Frequently Asked question

1. Write on the importance of water as a constituent of food.

Water as a constituent of food is understood as total water or moisture content and water activity. Research has highlighted the importance of water activity as more prominent than water content of a food. The choice of water activity over water content is due to water activity being the determinant of microbial growth, relation with chemical/enzymatic degradation in foods and its ease of measurement. Water can be a reactant or an end product and participate in reactions that can alter the characteristics of a food such as providing a pro oxidant or antioxidant action, dissolution or dilution of chemical reactants in foods. Thus, water has an important role in the stability of most of the food products. The quantity and characteristic of water present in foods has an impact on the chemical processes of value in terms of food safety.

2. Highlight the differences in physical characteristics between water and ice.

Water exhibits a high melting point of 0^0C and boiling point of 100^oC. Water transforms into ice on exposure to temperature of 0^oC or below. The thermal diffusivity which is indicative of the rate at which a material can undergo a change in temperature or the rate at which heat moves inside a compound is 9 times higher in ice than water. Vapour pressure of water (0.6113) is higher than ice at -20^oC (0.103). Thermal conductivity increases with decrease in temperature with water having 0.561 (W/m/K), ice at 0^oC having 2.240 (W/m/K) and ice at -20^0C having 2.433 (W/m/K) of thermal conductivity.

3. Explain the structure of water molecule.

Water consists of two hydrogen atoms and an oxygen atom. Each hydrogen molecule is bound to the central oxygen atom by a pair of electrons by a covalent bond. Out of the six electrons in the outer shell of oxygen atom, two are engaged in bonding with the hydrogen molecule and the other four atoms are free which arrange far from each other owing to the similar charges. This results in a tetrahedral formation. The repulsion of the electrons in the covalent bond by the electrons in the oxygen atom, the two hydrogen atoms are bought closer at an angle of 105^o.

4. Explain the structure of ice molecule.

Ice has a well-defined structure compared to water molecule. n the solid state (ice), The intermolecular interactions are highly organized yet the structure is loose where each oxygen atom is surrounded by four hydrogen atoms. Two among the four hydrogen atoms are covalently bonded to the oxygen atom, and the two others (at longer distances) are hydrogen bonded to the oxygen atom's unshared electron pairs.This open structure of ice causes its density to be less than that of the liquid state. On thawing, this bridging breaks open leading to the formation of liquid water.

5. Write on the various types of water present in foods.

Water in foods is classified into two categories namely free water and bound water. The proportion of total water that is bound by water soluble compounds resulting in a food matrix that further ceases the availability of bound water to physical, chemical and microbial activity. The free water on the other hand is available for the aforementioned reactions inside food and can support the growth of microbes. Major proportion of water is in the bound form i.e. bound to ions or bound to surfaces of large molecules or cell structures. The reactive nature of a food is thus dependent on the intensity of bound water.

6. Define water activity?

Water activity (a_w) is defined as the ratio of the vapour pressure of water in a substance to the vapour pressure of pure water. It is calculated using the following formula-

$$a_w = p/p_o$$

where a_w is the water activity of a food, p is the partial pressure of water in a substrate and p_o is the vapour pressure of pure water in the same temperature. Water activity defines the efficacy of water in the food to take part in chemical reactions. Bound water negatively affects the water activity as it has lower chances of escaping the food as vapour thus has zero partial pressure.

7. Write on equilibrium relative humidity.

Relative humidity of a food product is the humidity of air surrounding the food. When this humidity is in equilibrium with the humidity in the environment, it is termed as equilibrium relative humidity (ERH). At his point the food product does not gain nor lose water. Foods start gaining moisture when the relative humidity is higher than ERH and foods become drier when the relative humidity falls below ERH. ERH is dependent on the chemical compound, temperature, water content, storage conditions, absolute pressure and packaging.

Water activity can be derived from ERH using the following formula-

a_w = equilibrium relative humidity (ERH) /100

Thus a food with a water activity (aw) of 0.7 would produce an ERH of 70%.

8. What are sorption isotherms?

The relationship between water activity and moisture content at a given temperature is called the moisture sorption isotherm.This relationship is complex and unique for each food product due to difference inthe nature of physical and chemical interactionsbetween the water and solids in food. Adsorption and desorption isotherms are used for observation of hygroscopic products and the process of drying respectively. These processes are not fully reversible and can be differentiated based on the changes in moisture content. On adsorption, a food becomes wet (gains moisture) and desorption it becomes dry (loses moisture). Typically water sorption isotherms have a sigmoidal curve

9. Brief on the relation between water activity and shelf life.

Water activity (a_w) is one of the critical determinants of food quality and safety. Water activity affects the shelf life, safety, texture, flavor, and smell of foods.Although factors such as temperature and pH caninfluence the rate and extent of growth of microbes, water activity is the most important factor in controlling spoilage. Water activity determines the lower limit of water available for microbial growth and has a significant role in determining the activity of enzymes and vitamins in foods and can have a major impact their color, taste, and aroma. Physical changes include loss of crispness in dry products, caking and clumping of powders and loss of water from moist foods making them sticky.

10. How can water activity affect microbial growth?

Microbes with ability to induce food spoilage need certain conditions for proliferation and life processes namely available moisture, optimum pH, the right temperature and nutrients. The growth or microbes can be checked by controlling these factors and shelf life of a product can be increased and thus the water activity is related directly can promote or hamper microbial growth.Bacteria require higher values of a_w for growth compared to fungi and gram-negative bacteria require higher water activity than gram-positive bacteria. Foods with high water activity are highly perishable.Water activity is useful in predicting the growth of bacteria, yeast, and mold. Control of either acidity level (pH) or the level of water activity (aw) in a food can suppress microbial growth. This can effectively increase the stability of a food. Food safety can thus be ensured by lowering the water activity to a point that is unfavorable for microbial growth.

11. What is the influence of water activity on chemical reactivity of foods?

A complex relationship exists between water activity and reactions of both chemical and enzymatic in nature. Water activity in foods canalter the hydration of ionic groups, cause dissolution and mobilization of chemical components, can increase of a reactant or can dilute the reactant. Chemical deterioration of packaged foods can be due to three major reactions in food namely Oxidation of lipids, Enzymatic degradation and Non-enzymatic browning. Maximum browning has been reported between 0.3–0.7 water activity and the rate of browning decreases at high water activities due to the dilution of the reactants.Water can behave as an antioxidant at low $a_w$by hydrating the metal ions, formation of bonds with hydroperoxides and can also behave as a pro oxidant at higher water activity levels by increasing mobility and causing dissolution of reactants.

12. How is lipid degradation and water activity related?

Free radical synthesis is catalyzed by heat, light or metal ions for instance copper ions. Free radicals result in peroxides that are further converted into alcohols, aldehydes, ketones,and free fatty acids. Many of these compounds have strong flavors and odors referred to as ‘rancid fat’.At both very high and very low water activities, lipid oxidation rates are high compared to

the rate at intermediate water activities.Other reasons for lipid oxidation are action of free radicals, enzymatic actionand oxidation by light.Byproducts of lipid oxidation are known to promote vitamin degradation.

13. How is enzyme action dependent on water activity?

Enzymes are known to negatively transform foods and can prolong the enzyme activity in foods. Most enzymatic reactions are slowed down at water activities below 0.8, but some reactions occur even at very low a_w. Enzyme such as amylases, phenoloxidases, and peroxidases can be active at low water activity. The enzymatic action of lipase on triglycerides inside food, leads to the formation of free fatty acids resulting in rancidity. End products are detectable in a minute concentration of 0.3%. Butyric acid found in rancid butter is capable of producing rancid flavour at minimal concentration.

14. How is packaging of foods influenced by water activity?

After establishing the upper and lower water activity levels of a food, the information on temperature, relative humidity etc can help in the selection of a suitable packaging material. Sorption isotherms also have animportant role in the selection of packaging materials. Hygroscopic products need moisture proof material, for example glass containers with waterproof seals or thick polyvinylchloride material. Non hygroscopic products can be packed in polyethylene containers as reactions do not occur at normal storage conditions.Consider the example of processed cheese and baked goods, these foods require packaging material to prevent the loss of moisture as their equilibrium relative humidity is higher and environmental conditions.

15. Write on the water activity level at which various biochemical reactions occur in foods.

Water activity ranges from 0 to1.0, where 1.0 is water activity of pure water. Bacteria growth starts at >0.75 a_w, whereas as growth of all microbes is initiated >0.6a_w. Maillard reactions / browning occurs at a maximum rate at 0.6-0.7 a_w and inactivation of enzymes occurs at <0.75 a_w. Preservation of B-vitamins such as vitamin C, E and Thiamine is observed at lower $a_w$less than 0.6.