WATER IN FOODS

DR SARVENDRA KUMAR
COLLEGE OF FISHERIES KISHANGNJ

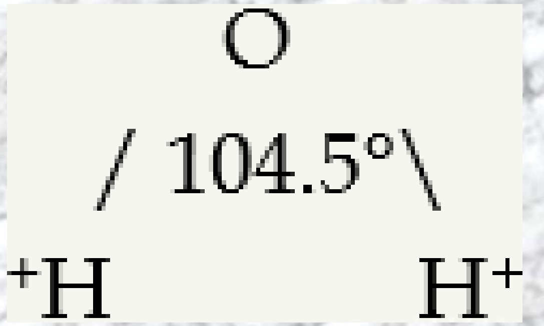
Introduction

- Water is the most critical of all nutrients and major component of all living organism
- It constitutes 60% or more of the weight of most living things
- Essential constituent of all cell structures and provide the medium in which all the chemical reactions of a cellular metabolism take place.
- Water is the universal solvent and dispersing agent, as well as a very reactive chemical compound.
- Biologically active structures of macromolecules are spontaneously formed only to aqueous media

- It is an active partner of molecular interactions, participating directly in many biochemical reactions (as a substrate or a product)
- high heat capacity allows water to act as a heat buffer in all organisms.
- Regulation of water contents is important in the maintenance of homeostasis in all living systems.
- Stability and shelf life are significant features of foods that are, influenced by the water content.
- The physical properties, quantity, and quality of water within food have a strong impact on food effectiveness, quality attributes, shelf life, textural properties and processing.

Structure and Properties of water

- Chemical composition, HOH, or H_2O, is universally known, the simplicity of its formula belies the complexity of its behavior.
- Although a water molecule is electrically neutral as a whole, it has a dipolar character.
- The high polarity of water is caused by the direction of the H-O-H bond angle, which is 104.5º, and by an asymmetrical distribution of electrons within the molecule.



- In a single water molecule, each hydrogen atom shares an electron pair with the oxygen atom
- Sharing of electrons between H and O is unequal because the more electronegative oxygen atom tends to draw electrons away from the hydrogen nuclei.
- The result of this unequal electron sharing is the existence of two electric dipoles in the molecule, one along each of the H-O bonds.
- The oxygen atom bears a partial negative charge and each hydrogen atom a partial positive charge. (Because the molecule is not linear, H-O-H has a dipole moment)
- **Water molecules can interact through electrostatic attraction between the oxygen atom of one water molecule and the hydrogen of another.**

Hydrogen bond in water

- Electrons on one molecule can be partially shared with the hydrogen on another, are known as **hydrogen bonds.**
- The H_2O molecule, which contains two hydrogen atoms and one oxygen atom in a non-linear arrangement, is ideally suited to engage in hydrogen bonding.
- An individual, isolated hydrogen bond is very labile.
- It is longer and weaker than a covalent O-H bond

- The hydrogen bond’s energy, that is, the energy required to break the bond, is about 20kJ/mol.
- These bonds are intermediate between those of weak Van der Waals interactions (about 1.2 kJ/mol) and those of covalent bonds (460kJ/mol).
- Hydrogen bonds are highly directional; they are stronger when the hydrogen atom and the two atoms that share it are in a straight line.
- They are formed between water and different chemical structures, as well as between other molecules (Intermolecular) or even within a molecule (Intramolecular)

Water in foods

- Most natural foods contain water up to 70% of their weight.
- Water in foods is classified in to two types: (a) bound water and (b) free water
- Water that can be extracted easily from foods by squeezing or pressing or cutting or pressing is called as **free water**

Bound Water

- Water that is held so tightly by another molecule (such as a protein)
- Not easily removed from the food is called bound water.
- This water is not free to act as solvent for salts and sugars.
- It can be frozen only at very low temperatures.
- density is greater than water.
- The water molecules are bound to polar groups or ions on molecules such as starches, pectin, and proteins.
- **The bound water is of three types**

i. Constitutional

ii. Vicinal

iii. Multilayer

i. Constitutional: They form an **integral part of a non aqueous constituent** forming **<0.03%.**

-It is constituted by a monolayer of water molecules absorbed on the polar absorption site of the molecule is almost immobilized and thus behaves, like part of the solid or like water in ice.

ii. Vicinal: It is the bound water that strongly acts with **specific hydrophilic sites** of non-aqueous constituents to form a monolayer coverage; water-ion and water-dipole bonds forming **0.1 to 0.9%.**

iii. Multilayer: Bound water that forms several additional layers around hydrophilic groups, water-water and water-solute hydrogen bonds. **It forms 1-5%.**

Free or entrapped water

- Water that can be extracted easily from foods by squeezing or cutting or pressing is called as free water.
- Free water is held within matrix or gel,
- Entrapped water is immobilized in capillaries or cells but if released during cutting or damage, it flows freely.

Water activity or a_w

- is a measurement of water content.
- It is defined as the vapour pressure of a liquid divided by that of vapour pressure of the pure water at the same temperature; therefore
- **pure distilled water has a water activity of exactly one.**

Water activity (a_w) $=P/P_o$

where P is the vapor pressure of water in the substance,

and P_0 is the vapor pressure of pure water at the same temperature

- Higher aw substances tend to support more microorganism.
- Bacteria usually require at least 0.91, and fungi at least 0.7.

- Many of the chemical and biological processes that cause deterioration of foods, and ultimately spoilage, are water dependent.
- Water activity a_w represents the water which is made available for the microbial action.
- Microbial growth is directly linked to water activity
- Essentially, water activity is the measure of the degree to which water is bound within the food, and hence is unavailable for further chemical or microbial activity
- Relative humidity is reported as a percentage whereas water activity is expressed as a fraction.
- Thus if a sample of meat sausage is sealed within an airtight container, the humidity of the air in the head space will rise and eventually equilibrate to a relative humidity of, say 83%, which means that the water activity (a_w) of the meat sausage is 0.83.

Water activity and Shelf life of Foods

- It is an important consideration for food product design and food safety.
- Food designers use water activity to formulate products that are shelf stable.
- **If a product is kept below a certain water activity, then mold growth is inhibited. This results in a longer shelf-life.**
- Water activity is used in many cases as a critical control point for Hazard Analysis and Critical Control Points (HACCP) programs.
- HACCP -management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production
- Samples of the food product are periodically taken from the production area and tested to ensure water activity values are within a specified range for food quality and safety.

WATER ACTIVITY OF SOME FOODS

Substance	a_w
Distilled Water	1
Tap water	0.99
Raw meats	0.99
Milk	0.97
Juice	0.97
Cooked bacon	< 0.85
Saturated NaCl solution	0.75
Dried fruits	0.60
Typical indoor air	0.5 - 0.7
Honey	0.5 - 0.7
Dried fruit	0.5 - 0.6

Microbial growth

- Many of the chemical and biological processes that cause deterioration of foods, and ultimately spoilage, are water dependent.
- Microbial growth is directly linked to water activity.
- No microbes can multiply at a water activity below 0.6.

Dehydration

- Dehydration is the oldest form of food preservation
- Drying - removing water for making it unavailable for microbial growth.

Salting or curing

- A saturated solution of common salt has a water activity of close to 0.75.
- Thus by adding sufficient salt to foods, the water activity can be lowered to a level where most pathogenic bacteria are inactivated but the moisture content remains high.
- The water activity of the salted food is 0.8.

Benefits of drying of food

- The dangerous pathogenic bacteria associated with food, such as *Clostridium* or *Vibrio* spp. which cause botulism and cholera, can multiply at water activity values below about 0.9.
- Drying or providing sufficient water-binding humectants is an effective method of preventing the growth of food-poisoning bacteria.
- Only Osmophilic yeast and some molds can grow at water activities in the range 0.6 to 0.65.
- Thus, by reducing the water activity below these values, foods are microbial stable.

Chemical reactions and water activity

- Various chemical reactions that proceed, and may be accelerated, at low values of water activity.
- Maillard reactions **(between amino acid and sugar)** leading to lysine loss and brown color development peaks at **a_w around 0.5 to 0.8.**
- Enzymatic hydrolysis decreases with water activity down to $a_w = 0.3$ and is then negligible.
- Water is facilitator of biochemical deterioration of foods.

- Dry foods are much more stable than wet foods, because low water activity, a_w.
- Freezing removes water from the food matrix by forming ice crystals.
- Although the ice crystals remain in the food, the remaining water which is in contact with the food matrix becomes concentrated with solutes and it’s a_w becomes low.
- Most micro-organisms stop functioning below the water activity of about 0.7.