1. **Explain the following briefly (Attempt Any Ten):**
    - **(a) Food foam.**
        - Food foam is a colloidal system where gas bubbles are dispersed within a continuous liquid or semi-solid phase (usually containing proteins or polysaccharides). It is a type of gas-in-liquid dispersion, often stabilized by amphiphilic molecules (like proteins or surfactants) that reduce surface tension at the gas-liquid interface and form a protective film around the bubbles. Examples include whipped cream, meringues, and bread dough.
    - **(b) Facultative Microorganisms.**
        - Facultative microorganisms are a type of microorganism (bacteria, fungi, etc.) that can grow and thrive in both the presence and absence of oxygen. They are highly adaptable and can switch their metabolic pathways to utilize either aerobic respiration (with oxygen) or anaerobic fermentation (without oxygen) depending on the environmental conditions. This adaptability makes them significant in various environments, including food spoilage and industrial fermentations.
    - **(c) CIP.**
        - CIP stands for Cleaning In Place. It is an automated method of cleaning the interior surfaces of pipes, vessels, process equipment, filters, and fittings, without requiring their disassembly. CIP systems use a combination of turbulent flow, heat, and chemical action (detergents, sanitizers) to remove soil and sanitize equipment, ensuring hygiene in food processing, dairy, beverage, and pharmaceutical industries.
    - **(d) Logarithmic growth phase.**

- The logarithmic growth phase (also known as the exponential phase) is a period in the microbial growth curve where microorganisms are dividing and growing at their maximum, constant rate under optimal conditions. During this phase, the population doubles at regular intervals, and the logarithm of the cell number increases linearly with time. This phase is characterized by abundant nutrients and minimal accumulation of toxic waste products.

- **(e) Threshold concentration.**
  - Threshold concentration, in the context of food science or toxicology, refers to the minimum concentration of a substance (e.g., a flavor compound, a chemical contaminant, or a microbial toxin) that produces a detectable or measurable effect. Below this concentration, the effect is generally not perceived or is considered negligible. For example, it can be the minimum concentration of a chemical perceived by human senses (taste, smell).

- **(f) Specific Gravity.**
  - Specific gravity is a dimensionless ratio of the density of a substance to the density of a reference substance, typically water at a specified temperature (usually $4°C$ where water density is $1g/cm^3$). It indicates how much denser or less dense a substance is compared to water. For example, a specific gravity of 0.8 means the substance is 0.8 times as dense as water. In food, it's used to assess quality or concentration, e.g., sugar content in syrups.

- **(g) Laminates in Packaging.**

  - Laminates in packaging are multi-layered packaging materials made by bonding together two or more different materials (e.g., plastics, paper, foil) to combine their individual desirable properties into a single, enhanced material. This creates a composite structure with improved barrier properties (against oxygen, moisture, light), strength, sealability, and printability, extending the shelf life and protecting the quality of packaged food products.

- **(h) Syneresis of Gel.**
  - Syneresis (also known as "weeping") of gel is the phenomenon where a gel contracts and exudes a small amount of liquid, resulting in the separation of a liquid phase from the gel matrix. This occurs due to the rearrangement and tightening of the polymer network within the gel, which expels the entrapped solvent. It is commonly observed in food gels like yogurt, cheese, or fruit jellies over time.

- **(i) Layout of Sensory Evaluation Lab.**
  - A sensory evaluation lab is specifically designed to provide a controlled environment for conducting sensory tests objectively. A typical layout includes:
    - **Preparation Area/Kitchen:** For preparing and portioning food samples.
    - **Testing Booths/Cabinets:** Individual, isolated booths with controlled lighting, ventilation, and temperature to minimize distractions and biases for panelists.
    - **Reception/Briefing Area:** For panelist check-in, instructions, and debriefing.

- **Storage Area:** For samples, equipment, and supplies. The design aims to prevent cross-contamination and ensure consistent testing conditions.

- **(j) Triangle test.**
  - The triangle test is a type of difference test (discriminatory test) used in sensory evaluation to determine if a perceptible difference exists between two samples. Panelists are presented with three samples, two of which are identical and one is different. Their task is to identify the odd sample. It is a simple, statistically powerful test used to detect overall differences, often in product development or quality control.
- **(k) Viscosity.**
  - Viscosity is a measure of a fluid's resistance to flow or deformation under shear stress. It describes the "thickness" or "stickiness" of a fluid. A highly viscous fluid (like honey) flows slowly, while a low-viscosity fluid (like water) flows easily. It is an important rheological property in food science, affecting processing (pumping, mixing), texture (mouthfeel), and product stability.

2. **Differentiate between any three the following:**
   - **(a) Sols and Gels.**
     - **Sols:**
       - **Definition:** Colloidal dispersions where solid particles are dispersed in a continuous liquid medium.
       - **Structure:** Relatively fluid, flowable systems where the solid phase is dispersed but does not form a continuous network.

        - **Examples:** Milk (fat globules in water), blood, starch solutions, paint.
        - **Properties:** Exhibit flow characteristics similar to true solutions but scatter light (Tyndall effect).
    - **Gels:**
        - **Definition:** Colloidal dispersions where a liquid is entrapped within a continuous, three-dimensional solid network, creating a semi-solid or jelly-like consistency.
        - **Structure:** The dispersed solid phase forms an interconnected network that immobilizes the liquid phase.
        - **Examples:** Jelly, gelatin, yogurt, cheese, agar.
        - **Properties:** Exhibit viscoelastic properties, are semi-rigid, and do not flow readily. Can undergo syneresis (weeping).

- **(b) Descriptive and discriminatory test.**
    - **Descriptive Test:**
        - **Objective:** To identify and quantify the sensory characteristics (attributes) of a food product. It describes *what* the product tastes, smells, feels, and looks like, and *how intense* each attribute is.
        - **Panel:** Requires trained panelists who are calibrated to use a common language and intensity scale.
        - **Output:** Generates a detailed sensory profile or "fingerprint" of the product, often presented as a spider plot or bar graph.

- **Application:** Product development, quality control, competitive analysis, understanding consumer preference drivers.

- **Discriminatory Test:**
  - **Objective:** To determine if a perceptible sensory difference exists between two or more samples, without necessarily describing the nature or magnitude of the difference. It answers the question *if* there is a difference.
  - **Panel:** Can use untrained or minimally trained panelists, as the task is simpler (detecting a difference).
  - **Output:** Statistical probability indicating whether the observed difference is significant or due to chance.
  - **Application:** Quality control (e.g., comparing new batch to standard), ingredient substitution, shelf-life studies, determining impact of processing changes (e.g., Triangle test, Duo-trio test).

- **(c) Primary and secondary packaging.**
  - **Primary Packaging:**
    - **Definition:** The packaging that is in direct contact with the food product. It is the first layer of protection.
    - **Function:** Directly contains the product, provides a barrier against contamination, moisture, oxygen, and light, and often carries necessary product information.

- **Examples:** A cereal bag inside a box, a plastic bottle for juice, a can for soup, a flexible pouch for snacks.
- **Material Choice:** Critical for product safety, shelf-life, and interaction with the food.

- **Secondary Packaging:**
  - **Definition:** The packaging that contains multiple primary packages. It does not directly contact the food product.
  - **Function:** Groups primary packages for easier handling, shipping, and display; provides additional protection; carries marketing information; and aids in branding.
  - **Examples:** A cardboard box holding multiple cereal bags, a shrink-wrapped tray of juice bottles, a carton containing several cans of soup.
  - **Material Choice:** Focuses on structural integrity, marketing, and logistics.

- **(d) COD and BOD.**
  - **COD (Chemical Oxygen Demand):**
    - **Definition:** A measure of the total amount of oxygen required to chemically oxidize all organic and inorganic pollutants in a water sample using a strong chemical oxidant (e.g., potassium dichromate) under acidic conditions.
    - **Measurement Time:** Relatively quick (a few hours).
    - **Scope:** Measures the oxygen demand from both biodegradable and non-biodegradable organic

matter, as well as some inorganic reducing substances.

- **Application:** Used for rapid assessment of total organic pollution in wastewater, industrial effluents, and environmental samples. Provides a good estimate of overall pollution load.

▪ **BOD (Biochemical Oxygen Demand):**

- **Definition:** A measure of the amount of dissolved oxygen consumed by aerobic microorganisms when decomposing organic matter in a water sample over a specific period (typically 5 days, BOD_5) at a specified temperature ($20°C$).
- **Measurement Time:** Long (usually 5 days for BOD_5).
- **Scope:** Measures only the oxygen demand from *biodegradable* organic matter.
- **Application:** Used to assess the impact of biodegradable organic pollutants on aquatic environments and to evaluate the effectiveness of biological wastewater treatment processes. Represents the oxygen consumed by microbial respiration.

○ **(e) Trained and Untrained Panel.**

▪ **Trained Panel (Descriptive Panel):**

- **Composition:** Consists of individuals selected for their sensory acuity and ability to consistently detect, identify, and quantify specific sensory attributes. They undergo extensive training (often hundreds of hours).

- **Role:** Develops a common sensory language, defines attributes, and rates their intensity using scales. Acts as a "measuring instrument."
- **Output:** Objective, quantitative sensory profiles used for detailed product characterization and understanding differences.
- **Application:** Product development, quality control, research to link sensory attributes to consumer liking.

- **Untrained Panel (Consumer Panel/Discriminatory Panel):**
  - **Composition:** Consists of individuals who represent the target consumer group. They are not specifically trained in sensory evaluation, reflecting the general public's perception.
  - **Role:** Primarily used to assess overall preference, acceptance, or to detect if a simple difference exists.
  - **Output:** Subjective data on liking, preference, or simple difference detection.
  - **Application:** Market research, new product launch decisions, quality control (difference detection).

3. **(a) Discuss the factors affecting foam formation and its stability.**
   - Foams are colloidal dispersions of gas in a liquid, and their formation and stability are critical in many food products (e.g., whipped cream, bread, beer, ice cream, meringues).
   - **Factors Affecting Foam Formation:**
     - **i. Presence of Surface-Active Agents (Surfactants):**

- **Explanation:** These are molecules that reduce the surface tension of the liquid, allowing gas bubbles to be easily incorporated and stabilized at the gas-liquid interface. Proteins (e.g., egg albumin, milk proteins) and some polysaccharides (e.g., gum arabic) are common food surfactants.
- **Impact:** Without effective surfactants, foams either don't form or are extremely unstable. Proteins denature and unfold at the interface, forming a strong film.

- **ii. Whipping/Agitation Method and Speed:**
  - **Explanation:** Mechanical energy (whipping, beating, aeration) is required to entrap gas into the liquid phase. The speed and type of agitation influence the size and distribution of gas bubbles.
  - **Impact:** Optimal agitation creates small, uniform bubbles, which contribute to better foam stability. Too little agitation won't form a foam, while excessive agitation can destabilize certain foams by over-shearing the interfacial film.
- **iii. Temperature:**
  - **Explanation:** Temperature affects the viscosity of the liquid, the solubility of gases, and the conformation of proteins.
  - **Impact:** Generally, lower temperatures increase liquid viscosity and gas solubility, aiding foam formation and stability (e.g., cold cream whips better). However, excessively low temperatures can cause fat crystallization that hinders protein adsorption. Optimal temperature varies by system.

- **iv. Concentration of Foaming Agents:**
  - **Explanation:** There's an optimal concentration of proteins or other foaming agents.
  - **Impact:** Too low concentration means insufficient film formation. Too high can lead to increased viscosity hindering aeration or protein aggregation reducing solubility.
- **v. Viscosity of the Liquid Phase:**
  - **Explanation:** A higher viscosity can make it harder to incorporate air initially but can improve stability by slowing drainage and preventing bubble coalescence once formed.
  - **Impact:** Thicker liquids tend to form more stable foams.

- **Factors Affecting Foam Stability:**
  - **i. Interfacial Film Properties:**
    - **Explanation:** The strength, elasticity, and permeability of the film surrounding the gas bubbles are paramount. A strong, flexible, and impermeable film prevents gas escape and bubble coalescence.
    - **Impact:** Proteins, upon denaturation and cross-linking at the interface, form a robust film that provides structural integrity. Polysaccharides can increase viscosity of the continuous phase, further stabilizing the film.
  - **ii. Drainage:**

- **Explanation:** Gravity causes the liquid between the bubbles to drain downwards, thinning the interfacial films and making them more prone to rupture.
- **Impact:** High viscosity of the continuous phase (e.g., by adding hydrocolloids like gums) slows down drainage, increasing foam stability.

▪ **iii. Disproportionation (Ostwald Ripening):**

- **Explanation:** Gas diffuses from smaller, higher-pressure bubbles to larger, lower-pressure bubbles. This causes small bubbles to shrink and disappear, while large bubbles grow at their expense, leading to coarsening of the foam structure.
- **Impact:** Reduces foam stability over time as larger bubbles are more prone to rupture. Minimizing the initial size variation of bubbles helps.

▪ **iv. Coalescence:**

- **Explanation:** The rupture of the liquid film between adjacent bubbles, leading to their merging and formation of larger bubbles.
- **Impact:** Leads to rapid foam collapse. Factors that strengthen the film (e.g., protein cross-linking, presence of finely dispersed solid particles like fat crystals in whipped cream) inhibit coalescence.

▪ **v. Presence of Lipids/Fats:**

- **Explanation:** The effect of lipids is complex. Low levels of free fat can destabilize foams by competing with proteins at the interface or by spreading across the film and causing rupture. However, solid fat crystals (e.g., in cream) can stabilize foams by piercing the interface and anchoring the protein film.

- **Impact:** Excess liquid fat is generally detrimental to foam stability (e.g., why greasy utensils prevent meringues from forming).

- **vi. pH:**
  - **Explanation:** pH affects the charge and conformation of proteins, influencing their solubility and ability to adsorb at the interface.
  - **Impact:** Proteins typically have maximum foaming properties away from their isoelectric point (where they have net zero charge and minimum solubility).

- **vii. Salts and Sugars:**
  - **Explanation:** Salts can affect protein solubility and charge. Sugars increase viscosity and can compete with proteins for water, influencing film formation.
  - **Impact:** Moderate sugar levels can stabilize foams by increasing viscosity, but very high sugar concentrations can hinder protein denaturation and foam formation initially.

(b) Discuss briefly the chemical composition of Foods.

- Foods are complex matrices composed of various chemical constituents that provide energy, nutrients, and define their sensory and physical properties. These can be broadly classified into macronutrients, micronutrients, and non-nutritive components.
- **i. Macronutrients:**
  - **Carbohydrates:**

- **Composition:** Organic compounds made of carbon, hydrogen, and oxygen ($C_n(H_2O)_n$).
- **Forms:** Sugars (monosaccharides like glucose, fructose; disaccharides like sucrose, lactose), starches (polysaccharides like amylose, amylopectin), and dietary fibers (e.g., cellulose, hemicellulose, pectin).
- **Role:** Primary source of energy, structural components in plants, contribute to texture, sweetness, and browning reactions.

- **Proteins:**
  - **Composition:** Large, complex molecules made up of chains of amino acids (containing carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur).
  - **Forms:** Globular (e.g., enzymes, albumins) and fibrous (e.g., collagen, myosin).
  - **Role:** Essential for growth, repair, and maintenance of tissues; form enzymes, hormones, and antibodies; contribute to texture (gelation, emulsification), foaming, and flavor.
- **Lipids (Fats and Oils):**
  - **Composition:** Diverse group of organic compounds insoluble in water, primarily made of carbon, hydrogen, and oxygen (but with less oxygen than carbohydrates). Primarily triglycerides (glycerol backbone + 3 fatty acids).
  - **Forms:** Saturated, monounsaturated, polyunsaturated fats; phospholipids; sterols (e.g., cholesterol).

        - **Role:** Concentrated source of energy, aid in absorption of fat-soluble vitamins, contribute to flavor, aroma, mouthfeel, and satiety.

- **ii. Micronutrients:**
    - **Vitamins:**
        - **Composition:** Organic compounds required in small amounts for normal metabolism, growth, and overall health.
        - **Forms:** Water-soluble (e.g., B vitamins, Vitamin C) and fat-soluble (e.g., Vitamins A, D, E, K).
        - **Role:** Act as coenzymes, antioxidants, and regulators of various bodily functions.
    - **Minerals:**
        - **Composition:** Inorganic elements (e.g., calcium, iron, potassium, sodium, zinc, selenium) required in various amounts.
        - **Forms:** Major minerals (needed in larger quantities) and trace minerals (needed in smaller quantities).
        - **Role:** Structural components (bones, teeth), nerve and muscle function, fluid balance, enzyme cofactors, oxygen transport.
- **iii. Water:**
    - **Composition:** H_2O.
    - **Role:** The most abundant component in most foods (often $70 - 90\%$). Acts as a solvent, participates in chemical reactions, influences texture, shelf life (water activity), and heat transfer during cooking.

- **iv. Non-Nutritive Components / Minor Constituents:**
  - **Organic Acids:** (e.g., citric acid in fruits, lactic acid in fermented products) - contribute to flavor, pH, and preservation.
  - **Pigments:** (e.g., chlorophylls, carotenoids, anthocyanins) - provide color.
  - **Flavor Compounds:** (e.g., esters, aldehydes, ketones) - responsible for aroma and taste.
  - **Enzymes:** Biological catalysts (e.g., proteases, amylases, lipases) - can cause desirable (ripening, fermentation) or undesirable (spoilage) changes.
  - **Antioxidants:** (e.g., flavonoids, polyphenols) - protect against oxidation and may have health benefits.
  - **Food Additives:** Substances added to food to preserve flavor, enhance taste, improve appearance, or extend shelf life (e.g., preservatives, colorants, emulsifiers, stabilizers).

(c) Outline the basic description of Texture of Foods.

- Food texture refers to the sensory properties of a food product that are detected by touch, primarily in the mouth (mouthfeel), but also by the hands (handfeel) and sometimes even visually (e.g., crispness of crackers). It describes how food feels.
- **Basic Aspects of Food Texture:**
  - **i. Mechanical Properties:** Describe how the food behaves when subjected to force (chewing, cutting, biting). These are often classified into primary parameters:

- **Hardness/Firmness:** The force required to deform a food to a given extent (e.g., biting into an apple vs. marshmallow).
- **Cohesiveness:** The degree to which a food deforms before breaking, and the internal forces holding the food together (e.g., chewing gum vs. shortbread).
- **Brittleness/Fracturability:** The ease with which a food shatters, crumbles, or fractures (e.g., a crisp cracker vs. soft bread). Related to the force required to break it.
- **Chewiness:** The energy or number of chews required to masticate a food to a state ready for swallowing (e.g., steak vs. pudding). A combination of hardness, cohesiveness, and springiness.
- **Springiness/Resilience:** The degree to which a food returns to its original shape after being compressed and the rate at which it does so (e.g., a bouncy marshmallow vs. dense cake).
- **Adhesiveness:** The force required to remove the food that adheres to the mouth (e.g., sticky caramel vs. plain rice).

▪ **ii. Geometrical Properties:** Describe the size, shape, and orientation of particles within the food.

- **Coarseness/Fininess:** The size of particles (e.g., coarse ground meat vs. finely ground flour).
- **Grittiness/Graininess:** Presence of small, hard particles (e.g., sandy texture in some chocolate).

- **Flakiness/Fibrousness:** Refers to layered or thread-like structures (e.g., flaky pastry, fibrous celery).

- **iii. Other Properties (often related to moisture/fat):**

  - **Moistness/Dryness:** The amount of water perceived on the surface or within the food (e.g., juicy steak vs. dry biscuit).

  - **Oiliness/Greasy:** Perception of lipid on the food surface.

  - **Smoothness/Creaminess:** Lack of particles or lumps, often associated with fat or emulsions (e.g., smooth yogurt vs. lumpy mashed potatoes).

  - **Mouthcoating:** The lingering film left in the mouth after swallowing (e.g., fatty foods).

- **Importance:** Texture is a critical driver of food acceptability and consumer preference, often as important as flavor. It influences processing requirements, packaging choices, and shelf life. Texture analysis (instrumental and sensory) is a key aspect of food product development and quality control.

4. **(a) List the various intrinsic factors affecting microbial growth. Describe the concept of Water activity and OR Potential.**

   - **Intrinsic Factors Affecting Microbial Growth:**

     - Intrinsic factors are inherent properties of the food itself that influence microbial growth.

     - **i. Water Activity (a_w):**

       - **Explanation:** The amount of unbound (free) water available for microbial growth and chemical reactions. Microorganisms need water to survive and multiply.

- **Impact:** Most bacteria require $a_w > 0.90$. Yeasts can grow down to 0.88, and molds down to 0.80. Foods with lower a_w (e.g., dried fruits, crackers, honey) are more shelf-stable.

- **ii. pH (Acidity/Alkalinity):**
  - **Explanation:** The measure of hydrogen ion concentration. Microorganisms have optimal pH ranges for growth.
  - **Impact:** Most bacteria prefer near-neutral pH ($6.5 - 7.5$). Yeasts and molds are more acid-tolerant ($2.0 - 8.5$). Foods with low pH (e.g., fruits, fermented products like yogurt, pickles) inhibit bacterial growth.

- **iii. Nutrient Content:**
  - **Explanation:** The availability of essential nutrients (carbohydrates, proteins, lipids, vitamins, minerals) required for microbial metabolism and cell synthesis.
  - **Impact:** Foods rich in nutrients (e.g., meat, milk, eggs) support rapid microbial growth, making them highly perishable.

- **iv. Oxidation-Reduction (OR) Potential / Redox Potential (E_h):**
  - **Explanation:** The tendency of a chemical environment to gain or lose electrons. It indicates whether the environment is oxidizing (electron-accepting) or reducing (electron-donating).

- **Impact:** Aerobic microorganisms require positive E_h. Anaerobic microorganisms require negative E_h. Facultative anaerobes can grow across a range. Food packaging (vacuum packaging, MAP) can alter E_h to inhibit specific microbial groups.

- **v. Natural Antimicrobial Compounds:**
  - **Explanation:** Presence of naturally occurring substances in food that inhibit or kill microorganisms.
  - **Impact:** Examples include lysozyme in eggs, lactoferrin and lactoperoxidase in milk, essential oils in spices (e.g., thymol, eugenol), organic acids in fruits.

- **vi. Biological Structures (Hurdle Concept):**
  - **Explanation:** Physical barriers that prevent microbial entry or growth.
  - **Impact:** Skin on fruits, shell on eggs, rind on cheese, tough outer layers of grains act as physical barriers, protecting the inner edible portions.

- **Concept of Water Activity (a_w):**
  - Water activity is a critical intrinsic factor defining the availability of "free" or unbound water in a food system for microbial growth and chemical reactions. It is not the same as moisture content.
  - **Definition:** It is defined as the ratio of the vapor pressure of water in a food (P) to the vapor pressure of pure water (P_0) at the same temperature: $a_w = P/P_0$. It ranges from 0 (completely dry) to 1.0 (pure water).

- **Significance:** Microorganisms require a certain minimum a_w for their metabolic activities.
  - Bacteria generally require $a_w > 0.90$.
  - Yeasts can grow down to $a_w \approx 0.88$.
  - Molds can grow down to $a_w \approx 0.80$.
  - Xerophilic (dry-loving) molds can grow at even lower a_w (0.65).
- **Food Preservation:** Reducing water activity is a primary method of food preservation (e.g., drying, salting, sugaring, concentrating), as it limits the growth of spoilage and pathogenic microorganisms.

- **Concept of Oxidation-Reduction (OR) Potential / Redox Potential (E_h):**
  - **Definition:** Redox potential (E_h) measures the tendency of a chemical environment (e.g., food or growth medium) to cause oxidation or reduction. It is expressed in millivolts (mV).
  - **Significance:**
    - **Electron Availability:** A high (positive) E_h indicates an oxidizing environment (readily accepts electrons), while a low (negative) E_h indicates a reducing environment (readily donates electrons).
    - **Microbial Preferences:** Different groups of microorganisms have specific E_h requirements for growth:
      - **Aerobes:** Require a positive E_h (oxidizing environment) as they use oxygen as the

terminal electron acceptor. (e.g., Pseudomonas).

- **Anaerobes:** Require a negative E_h (reducing environment) as they cannot tolerate oxygen and use other electron acceptors. (e.g., Clostridium).
- **Facultative Anaerobes:** Can grow under both positive and negative E_h conditions (e.g., E. coli, yeasts).

- **Food Preservation:** Controlling E_h is a food preservation strategy. For example, vacuum packaging or modified atmosphere packaging (MAP) reduces the E_h of a food, inhibiting aerobic spoilage organisms. Some foods, like cured meats, are naturally low in E_h.

(b) "Food is an excellent substrate for growth of Microorganisms". Justify the statement.

- The statement "Food is an excellent substrate for growth of Microorganisms" is largely true and can be justified by considering the diverse nutritional and environmental requirements of microorganisms that are readily met by most food matrices.
- **i. Abundant and Diverse Nutrients:**
  - **Energy Sources:** Foods are rich in macronutrients (carbohydrates, proteins, lipids) which provide readily available carbon and energy sources for microbial metabolism. For example, sugars are easily fermented by many microorganisms.
  - **Nitrogen Sources:** Proteins and amino acids in food provide essential nitrogen for microbial protein synthesis.

- **Vitamins and Minerals:** Foods naturally contain various vitamins and minerals that serve as cofactors for microbial enzymes and structural components, supporting their growth.

- **ii. Favorable Water Activity (a_w):**
  - Most fresh and minimally processed foods (e.g., meat, vegetables, fruits, milk) have high water activity ($a_w > 0.95$). This high availability of free water is crucial for all biochemical reactions within microbial cells and for nutrient transport.

- **iii. Suitable pH Range:**
  - Many foods, particularly those derived from animals (meat, milk, eggs), have a pH close to neutral ($pH \approx 6.0 - 7.0$), which is optimal for the growth of most common spoilage and pathogenic bacteria. Even acidic foods (fruits, fermented products) provide suitable pH for acid-tolerant yeasts and molds.

- **iv. Optimal Redox Potential (E_h):**
  - Foods present a range of redox potentials that accommodate different types of microorganisms. For instance, the surface of fresh meat has a high E_h suitable for aerobes, while the interior has a low E_h suitable for anaerobes. This allows various microbial groups to thrive in different parts of the food.

- **v. Presence of Growth Factors:**
  - Foods contain various complex organic compounds that serve as growth factors, essential for microbes that cannot synthesize them themselves. These include specific amino acids, vitamins, and nucleic acid precursors.

- **vi. Lack of Significant Antimicrobial Compounds (in many foods):**
  - While some foods contain natural antimicrobials, many common foods lack sufficient concentrations of these compounds to inhibit microbial growth effectively, especially once physical barriers are breached or processing occurs.
- **vii. Physical Structure and Protection:**
  - While some food structures (e.g., fruit skins) offer initial protection, once a food is processed (cut, minced, ground) or damaged, it provides an even more accessible and extensive surface area for microbial colonization and growth. The internal environment of many foods is ideal in terms of moisture, nutrients, and pH.
- **Justification:** The combination of abundant nutrients, high water activity, suitable pH, and appropriate redox potential makes most foods highly conducive environments for a wide range of microorganisms, leading to rapid multiplication and, consequently, food spoilage or safety concerns. This is why various food preservation methods are necessary to alter these intrinsic factors and extend shelf life.

5. **(a) What is the significance of sensory testing? Explain types of sensory panels in detail.**
   - **What is the Significance of Sensory Testing?**
     - Sensory testing (or sensory evaluation) is a scientific discipline that measures, analyzes, and interprets the responses of humans (using their senses of sight, smell, taste, touch, and hearing) to the properties of foods and other products. Its significance is immense in the food industry for several reasons:

- **i. Product Development and Optimization:** Guides the creation of new products and the improvement of existing ones to meet consumer preferences.
- **ii. Quality Control and Assurance:** Ensures product consistency over time, identifies deviations from specifications, and monitors the impact of processing changes on sensory attributes.
- **iii. Shelf-Life Studies:** Determines how sensory properties change over time, helping to establish expiration dates and optimal storage conditions.
- **iv. Consumer Acceptance and Preference:** Predicts how well a product will be liked by consumers and helps understand the drivers of liking.
- **v. Ingredient and Packaging Changes:** Evaluates the sensory impact of substituting ingredients, changing suppliers, or altering packaging materials.
- **vi. Marketing and Claims Substantiation:** Provides objective data to support marketing claims (e.g., "new improved taste").
- **vii. Competitive Analysis:** Benchmarks a product against competitors to identify strengths and weaknesses.
- **viii. Regulatory Compliance:** Ensures products meet certain sensory standards where applicable.
- **ix. Cost Savings:** Helps prevent costly product failures by identifying sensory issues early in development.

- **Explain types of sensory panels in detail.**
  - Sensory panels are groups of individuals who participate in sensory tests. They are categorized based on their training level and the type of information they are intended to provide.
  - **i. Trained Panels (Descriptive Panels):**
    - **Composition:** Consists of a small group of highly selected and intensively trained individuals (typically 8-15 panelists). They are chosen for their sensory acuity, consistency, and ability to articulate sensory perceptions.
    - **Training:** Undergo rigorous and extensive training (hundreds of hours) to develop a common vocabulary for sensory attributes, recognize specific attributes, and rate their intensity using standardized scales. They are treated as "human instruments."
    - **Role/Task:** To objectively identify, describe, and quantify the specific sensory attributes of a product (e.g., sweetness, bitterness, crispness, aroma notes like citrus, nutty). They do *not* express personal preference or liking.
    - **Output:** Detailed, quantitative sensory profiles (e.g., Quantitative Descriptive Analysis - QDA, Spectrum method), often presented as spider plots or bar graphs, showing the intensity of each attribute. This provides a "sensory fingerprint" of the product.
    - **Application:** Ideal for product development, quality control (to ensure consistency), identifying sensory drivers of consumer preference, and relating sensory properties to instrumental measurements.

- **ii. Untrained Panels (Consumer Panels / Affective Panels):**
    - **Composition:** Consists of a large group of individuals (typically 50-200 or more) selected to be representative of the target consumer population. They receive minimal or no specific sensory training.
    - **Training:** Brief instructions on how to use the rating scale or how to perform the specific task.
    - **Role/Task:** To assess overall liking, preference, or acceptance of a product. They answer questions like "Do you like this product?" or "Which product do you prefer?". They express their subjective opinions.
    - **Output:** Quantitative data on consumer preference, liking scores (e.g., using a 9-point Hedonic scale from "dislike extremely" to "like extremely"), purchase intent, or relative preference between products.
    - **Application:** Crucial for go/no-go decisions in product launch, market research, determining consumer acceptance of new products or reformulations, and comparing products against competitors in a market context.
- **iii. Discriminatory Panels:**
    - **Composition:** Can involve trained or untrained panelists, depending on the specific test. For simple difference tests (e.g., triangle test), untrained panelists are often sufficient. For more subtle differences, some level of training or screening for acuity might be beneficial.

- **Training:** Minimal training focusing on the specific task (e.g., "identify the odd sample").
- **Role/Task:** To determine if a perceptible sensory difference exists between two or more samples. They do *not* describe the nature or magnitude of the difference. Common tests include:
    - **Triangle Test:** Given three samples (two alike, one different), identify the odd one.
    - **Duo-Trio Test:** Given a reference and two other samples, identify which one matches the reference.
    - **Paired Comparison Test:** Given two samples, choose which one is higher in a specific attribute (e.g., sweeter, crunchier) or which one is preferred.
- **Output:** Statistical probability (p-value) indicating whether the observed difference is statistically significant.
- **Application:** Quality control (e.g., checking if a new batch is different from a standard), evaluating the impact of minor processing changes, determining if an ingredient substitution is detectable by consumers.

(b) Discuss the role and types of Sanitizers used in food industry.

- **Role of Sanitizers in Food Industry:**
    - Sanitizers are chemical agents or physical processes applied to inanimate surfaces to reduce the number of microorganisms to a safe level, typically to kill or irreversibly inactivate 99.999% (5-log reduction) of

relevant vegetative bacteria within 30 seconds. They do not necessarily eliminate all microbial forms (like spores).

- **i. Food Safety:** The primary role is to prevent the spread of pathogenic microorganisms (e.g., Salmonella, E. coli, Listeria) from surfaces to food products, thereby reducing the risk of foodborne illnesses.
- **ii. Shelf-Life Extension:** By reducing spoilage microorganisms on equipment, sanitizers help to extend the shelf life of food products.
- **iii. Quality Maintenance:** Prevents microbial spoilage that can lead to off-flavors, off-odors, discoloration, and textural degradation of food.
- **iv. Regulatory Compliance:** Adherence to sanitation procedures, including proper sanitization, is a critical requirement for food processing facilities by regulatory bodies.
- **v. Preventing Cross-Contamination:** Ensures that food contact surfaces are clean and free from harmful microbes, minimizing the transfer of microorganisms from raw materials or environmental sources to finished products.
- **vi. Enhancing Cleaning Efficacy:** Sanitization typically follows cleaning (removal of visible soil), acting as the final step to reduce the microbial load after physical removal of organic matter.

- **Types of Sanitizers used in Food Industry:**
  - The choice of sanitizer depends on factors like efficacy against target microbes, compatibility with surfaces, water quality, temperature, safety, and cost.
  - **i. Chlorine-based Sanitizers:**

- **Examples:** Hypochlorites (sodium hypochlorite - bleach, calcium hypochlorite), chlorine dioxide (ClO_2).
- **Mechanism:** Oxidize cellular material, interfere with enzymes, and denature proteins.
- **Advantages:** Broad spectrum against bacteria, yeasts, molds, and viruses; relatively inexpensive; fast-acting.
- **Disadvantages:** Corrosive to some metals; can be deactivated by organic matter; irritating odor; unstable at high temperatures or in acidic conditions; can form harmful disinfection byproducts.

▪ **ii. Quaternary Ammonium Compounds (QACs / Quats):**

- **Examples:** Benzalkonium chloride, didecyldimethylammonium chloride.
- **Mechanism:** Disrupt cell membranes, denature proteins, and inactivate enzymes.
- **Advantages:** Stable over a wide pH and temperature range; relatively non-corrosive; effective against a broad spectrum of bacteria, molds, and some viruses; good residual activity.
- **Disadvantages:** Less effective against some gram-negative bacteria (e.g., Pseudomonas) and bacterial spores; can leave a film on surfaces; incompatible with anionic detergents.

▪ **iii. Iodophors (Iodine-based Sanitizers):**

- **Examples:** Complexes of iodine with a solubilizing agent (surfactant).
- **Mechanism:** Oxidize cellular components, interfere with protein synthesis, and disrupt cell membranes.
- **Advantages:** Broad spectrum; effective at low concentrations; stable; non-irritating to skin at use concentrations; visible color indicates presence.
- **Disadvantages:** Can stain porous surfaces; corrosive to some metals at high concentrations; less stable at high temperatures; can be inactivated by organic matter; can produce off-odors.

- **iv. Peroxy Compounds (Peracetic Acid - PAA, Hydrogen Peroxide - H_2O_2):**
  - **Examples:** Peracetic acid, hydrogen peroxide. Often used as blends.
  - **Mechanism:** Powerful oxidizers that denature proteins and disrupt cell walls.
  - **Advantages:** Very broad spectrum (effective against bacteria, yeasts, molds, spores, viruses); effective at low temperatures; leaves no harmful residues (breaks down to acetic acid, water, and oxygen); relatively non-corrosive at recommended concentrations.
  - **Disadvantages:** More expensive than chlorine; can be corrosive at high concentrations; strong odor; requires caution in handling.
- **v. Acid-Anionic Sanitizers:**
  - **Examples:** Solutions containing phosphoric acid and anionic surfactants.

- **Mechanism:** Low pH and surfactant action disrupt cell membranes and inhibit enzyme activity.
- **Advantages:** Non-foaming (good for CIP); non-corrosive to stainless steel; stable in hard water; effective against many bacteria and yeasts.
- **Disadvantages:** Less effective against spores and some viruses; can be irritating to skin; foaming can be an issue if formulation is not correct.

6. **(a) What are the objectives of food packaging? Discuss the use and advantages of polyethylene for food packaging.**
    - **What are the objectives of food packaging?**
        - Food packaging serves multiple critical objectives throughout the product lifecycle, from production to consumption:
            - **i. Protection:**
                - **Physical Protection:** Protects against mechanical damage (e.g., impacts, vibration, compression) during handling, storage, and transportation.
                - **Chemical Protection:** Acts as a barrier against oxygen, moisture, light, and odors, which can cause oxidation, spoilage, nutrient loss, and off-flavors.
                - **Microbiological Protection:** Prevents contamination by microorganisms (bacteria, molds, yeasts) and insects, maintaining hygiene and safety.
                - **Temperature Protection:** Provides some insulation against temperature fluctuations.

- **ii. Containment:** Holds the food product, preventing leakage, spillage, and ensuring easy handling of various forms (liquids, powders, solids).
- **iii. Preservation and Shelf Life Extension:** Creates an appropriate microenvironment to slow down spoilage processes (e.g., oxidation, moisture loss/gain, microbial growth) and extend the product's freshness and usability.
- **iv. Information and Communication:** Carries essential information for consumers (ingredients, nutritional facts, allergens, cooking instructions, expiry date, batch number) and for supply chain management (barcodes, traceability).
- **v. Marketing and Sales Appeal:** Attracts consumers through visual design, branding, and product differentiation. It's often the first point of contact with the consumer.
- **vi. Convenience and Usability:** Facilitates portion control, ease of opening/closing, dispensing, cooking (e.g., microwaveable packaging), and storage for the consumer.
- **vii. Tamper Evidence and Security:** Provides features that indicate if the product has been opened or tampered with, ensuring consumer safety and product integrity.
- **viii. Traceability and Logistics:** Enables efficient handling, storage, and distribution throughout the supply chain, facilitating inventory management and recall procedures.

- **ix. Sustainability:** Increasingly, objectives include minimizing environmental impact through reduced material use, recyclability, biodegradability, and use of renewable resources.

- **Discuss the use and advantages of polyethylene for food packaging.**

  - Polyethylene (PE) is one of the most widely used plastics in food packaging due to its versatility, cost-effectiveness, and excellent properties. It exists in various forms, primarily Low-Density Polyethylene (LDPE), Linear Low-Density Polyethylene (LLDPE), and High-Density Polyethylene (HDPE), each with slightly different characteristics.

  - **Uses of Polyethylene in Food Packaging:**

    - **Films and Bags:** Most common use for packaging bread, produce (fruits, vegetables), frozen foods, snacks, dairy products (milk pouches), meat, and baked goods.
    - **Bottles:** HDPE is widely used for milk jugs, juice bottles, and other beverage containers.
    - **Containers and Tubs:** For yogurt, margarine, ice cream, and other dairy or deli products.
    - **Flexible Packaging Components:** As a sealing layer in laminates (e.g., in stand-up pouches, retort pouches) due to its excellent heat-sealability.
    - **Liners:** As liners for cereal boxes or other cartons.
    - **Stretch/Shrink Wrap:** For pallet wrapping or bundling.

  - **Advantages of Polyethylene for Food Packaging:**

- **i. Cost-Effective:** PE is one of the most inexpensive plastics, making it economically viable for mass-produced food packaging.
- **ii. Good Barrier Properties (for some applications):**
    - **Moisture Barrier:** Excellent barrier to water vapor, protecting moisture-sensitive foods (e.g., dry goods, cereals) from humidity and preventing moisture loss from high-moisture foods.
    - **Chemical Resistance:** Good resistance to many chemicals, acids, and bases.
- **iii. Flexibility and Durability:**
    - LDPE and LLDPE are highly flexible, allowing for easy wrapping, bag formation, and resistance to tearing.
    - HDPE offers good rigidity and impact strength, suitable for bottles and containers.
- **iv. Excellent Heat-Sealability:** PE can be easily heat-sealed, creating strong, airtight seals, which is crucial for hygiene and shelf life. This makes it a preferred sealing layer in multi-layer laminates.
- **v. Low Density:** Light in weight, which reduces transportation costs.
- **vi. Transparency/Clarity (variable):** LDPE can be clear, allowing product visibility.
- **vii. Recyclability:** PE is widely recyclable (HDPE and LDPE are often collected) in many regions, contributing to sustainability efforts.

- **viii. Non-Toxic and Food Safe:** Generally recognized as safe (GRAS) for food contact by regulatory bodies, it does not leach harmful substances into food under normal conditions.
- **ix. Versatility:** Can be processed using various methods (blown film extrusion, injection molding, blow molding), allowing for a wide range of packaging formats.

(b) Describe the basic aspects of taste of foods.

- Taste is one of the five primary senses, involving the perception of non-volatile chemical compounds dissolved in saliva by specialized receptors on the taste buds, primarily located on the tongue. It is a fundamental aspect of food sensory experience.
- **Basic Aspects of Taste:**
  - **i. Five Basic Tastes:** While perceived flavor is complex, human taste perception is generally agreed upon to involve five basic tastes:
    - **Sweet:** Detected by sugars (sucrose, glucose, fructose) and artificial sweeteners. Indicates the presence of energy-rich compounds.
    - **Sour:** Detected by acids (e.g., citric acid in lemons, acetic acid in vinegar). Associated with acidity and unripe foods.
    - **Salty:** Detected by ionic salts, primarily sodium chloride (table salt). Essential for electrolyte balance.
    - **Bitter:** Detected by a wide range of diverse chemical compounds (e.g., caffeine, quinine, some

plant toxins). Often associated with potentially toxic substances, serving as a protective mechanism.

- **Umami (Savory):** Detected by L-glutamate and certain nucleotides (e.g., inosine monophosphate, guanosine monophosphate). Associated with savory, meaty flavors, often found in protein-rich foods (e.g., mushrooms, aged cheese, broths, tomatoes).

- **ii. Taste Buds and Receptors:**
  - Taste buds are microscopic structures located primarily on the papillae of the tongue, but also on the soft palate, epiglottis, and pharynx.
  - Each taste bud contains 50-100 taste receptor cells.
  - These receptor cells have specific protein receptors that bind with taste molecules (tastants), triggering electrical signals that are sent to the brain for interpretation.
  - Sweet, umami, and bitter tastes are detected by G-protein coupled receptors. Salty and sour tastes are detected by ion channels.
- **iii. Taste Thresholds:**
  - The minimum concentration of a tastant required for it to be detected (detection threshold) or recognized (recognition threshold).
  - Thresholds vary among individuals and for different tastes (e.g., bitter compounds often have very low thresholds, meaning they can be detected at very low concentrations).
- **iv. Taste Interactions:**

- Tastes do not act in isolation but can interact with each other:
  - **Suppression:** One taste can reduce the intensity of another (e.g., sugar reducing sourness).
  - **Enhancement:** One taste can enhance another (e.g., salt enhancing sweetness in some contexts, umami enhancing other flavors).
  - **Mixture Effects:** The perceived intensity of a mixture of tastes is not always the sum of individual intensities.

- **v. Influence of Temperature:**
  - The perceived intensity of tastes can be influenced by temperature. For example, sweetness is often perceived as stronger at warmer temperatures, while bitterness can be more pronounced at colder temperatures.
- **vi. Adaption:**
  - Prolonged exposure to a particular taste can lead to a decrease in its perceived intensity (adaptation). For instance, after eating a very sweet food, subsequent sweet foods may taste less sweet.
- **vii. Genetic Variation:**
  - Individuals vary in their sensitivity to different tastes, sometimes due to genetic differences in taste receptors (e.g., supertasters, non-tasters for PROP bitterness).
- **viii. Contribution to Flavor:**

- While taste is distinct, it is a crucial component of overall "flavor," which is a multimodal sensation resulting from the integration of taste, smell (aroma via retronasal olfaction), texture (mouthfeel), and other chemical sensations (e.g., pungency, cooling). Taste provides the foundational "what" of a food's chemical identity.

7. **(a) Describe the basic concept and process of Chlorination of Water.**
   - **Basic Concept of Chlorination of Water:**
     - Chlorination is a common and highly effective method for disinfecting drinking water and wastewater. The basic concept involves adding chlorine or chlorine-containing compounds to water to kill or inactivate pathogenic microorganisms (bacteria, viruses, protozoa) that can cause waterborne diseases.
     - It relies on the strong oxidizing power of chlorine and its derivatives when dissolved in water to destroy the cellular components and metabolic functions of microbes.
     - Beyond disinfection, chlorination also helps oxidize certain undesirable substances (like iron, manganese, hydrogen sulfide) and can aid in taste and odor control.
   - **Process of Chlorination of Water:**
     - **i. Chlorine Addition:**
       - **Source:** Chlorine is typically added to water in various forms:
         - **Chlorine Gas (Cl_2):** A highly effective but hazardous gas, usually stored in cylinders.

- **Sodium Hypochlorite ($NaOCl$):** A liquid solution (commonly known as bleach), easier to handle than gas but less stable.
- **Calcium Hypochlorite ($Ca(OCl)_2$):** A solid granular or tablet form, suitable for smaller systems or emergency use.

- **Application Point:** Chlorine is usually added at specific points in the water treatment process:
  - **Pre-chlorination:** Added at the very beginning of treatment to control algae, odors, and reduce microbial load before other treatment steps.
  - **Intermediate Chlorination:** Added during the treatment process (e.g., after sedimentation or filtration) to maintain disinfection levels.
  - **Post-chlorination:** Added at the final stage, just before distribution, to ensure the water leaving the treatment plant is disinfected and to maintain a residual disinfectant level in the distribution system to prevent re-growth.

- **ii. Formation of Hypochlorous Acid and Hypochlorite Ion (Hydrolysis):**
  - When chlorine gas (Cl_2) or hypochlorites ($NaOCl$, $Ca(OCl)_2$) are added to water, they rapidly react to form hypochlorous acid ($HOCl$) and hypochlorite ion (OCl^-). This reaction is pH-dependent.
  - **If Chlorine Gas is Used:** $Cl_2(g) + H_2O(l) \rightleftharpoons HOCl(aq) + HCl(aq)$

- **If Hypochlorite is Used:** $NaOCl(aq) + H_2O(l) \rightleftharpoons HOCl(aq) + NaOH(aq)$
- **Equilibrium between $HOCl$ and OCl^-:** $HOCl(aq) \rightleftharpoons H^+(aq) + OCl^-(aq)$
  - $HOCl$ is a much more effective disinfectant than OCl^-. The optimal pH for chlorination is typically between 6.5 and 7.5, where $HOCl$ is the predominant species.

- **iii. Disinfection (Contact Time):**
  - The $HOCl$ and OCl^- species attack the cell membranes of microorganisms, denature their enzymes, and interfere with their metabolic processes, leading to inactivation or death.
  - **Contact Time (CT value):** The water must be held in contact with the chlorine for a sufficient period (contact time) to allow the disinfection process to occur effectively. This time varies depending on the initial microbial load, chlorine concentration, pH, and temperature.

- **iv. Chlorine Demand and Residual Chlorine:**
  - **Chlorine Demand:** Some chlorine reacts with inorganic (e.g., Fe^{2+}, Mn^{2+}, H_2S, NH_3) and organic substances present in the raw water. This consumed chlorine is known as the "chlorine demand."
  - **Residual Chlorine:** The amount of chlorine remaining in the water after the chlorine demand has been satisfied and after a specified contact time. This residual (typically $0.2 - 0.5\ mg/L$ in drinking water) provides ongoing protection against

recontamination in the distribution system. It can be "free chlorine" (HOCl + OCl^-) or "combined chlorine" (chloramines, formed by reaction with ammonia).

- **v. Dechlorination (Optional):**
  - In some cases, especially with wastewater treatment or when high chlorine doses are used, the residual chlorine might be too high or could pose environmental risks. Dechlorination (e.g., using sulfur dioxide or activated carbon) might be performed to reduce chlorine levels before discharge or further use.

(b) Explain the importance of Food Texture and discuss the major classification of Texture profile.

- **Importance of Food Texture:**
  - Food texture is a critical sensory attribute that defines how food feels in the mouth (mouthfeel) and to the hand. Its importance in food is multi-faceted:
    - **i. Consumer Acceptance and Liking:** Texture is a primary driver of consumer preference and acceptance. An undesirable texture (e.g., soggy, tough, mushy) can lead to product rejection, even if the flavor is good.
    - **ii. Perceived Quality and Freshness:** Texture attributes often signal freshness (e.g., crispness of vegetables, firmness of bread) and quality. Loss of desired texture can indicate spoilage or staleness.
    - **iii. Oral Processing and Eating Experience:** Texture dictates how food is chewed, lubricated,

and swallowed. It influences the effort required for mastication and the overall oral experience.

- **iv. Satiety and Satisfaction:** Certain textures (e.g., chewy, crunchy) can contribute to a feeling of satiety and satisfaction during eating.
- **v. Product Development:** Texture is a key target in product development. Formulating foods with specific textures (e.g., creamy yogurt, crunchy snacks) is crucial for market success.
- **vi. Quality Control:** Instrumental and sensory texture measurements are vital for ensuring consistency in production batches and adherence to product specifications.
- **vii. Processing and Handling:** Texture affects how foods are processed (e.g., pumping, mixing, cutting) and handled throughout the supply chain.
- **viii. Safety:** In some cases, texture relates to safety (e.g., preventing choking hazards in foods for children or the elderly).

- **Major Classification of Texture Profile (Texture Profile Analysis - TPA):**
  - Texture Profile Analysis (TPA) is a widely used method to objectively measure and describe the mechanical textural properties of a food by mimicking the action of biting or chewing. It uses a force-deformation curve obtained from a two-bite compression test. The primary and secondary parameters derived from TPA are:
  - **I. Primary Parameters (directly measured from the first bite/compression):**

- **1. Hardness (Force):** The peak force recorded during the first compression. It represents the force required to deform a food to a given extent.
  - *Example:* High in crackers, low in yogurt.
- **2. Cohesiveness (Area 2 / Area 1):** The ratio of the positive force area during the second compression to that of the first compression. It describes the strength of the internal bonds making up the food's body.
  - *Example:* High in chewing gum, low in a crumbly biscuit.
- **3. Adhesiveness (Negative Area of Force):** The negative force area for the first bite, representing the work required to overcome the attractive forces between the food surface and the contact surface (e.g., probe or teeth).
  - *Example:* High in sticky caramel, low in a dry cracker.
- **4. Springiness (Height 2 / Height 1):** The height that the food recovers after the first compression, divided by the original compression height. It describes the rate at which the deformed food returns to its un-deformed condition.
  - *Example:* High in marshmallows, low in bread dough.
- **5. Gumminess (Hardness x Cohesiveness):** The energy required to disintegrate a semi-solid food to a state ready for swallowing. Applicable to semi-solid foods.
  - *Example:* High in gummy candies.

- **6. Brittleness / Fracturability (Force at first break):** For foods that fracture easily, this is the force at which the first significant break occurs during the first compression.
  - *Example:* High in hard candy, low in soft cheese.

▪ **II. Secondary Parameters (derived from primary parameters, related to chewing):**

- **7. Chewiness (Gumminess x Springiness):** The energy required to masticate a solid food to a state ready for swallowing. Applicable to solid foods.
  - *Example:* High in steak, low in gelatin.
- **8. Resilience (Area of recovery / Area of deformation on first bite):** The ratio of the work recovered (during probe withdrawal) to the work applied during the first compression. It indicates how well the sample recovers from deformation.
  - *Example:* Indicates the "bounciness" or "elasticity" of a food.

▪ **Other Parameters (not always part of TPA, but important aspects of texture):**

- **Viscosity:** Resistance to flow (for liquid or semi-liquid foods).
- **Mouthcoating:** Sensation of film on the oral surfaces (e.g., oily, waxy).
- **Moistness/Dryness:** Perceived water content.
- **Fatness/Oiliness:** Perceived lipid content.

- **Grittiness/Graininess:** Presence of small, hard particles.

8. **Write short notes on (Any three):**
   - **(i) Use of metals in food packaging.**
     - Metals have been used for food packaging for centuries due to their excellent barrier properties and structural integrity. The primary metals used are steel (especially tin-plated steel, i.e., tinplate) and aluminum.
     - **Tinplate (Steel Cans):**
       - **Use:** Widely used for canning fruits, vegetables, meat, fish, soups, and beverages. Steel cans are robust and stackable.
       - **Advantages:** Excellent barrier to oxygen, moisture, light, and microorganisms, providing a long shelf life, often without refrigeration. High strength and rigidity protect against physical damage. Hermetic sealing prevents contamination. Good thermal conductivity for sterilization (retorting). Recyclable.
       - **Disadvantages:** Heavy weight, potential for corrosion (often lined with lacquer), not transparent, more expensive than some plastics.
     - **Aluminum:**
       - **Use:** Primary material for beverage cans (soda, beer), foil wraps (household foil, pharmaceutical foils), flexible laminates (e.g., retort pouches, juice boxes), and trays/containers for ready meals.
       - **Advantages:** Lightweight, excellent barrier to gases and light, non-toxic, non-corrosive (unless in contact with highly acidic/alkaline foods without proper

lining), good thermal conductivity (for cooling/heating), easily recyclable, good formability.

- **Disadvantages:** Less rigid than steel, can be easily dented (unless thick), more expensive than plastics for some applications.

- **Overall Role:** Metals play a crucial role in preserving food quality and safety, enabling long-distance transport and storage, particularly for shelf-stable products. Their excellent barrier properties are often superior to many plastics for specific applications.

- **(ii) Application of food emulsions.**

  - Food emulsions are colloidal systems consisting of two immiscible liquids (typically oil and water) where one liquid is dispersed as tiny droplets within the other continuous liquid phase. They are thermodynamically unstable and require emulsifying agents (surfactants like proteins, phospholipids, polysaccharides) to stabilize them.

  - **Applications:** Emulsions are pervasive in the food industry, influencing texture, flavor, and stability:

    - **Sauces and Dressings:** Mayonnaise (oil-in-water emulsion stabilized by egg yolk lecithin), salad dressings (vinegarettes can be temporary emulsions), hollandaise sauce. Emulsions provide a smooth, creamy texture and allow for uniform distribution of flavor compounds.

    - **Dairy Products:** Milk (oil-in-water emulsion of fat globules in an aqueous phase), cream, butter (water-in-oil emulsion). Emulsification contributes to their characteristic texture and appearance.

- **Baked Goods:** Margarine and shortening (water-in-oil emulsions) are used to provide plasticity, aid in aeration, and contribute to texture in pastries, cakes, and cookies.
- **Beverages:** Fruit juices with pulp (stabilized emulsions), flavored milk drinks, cream liqueurs. Emulsification prevents separation of components and provides a desirable mouthfeel.
- **Processed Meats:** Sausages and pates often involve finely chopped fat dispersed in a protein-water matrix, forming an emulsion that contributes to juiciness and texture.
- **Confectionery:** Chocolates, ice cream, and some candies utilize emulsions to achieve smooth textures and prevent fat blooming or crystallization.
- **Soups:** Cream soups often rely on emulsified fats to provide richness and smooth consistency.

▪ **Importance:** Emulsions are vital for creating desired textures (creamy, smooth), improving mouthfeel, uniformly distributing fat-soluble flavors, preventing separation of ingredients, and enhancing the overall sensory appeal and stability of a wide range of food products.

○ **(iii) Primary methods of waste water treatment.**

▪ Wastewater treatment is a multi-stage process designed to remove pollutants from domestic and industrial wastewater before it is discharged into natural water bodies or reused. Primary treatment is the first physical stage.

- **Objective:** To remove large, settleable solids and floating materials from the raw wastewater. It is a physical treatment process that reduces the suspended solids and organic load, preparing the wastewater for subsequent biological (secondary) treatment.
- **Process Steps:**
    - **a. Screening:**
        - **Purpose:** To remove large debris (rags, sticks, plastics, grit) that could clog pipes or damage pumps.
        - **Process:** Wastewater passes through bar screens (coarse) or fine screens, which physically retain larger solids. Accumulated debris is removed and disposed of.
    - **b. Grit Removal:**
        - **Purpose:** To remove heavy inorganic particles (sand, grit, gravel) that could settle in pipes or damage equipment, but are too small to be caught by screens.
        - **Process:** Wastewater flows through grit chambers where the velocity is slowed down enough to allow heavier grit particles to settle by gravity, while lighter organic solids remain suspended. Various types exist (e.g., aerated grit chambers, vortex grit chambers).
    - **c. Primary Sedimentation (Clarification):**
        - **Purpose:** To remove finer suspended organic and inorganic solids that were not removed by screening or grit removal.

- **Process:** Wastewater enters large sedimentation tanks (primary clarifiers) where it flows very slowly. This reduced velocity allows suspended solids (flocculated particles, organic matter) to settle to the bottom by gravity, forming a sludge (primary sludge). Lighter materials (fats, oils, grease - FOG) float to the surface and are skimmed off.
- **Result:** Primary treatment typically removes $50 - 65\%$ of suspended solids and $25 - 40\%$ of the Biochemical Oxygen Demand (BOD), significantly reducing the pollution load. The settled primary sludge is then pumped for further treatment (e.g., anaerobic digestion).

- **(iv) Pectin Gels.**
  - Pectin gels are a type of food gel formed using pectin, a natural polysaccharide found in the cell walls of fruits and vegetables. Pectin is widely used as a gelling agent, thickener, and stabilizer in various food products.
  - **Mechanism of Gel Formation:** Pectin forms gels under specific conditions, primarily determined by its degree of methylation (DM) and the presence of sugar and acid.
    - **High-Methoxyl Pectins (HMP, DM > 50%):** Require high sugar concentration ($> 55\%$) and acidic pH ($2.8 - 3.5$) for gel formation. In this system, sugar competes for water, dehydrating the pectin molecules, which then aggregate via hydrophobic interactions and hydrogen bonds to form a network stabilized by calcium bridges (though less critical than for LMP). The low pH reduces charge repulsion between pectin molecules.

- **Low-Methoxyl Pectins (LMP, DM < 50%):** Do not require high sugar but absolutely require the presence of divalent cations, typically calcium ions (Ca^{2+}), to form gels. The calcium ions bind to the negatively charged carboxyl groups on adjacent pectin molecules, forming "egg-box" junctions that create a robust gel network. Gelation can occur over a wider pH range.

- **Applications in Food:**
  - **Jams, Jellies, Marmalades:** Traditional application for HMP, where pectin provides the characteristic set and texture with sugar and fruit acid.
  - **Fruit Preparations:** Used in fruit fillings for baked goods, yogurt, and desserts.
  - **Confectionery:** In fruit gums, pastilles, and some jellied candies.
  - **Beverages:** As a stabilizer in acidic fruit juices to prevent sedimentation.
  - **Dairy Products:** In acidified milk products (e.g., drinking yogurt, fruit yogurts) to stabilize protein and prevent syneresis.
- **Characteristics:** Pectin gels are typically clear, resilient, and have a good mouthfeel. Their texture can be controlled by adjusting pectin type, concentration, pH, sugar level, and calcium content.

- **(v) Detergents used in Food Industry.**
  - Detergents are cleaning agents designed to remove various types of soil (food residues, grease, dirt) from surfaces. In the food industry, proper cleaning with

detergents is the crucial first step before sanitization, as sanitizers are ineffective on soiled surfaces.

- **Role:**
  - **Soil Removal:** Emulsify fats, saponify greases, dissolve proteins, suspend particulate matter, and solubilize carbohydrates from food contact surfaces.
  - **Preventing Contamination:** By removing soil, detergents reduce the breeding grounds for microorganisms and prevent the buildup of biofilms.
  - **Maintaining Hygiene:** Essential for maintaining high standards of hygiene, critical for food safety and quality assurance.
  - **Optimizing Sanitization:** Clean surfaces allow sanitizers to be effective.

- **Types of Detergents:** Detergents are formulated based on their chemical composition and pH, targeting different types of soil and surfaces.
  - **i. Alkaline Detergents:**
    - **Composition:** Contain strong alkalis (e.g., sodium hydroxide, sodium carbonate, sodium silicates) often combined with chelating agents (e.g., EDTA, phosphates) and surfactants.
    - **Mechanism:** Saponify fats (convert them to soluble soaps), peptize proteins, and emulsify oils.
    - **Use:** Highly effective for removing heavy greasy soils, baked-on residues, and protein

films. Used for cleaning equipment, floors, and general heavy-duty cleaning.

  - **Advantages:** Excellent cleaning power.
  - **Disadvantages:** Corrosive to certain metals (e.g., aluminum) at high concentrations; can be hazardous to personnel.

- **ii. Acid Detergents:**
  - **Composition:** Contain acids (e.g., nitric acid, phosphoric acid, citric acid) and often surfactants.
  - **Mechanism:** Dissolve mineral deposits (limescale, milkstone), rust, and some protein films.
  - **Use:** Used to remove inorganic scale, hard water deposits, and milkstone (calcium phosphate deposits in dairy processing). Often used cyclically with alkaline detergents to prevent mineral buildup.
  - **Advantages:** Effective on mineral scale.
  - **Disadvantages:** Can be corrosive to some metals; generally less effective on organic soils than alkaline detergents.
- **iii. Neutral Detergents:**
  - **Composition:** Primarily consist of surfactants (anionic, non-ionic, or amphoteric) and builders.
  - **Mechanism:** Rely primarily on the wetting, emulsifying, and suspending action of surfactants.

  - **Use:** For light to moderate soils, hand washing of utensils, and cleaning sensitive surfaces where strong acids or alkalis might cause damage.
  - **Advantages:** Mild on surfaces and skin; less corrosive.
  - **Disadvantages:** Less effective on heavy or tenacious soils.

- **iv. Enzyme-based Detergents:**
  - **Composition:** Contain specific enzymes (e.g., proteases for proteins, amylases for starches, lipases for fats) along with surfactants and other components.
  - **Mechanism:** Enzymes break down large organic molecules into smaller, more soluble components that are easier to remove.
  - **Use:** Effective for specific soil types, particularly proteinaceous or starchy soils, especially at lower temperatures where other detergents might be less effective. Good for cleaning complex equipment.
  - **Advantages:** Highly specific, effective at lower temperatures, reduce need for harsh chemicals.
  - **Disadvantages:** Can be more expensive; enzymes have specific temperature and pH optima for activity.

- Many modern detergents are blended formulations, combining different types of chemicals (alkalis, acids, surfactants, chelants, enzymes) to achieve optimal cleaning performance for specific food industry applications.