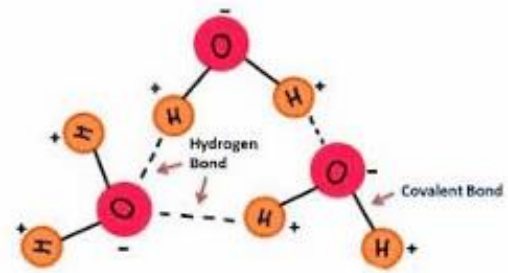
Chemical Composition:

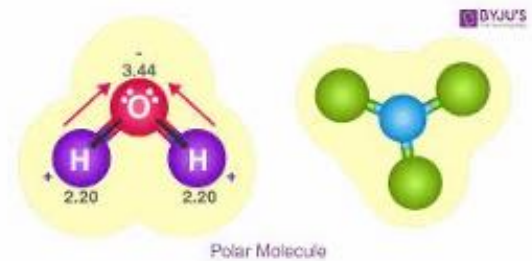
Water is an inorganic compound with the chemical formula H_2O.

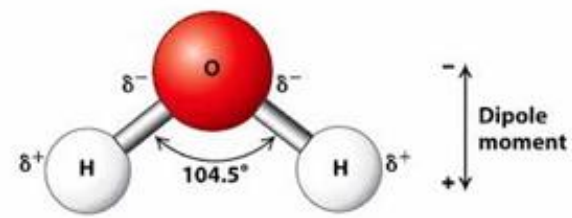
It consists of two hydrogen atoms bonded to one oxygen atom

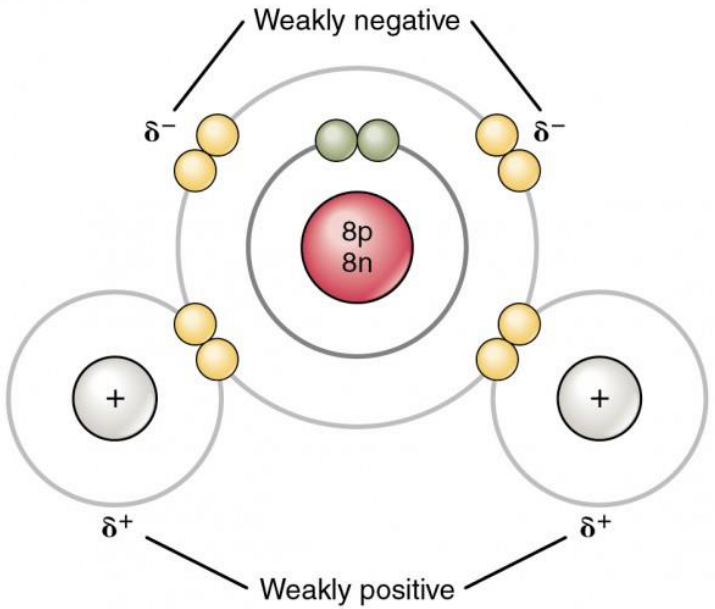



O
H
H
O
H
H

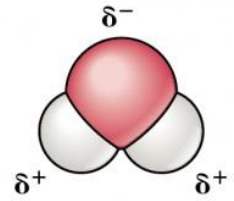

Hydrogen Bond
Covalent Bond


3.44
2.20
2.20
Polar Molecule

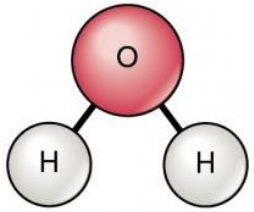

δ⁻
δ⁻
δ⁺
δ⁺
104.5°
Dipole moment



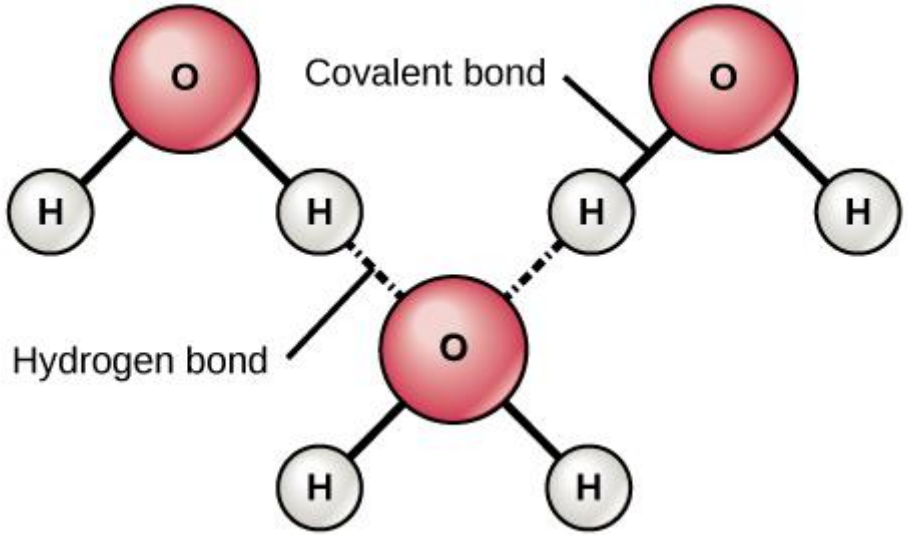
(a) Planetary model of a water molecule



(b) Three-dimensional model of a water molecule



(c) Structural formula for water molecule



Why water is inorganic?

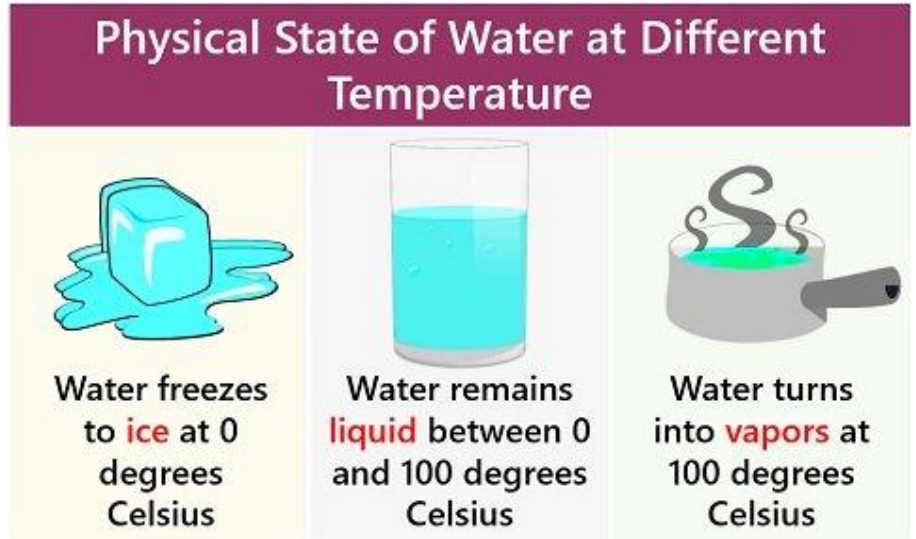
Water (H_2O) is classified as **an inorganic compound** because it does not contain carbon as the primary structural component.

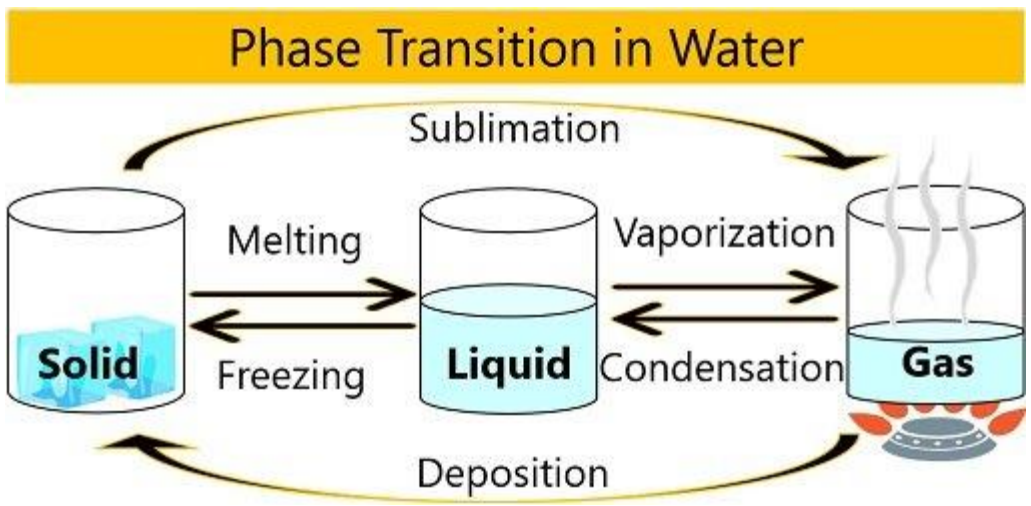
Organic compounds are typically defined as substances that contain carbon bonded to hydrogen. While water does contain hydrogen, the central element is oxygen, not carbon.

Physical States:

Water can exist in three states:

- **Solid:** Ice
- **Liquidwhy water is inorganic?:** Water
- **Gas:** Water vapor


Physical State of Water at Different Temperature
Water freezes to ice at 0 degrees Celsius
Water remains liquid between 0 and 100 degrees Celsius
Water turns into vapors at 100 degrees Celsius


Phase Transition in Water
Sublimation
Melting
Vaporization
Solid
Freezing
Liquid
Condensation
Gas
Deposition

Why water is not providing energy or calorie?

Water itself doesn't provide calories because it doesn't contain the building blocks for energy production.

No Energy-Yielding Nutrients: Calories are a measure of energy derived from macronutrients like carbohydrates, proteins, and fats. Water, composed solely of hydrogen and oxygen, lacks these energy-rich components.

Simple Molecular Structure: The molecular structure of water (H_2O) is relatively simple. Unlike complex molecules found in carbohydrates, proteins, and fats, water molecules cannot be broken down to release energy through metabolic processes.

Water Bonds in Food

Water in food doesn't form specific **"bonds"** in the traditional chemical sense like covalent or ionic bonds. Instead, water interacts with food components through various forces:

Hydrogen Bonding: Water molecules, with their polar nature (positive hydrogen end and negative oxygen end), can form hydrogen bonds with other polar molecules in food, such as carbohydrates (like sugars and starches) and proteins. These weak bonds influence the structure and properties of food.

Hydrophobic Interactions: Water molecules tend to cluster together and exclude nonpolar molecules (like fats and oils). This hydrophobic interaction plays a role in how water interacts with different components within food systems.

Ionic Interactions: Water can interact with ions (charged particles) present in food, such as those from salts. These interactions influence the solubility of various food components.

Important roles of water in food:

Essential Component of Most Foods:

- High water content in foods like fruits and vegetables (over 70%).
- Maintains structure and integrity of tissues.

Food Processing:

- Acts as a solvent for extracting flavors, colors, and nutrients.
- Efficient heat transfer medium for cooking (boiling, steaming).
- Key for cleaning and sanitation.

Food Safety:

- Water activity affects microbial growth; reducing it (e.g., drying) preserves food.
- Hygiene involving water prevents foodborne illnesses.

Food Texture and Quality:

- Contributes to texture (e.g., crispiness of fruits).
- Enhances and carries flavors.

Food Preservation:

- Freezing creates ice crystals, affecting cell structures.
- Drying removes water to inhibit microbial growth and extend shelf life.

Types of Water in Food:

It's important to understand that water exists in different forms within food:

1. Free Water:

Water that is not bound to food components and is easily removed by drying or freezing

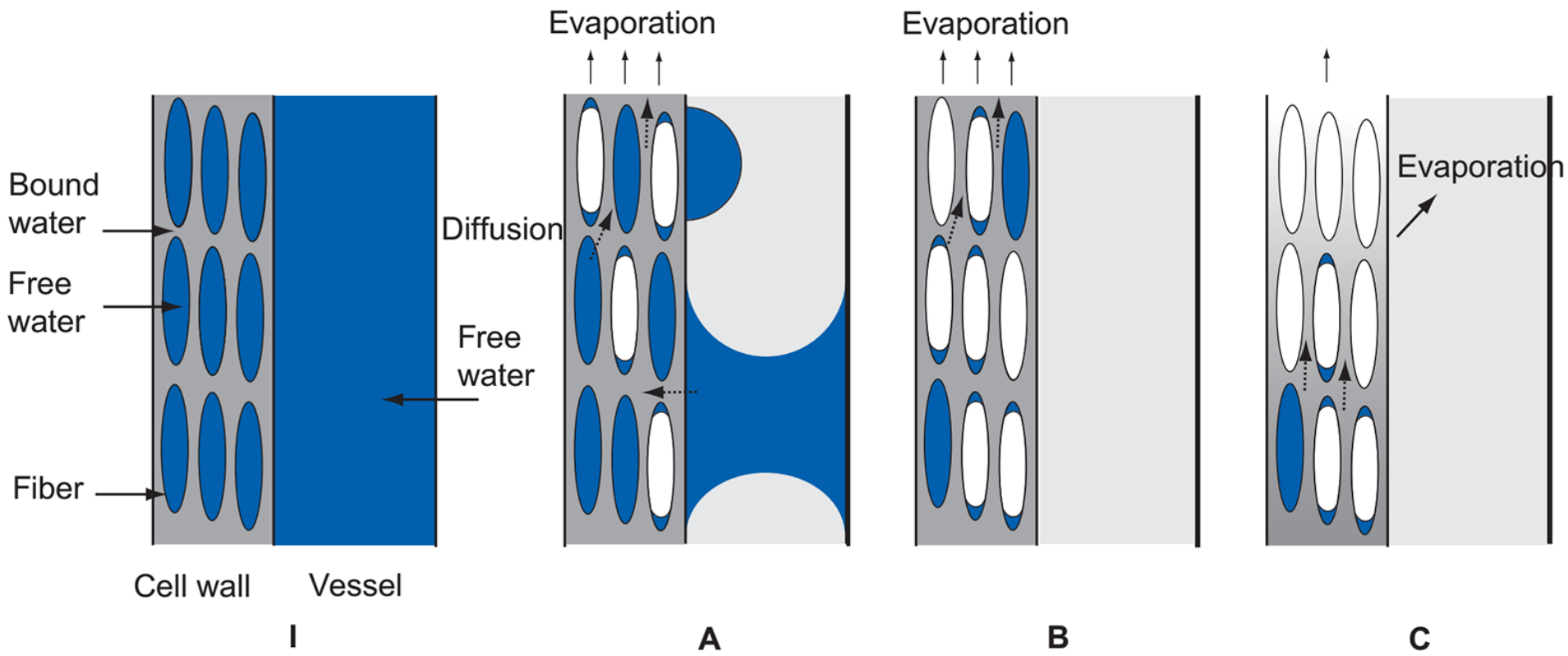
Characteristics

Available for microbial growth.

Contributes to food juiciness and moisture.

Can be extracted mechanically (e.g., squeezing fruits).

Example: The water in fresh fruits and vegetables.


Evaporation
Evaporation
Evaporation
Bound water
Free water
Fiber
Diffusion
Free water
Cell wall
Vessel
I
A
B
C

2. Bound Water: Water that is chemically or physically bound to food molecules, such as proteins, carbohydrates, and salts.

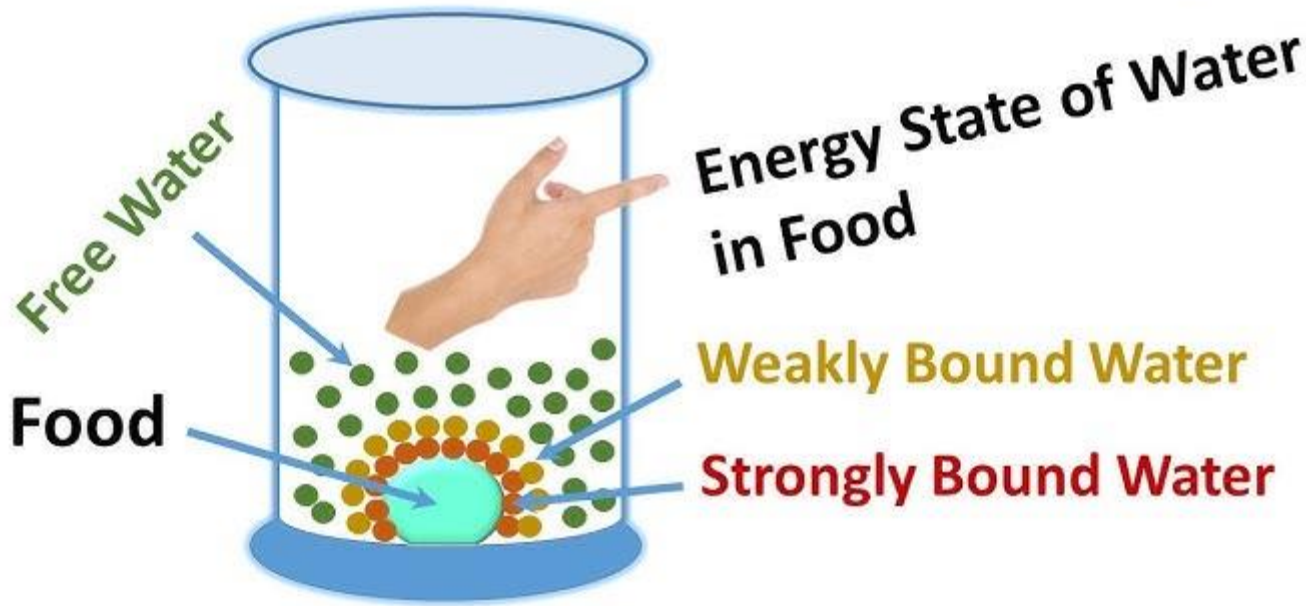
Characteristics:

- Not available for microbial growth.
- Does not freeze at normal freezing temperatures.
- Difficult to remove.

Example:

Water in **proteins or starch gels**.

Understanding of Water Activity



3. Adsorbed Water

- Water held tightly on the surface of food particles by adhesion.

Characteristics:

- Less mobile than free water.
- Does not contribute to microbial growth.
- Plays a role in food texture.
- **Example**: Water adsorbed on the surface of flour particles.

Activity (Aw) is a measurement of the availability of water in a food product for **microbial growth, chemical reactions**, and enzymatic activities.

moisture content: Moisture content simply measures the total amount of water in a food, while water activity measures the availability of that water.

It is expressed as a ratio between the vapor pressure of water in the food and the vapor pressure of pure water at the same temperature:

Water Activity

$$a_w = \frac{P}{P_0}$$

P = vapor pressure in food

P_0 = vapor pressure of pure water

The value of **Aw** ranges from 0 (completely dry) to 1 (pure water).

Importance of Water Activity

1. Microbial Growth:

Most bacteria grow at **Aw > 0.90** (e.g., fresh meats, fruits).

Molds and yeasts can grow at lower **Aw values**, with some tolerating **Aw ~ 0.60**.

Controlling water activity is crucial to prevent spoilage and foodborne illnesses.

2. Food Preservation:

Reducing water activity (e.g., drying, adding salt or sugar) inhibits microbial growth, extending shelf life.

Foods with low **Aw** (e.g., dried fruits, honey) are less prone to spoilage.

3. Chemical Reactions:

Low water activity slows down chemical reactions like enzymatic browning and lipid oxidation.

Helps maintain food quality during storage.

4. Texture and Flavor:

Water activity impacts the crispness, softness, and moisture perception in foods.

Improper control of **Aw** can lead to undesirable texture changes (e.g., soggy crackers).

Factors Affecting Water Activity

Moisture Content:

- Total water in food influences, but does not directly determine, water activity.

Binding Agents:

- Solutes like salt, sugar, and glycerol bind free water, reducing **Aw**.

Temperature:

- increases **Aw**, affecting microbial growth.

Processing Methods:

- Drying, freezing, and concentration reduce water activity.

Water Activity Levels for Common Foods

Fresh fruits: **0.95–1.00**

Bread: **0.93–0.95**

Cheese: **0.91–0.94**

Dried fruits: **0.60–0.75**

Honey: **0.50–0.60**

Crackers and powdered foods: **<0.30**

Applications of Lowering Water Activity

Food Safety: Helps identify safe moisture levels for packaging and storage.

Quality Control: Ensures product stability and prevents spoilage.

Shelf Life Prediction: Lower **Aw** corresponds to longer shelf life.

The equation for water activity (Aw) is:

$$a_w = \frac{P}{P_0}$$

What It Means

•**Vapor Pressure of Water in Food**: The pressure of water vapor that is released by the food product.

•**Vapor Pressure of Pure Water**: The pressure of water vapor released by pure water at the same temperature.

Aw measures how much water in the food is *free* or *available* for microbial activity, chemical reactions, or enzymatic processes.

It ranges from 0 (completely dry) to 1 (pure water).

Calculations

Fresh Fruit (e.g., a fresh apple)

•Fresh apples have a high moisture content. The vapor pressure of water in the apple is almost the same as pure water.
•If the vapor pressure of the apple's water is **23.5 mmHg** and the vapor pressure of pure water is **25 mmHg**

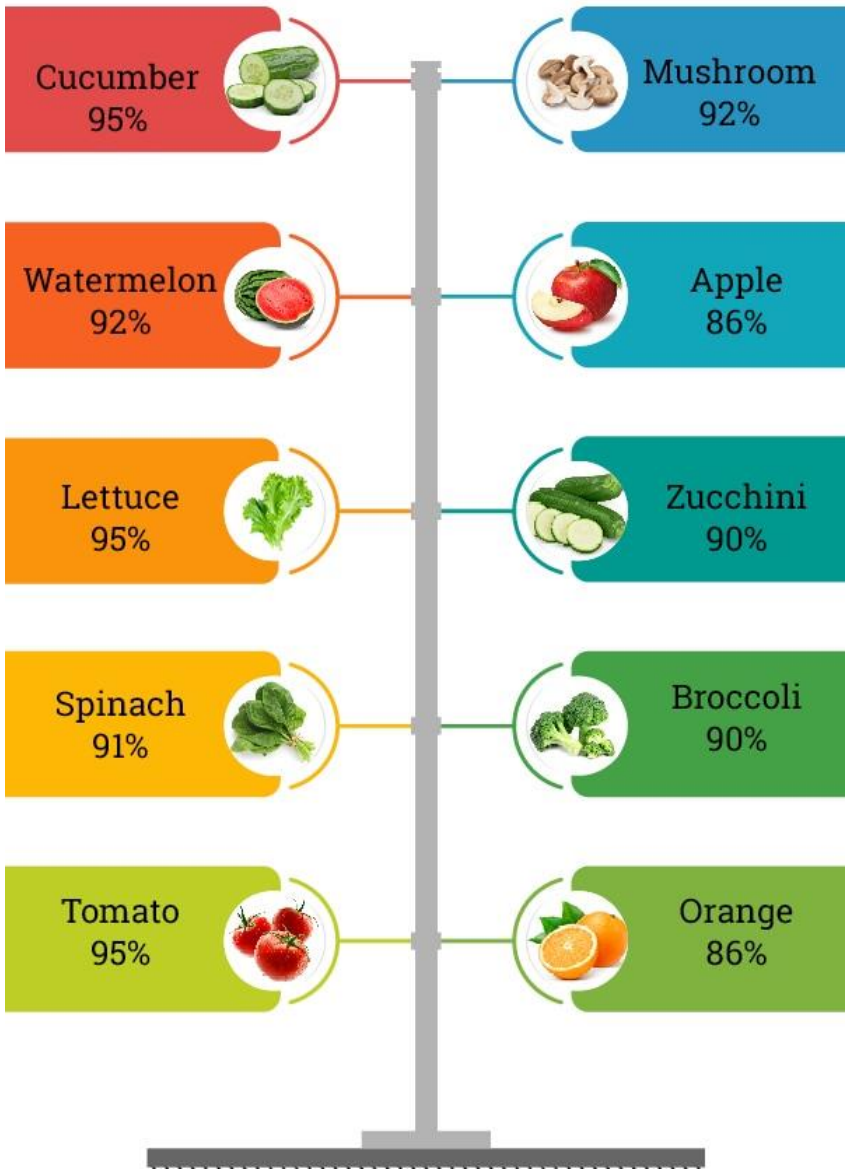
Calculations

Dried Fruit (e.g., raisins)

•In dried fruit, most of the water is bound to solutes like sugars, and less free water is available.

•If the vapor pressure of water in raisins is **10 mmHg** and the vapor pressure of pure water is still **25 mmHg**,

WATER-RICH FOODS




thank
you