1. Justify the following statements (any 6): (3x6=18). (a) Browning in cut potatoes is an enzymatic reaction. (b) Hard wheat flour contains damaged starch. (c) Fresh fish does not have any offensive odour. (d) Mangoes are plucked when they are not fully ripe. (e) Marbling is desirable. (f) Air cell size is an indicator of freshness of egg. (g) Germination improves quality of pulses.

- **(a) Browning in cut potatoes is an enzymatic reaction.**
    - This statement is justified because the browning observed in cut potatoes is due to the enzymatic oxidation of phenolic compounds present in the potato.
    - When the potato is cut, the cell structure is disrupted, bringing enzymes, specifically polyphenol oxidases (PPOs), into contact with phenolic substrates and oxygen from the air.
    - The PPOs catalyze the oxidation of colorless phenolic compounds into colored quinones, which then polymerize to form brown, black, or red pigments, leading to the characteristic browning.
- **(b) Hard wheat flour contains damaged starch.**
    - This statement is justified because the milling process used to produce flour from hard wheat varieties causes mechanical damage to some of the starch granules.
    - Hard wheat has a strong protein matrix (gluten) that firmly holds the starch granules. During the intense grinding and shearing action in roller mills, a certain percentage of starch granules are fractured or abraded.
    - Damaged starch granules absorb more water and are more susceptible to enzymatic degradation by amylases, which influences dough rheology and bread quality.
- **(c) Fresh fish does not have any offensive odour.**

  - This statement is justified because the distinctive "fishy" odor associated with fish spoilage is primarily due to the breakdown of trimethylamine oxide (TMAO) into trimethylamine (TMA) by bacterial enzymes after the fish dies.
  - TMAO is naturally present in the tissues of many marine fish and acts as an osmoregulator. In live or very fresh fish, this conversion does not occur.
  - Therefore, very fresh fish, while it may have a mild, clean, or seaweed-like smell, lacks the strong, pungent, ammonia-like, or "fishy" odor that develops during microbial spoilage.
- **(d) Mangoes are plucked when they are not fully ripe.**
  - This statement is justified because mangoes are climacteric fruits, meaning they can continue to ripen after being harvested.
  - Plucking mangoes before they are fully ripe, at a mature green stage, offers several advantages:
    - **Reduced transportation damage:** Less ripe fruits are firmer and less susceptible to bruising and physical damage during handling and transportation.
    - **Extended shelf life:** Harvesting them at a premature stage allows for a longer storage and distribution period before they become overripe.
    - **Controlled ripening:** Ripening can be controlled in storage or during transit to meet market demands, ensuring optimal quality upon arrival at the consumer.
- **(e) Marbling is desirable.**
  - This statement is justified because marbling refers to the visible streaks or flecks of intramuscular fat found within the lean muscle tissue of meat, particularly beef.
  - Marbling is highly desirable for several reasons:

- **Flavor:** The fat melts during cooking, releasing volatile compounds that contribute significantly to the rich, characteristic flavor of meat.
- **Juiciness:** Melting fat lubricates the muscle fibers, making the cooked meat feel more moist and juicy.
- **Tenderness:** Marbling contributes to the tenderness of meat by weakening the connective tissue and providing a more succulent mouthfeel.
- **Palatability:** The combination of enhanced flavor, juiciness, and tenderness significantly improves the overall eating quality and palatability of the meat.

- **(f) Air cell size is an indicator of freshness of egg.**
  - This statement is justified because the air cell in an egg forms between the two shell membranes, usually at the large end of the egg.
  - When an egg is laid, it is warm and contains no air cell or a very small one. As the egg cools, the liquid contents contract, and air enters through the pores of the shell to form the air cell.
  - Over time, as an egg ages, moisture and carbon dioxide are lost through the shell pores due to evaporation. This continuous loss causes the egg contents to shrink further, leading to an increase in the size of the air cell.
  - Therefore, a small air cell indicates a fresh egg, while a larger air cell suggests an older egg.
- **(g) Germination improves quality of pulses.**
  - This statement is justified because the process of germination (sprouting) significantly improves the nutritional and sensory quality of pulses.
  - **Nutritional Improvement:**

- **Increased bioavailability of nutrients:** Germination breaks down phytic acid, an anti-nutritional factor that binds minerals, thus increasing the bioavailability of iron, zinc, and calcium.
- **Enhanced vitamin content:** It leads to a notable increase in the synthesis of certain vitamins, especially B-complex vitamins (e.g., riboflavin, niacin, thiamine) and vitamin C.
- **Improved protein digestibility:** Sprouting initiates the breakdown of complex proteins into simpler amino acids and peptides, making them easier to digest.
- **Reduction of anti-nutritional factors:** Besides phytic acid, germination reduces other anti-nutritional compounds like trypsin inhibitors and flatulence-causing oligosaccharides.

- **Sensory Improvement:**
  - **Improved texture:** Sprouted pulses become softer and easier to chew.
  - **Milder flavor:** The raw taste often becomes less beany and more palatable.
  - **Increased versatility:** Sprouted pulses can be eaten raw in salads or cooked quickly.

2. Draw a neat diagram of the following and explain the structure briefly: (9x2=18). (a) Wheat grain. (b) Egg.

- **(a) Wheat Grain:**
  - A wheat grain (caryopsis) is a dry, indehiscent fruit in which the pericarp (fruit wall) is fused with the seed coat. It consists of three main parts: the bran, endosperm, and germ.
  - **Structure of Wheat Grain:**

- **Bran (approximately 14-16% of the grain):**
    - The outermost layer, primarily composed of several protective layers.
    - Rich in fiber (especially insoluble fiber), B vitamins, minerals (e.g., magnesium, iron, zinc), and antioxidants.
    - Acts as a protective barrier for the inner parts of the grain.
    - Consists of pericarp (outermost layers: epicarp, mesocarp, endocarp), testa (seed coat), and aleurone layer.
- **Endosperm (approximately 80-83% of the grain):**
    - The largest part of the grain, located beneath the bran.
    - Primarily composed of starch granules embedded in a protein matrix.
    - This is the source of white flour.
    - Contains most of the protein (gluten-forming proteins), carbohydrates (starch), and some B vitamins.
    - The texture of the endosperm varies from hard to soft, influencing flour characteristics.
- **Germ (embryo) (approximately 2-3% of the grain):**
    - The embryo of the wheat plant, located at one end of the grain.

        - Rich in nutrients, including healthy fats (unsaturated fatty acids), B vitamins, vitamin E, antioxidants, and minerals.
        - It is the part that sprouts into a new plant if conditions are favorable.
        - Due to its fat content, it can make whole wheat flour more susceptible to rancidity.

- **(b) Egg:**
    - An egg (typically referring to a chicken egg) is a complex structure designed to protect and nourish a developing embryo. It consists of the shell, albumen (egg white), and yolk.
    - **Structure of an Egg:**
        - **Shell (approximately 9-12% of the egg weight):**
            - The hard, porous outer covering of the egg, primarily composed of calcium carbonate.
            - Contains thousands of tiny pores that allow for gas exchange (oxygen in, carbon dioxide and water vapor out) but also make the egg susceptible to bacterial entry.
            - Has a protective **cuticle** or bloom on its surface, which seals the pores and helps prevent bacterial contamination and moisture loss.
        - **Shell Membranes:**
            - Two thin, protective membranes (outer and inner) located just inside the shell.
            - They provide a defense against bacterial invasion.

- At the large end of the egg, these two membranes separate to form the **air cell** (or air sac), which increases in size as the egg ages due to moisture loss.

▪ **Albumen (Egg White) (approximately 58-60% of the egg weight):**

- The clear, viscous liquid surrounding the yolk.
- Primarily composed of water (about 88%) and protein (about 11%, mainly ovalbumin, conalbumin, ovomucoid, lysozyme).
- Provides protection and nutrients for the embryo.
- Divided into distinct layers based on viscosity: thin outer albumen, thick albumen, inner thin albumen, and chalaziferous albumen.

▪ **Chalazae:**

- Two opaque, rope-like strands found in the albumen, extending from opposite sides of the yolk to the shell membranes.
- They are made of thick albumen and anchor the yolk in the center of the egg, preventing it from touching the shell.

▪ **Yolk (approximately 30-32% of the egg weight):**

- The yellow or orange central part of the egg, containing the primary nutrients for embryo development.
- Rich in fat (about 33%, including phospholipids like lecithin, cholesterol), protein (about 16%), vitamins

(A, D, E, K, B vitamins), and minerals (iron, phosphorus).

- The color of the yolk is influenced by the hen's diet (carotenoids).
- Surrounded by the **vitelline membrane**, a thin, clear membrane that holds the yolk in place.
- Contains a small, white spot on its surface called the **germinal disc (blastoderm)**, which is where embryonic development would begin if the egg were fertilized.

3. Differentiate between the following (any 3): (6x3=18). (a) Caramelization and Maillard browning. (b) Climacteric and non climacteric fruits. (c) Fats and oils. (d) Oxidative and Hydrolytic rancidity.

- **(a) Caramelization and Maillard browning.**
  - **Caramelization:**
    - **Definition:** A non-enzymatic browning reaction that occurs when sugars are heated to high temperatures (above their melting point).
    - **Reactants:** Involves only sugars (sucrose, glucose, fructose, maltose).
    - **Process:** Sugars undergo a series of complex chemical reactions including dehydration, isomerization, polymerization, and fragmentation.
    - **Products:** Produces a range of flavorful compounds (e.g., furans, pyrones, diacetyl) and brown pigments (caramelans, caramelens, caramelins).

- **Conditions:** Requires high heat and no protein is involved. pH can influence the rate.
- **Examples:** Caramel sauce, toasted marshmallows, browned onions (from sugars), traditional caramel candies.

  - **Maillard Browning:**
    - **Definition:** A complex series of non-enzymatic reactions that occur between amino acids (or proteins) and reducing sugars when heated.
    - **Reactants:** Requires both a reducing sugar (e.g., glucose, fructose, lactose) and an amino acid (or protein).
    - **Process:** Involves three main stages: initial condensation (Schiff base formation), rearrangement (Amadori products), and subsequent degradation and polymerization reactions.
    - **Products:** Produces a wide variety of volatile flavor and aroma compounds (e.g., pyrazines, pyrroles, thiophenes) and brown nitrogenous polymers (melanoidins).
    - **Conditions:** Favored by heat, neutral to alkaline pH, and lower water activity.
    - **Examples:** Browning of bread crust, roasted coffee beans, grilled meat, seared scallops, roasted vegetables, fried potatoes.

- **(b) Climacteric and non climacteric fruits.**
  - **Climacteric Fruits:**
    - **Ripening Process:** Continue to ripen significantly after being harvested.

        - **Respiration and Ethylene Production:** Exhibit a sudden increase (a "climacteric rise") in respiration rate and a surge in ethylene gas production (a plant hormone that promotes ripening) during the ripening phase.
        - **Harvesting:** Can be harvested at a mature but still unripe stage.
        - **Storage:** Can be stored unripe and then ripened later, allowing for easier transport and extended shelf life.
        - **Examples:** Mangoes, bananas, apples, tomatoes, avocados, peaches, plums, kiwi fruit.
    - **Non-Climacteric Fruits:**
        - **Ripening Process:** Do not ripen significantly after being harvested; they must be harvested when fully ripe.
        - **Respiration and Ethylene Production:** Do not show a climacteric rise in respiration or a surge in ethylene production. Their respiration rate gradually declines after harvest.
        - **Harvesting:** Must be harvested when fully ripe and ready for consumption.
        - **Storage:** Have a shorter post-harvest life compared to climacteric fruits and cannot be stored unripe for later ripening.
        - **Examples:** Citrus fruits (oranges, lemons), grapes, strawberries, cherries, pineapple, watermelon, cucumber.
- **(c) Fats and oils.**
    - **Fats:**
        - **State at Room Temperature:** Typically solid or semi-solid at room temperature ($20 - 25°C$).

- **Fatty Acid Composition:** Generally contain a higher proportion of saturated fatty acids. The straight chain of saturated fatty acids allows them to pack more tightly, leading to a higher melting point.
- **Source:** Often derived from animal sources (e.g., butter, lard, tallow) but can also be from tropical plants (e.g., coconut oil, palm oil).
- **Examples:** Butter, lard, suet, beef fat, cocoa butter.

- **Oils:**
  - **State at Room Temperature:** Typically liquid at room temperature ($20 - 25°C$).
  - **Fatty Acid Composition:** Generally contain a higher proportion of unsaturated fatty acids (monounsaturated or polyunsaturated). The double bonds in unsaturated fatty acids introduce kinks in the carbon chains, preventing tight packing and resulting in a lower melting point.
  - **Source:** Primarily derived from plant sources (e.g., vegetable oils, nut oils, seed oils). Some marine animal oils are liquid.
  - **Examples:** Olive oil, sunflower oil, canola oil, soybean oil, fish oil.

- **(d) Oxidative and Hydrolytic rancidity.**
  - **Oxidative Rancidity:**
    - **Mechanism:** Occurs when unsaturated fatty acids react with oxygen from the air. This is a free radical chain reaction.
    - **Initiation:** Triggered by factors like light, heat, metal ions (e.g., iron, copper), and enzymes (lipoxygenases).

- **Products:** Leads to the formation of hydroperoxides, which further break down into volatile compounds such as aldehydes, ketones, and short-chain fatty acids.
- **Consequences:** Results in unpleasant "off-flavors" and "off-odors" (rancid smell), discoloration, and degradation of fat-soluble vitamins. It is a major cause of spoilage in foods rich in unsaturated fats.
- **Prevention:** Use of antioxidants, vacuum packaging, storage in cool, dark conditions, exclusion of pro-oxidant metals.

- **Hydrolytic Rancidity:**
  - **Mechanism:** Occurs when triglycerides (the main form of fat) are broken down into free fatty acids and glycerol.
  - **Catalyst:** Catalyzed by water (hydrolysis) in the presence of heat, strong acids, or enzymes called lipases.
  - **Products:** Primarily results in the release of free fatty acids. If these free fatty acids are short-chain (e.g., butyric acid in butter), they can be volatile and contribute to rancid flavors.
  - **Consequences:** Leads to a soapy or cheesy off-flavor, particularly noticeable in dairy products and coconut oil (due to their short-chain fatty acids).
  - **Prevention:** Keeping fats and oils dry, inactivating lipases (e.g., by heat treatment like pasteurization), proper storage.

4. (a) What is malting? Explain the process and its uses. (6). (b) Discuss the various methods used for tenderization of meat. (6). (c) Briefly discuss composition of pulses. (6).

- **(a) What is malting? Explain the process and its uses.**

- **What is Malting?**
    - Malting is a controlled germination process applied to cereal grains, most commonly barley, but also wheat, rye, and sorghum. The primary goal is to partially germinate the grain to activate and synthesize various enzymes, particularly amylolytic (starch-degrading) and proteolytic (protein-degrading) enzymes, and then halt the germination process by drying.
- **Process of Malting:**
    - **1. Steeping:**
        - Cleaned grains are steeped (soaked) in water for a period (typically 24-48 hours) to increase their moisture content (to about 40-45%).
        - This activates dormant enzymes and triggers the metabolic processes necessary for germination. Air rests are usually interspersed to prevent anoxia.
    - **2. Germination (Malting Proper):**
        - The steeped grains are transferred to germination beds or drums where they are kept under controlled conditions of temperature ($12 - 18°C$), humidity, and aeration.
        - The grains begin to sprout, developing rootlets (radicles) and a shoot (acrospire).
        - During this phase, enzymes like alpha-amylase, beta-amylase, proteases, and glucanases are synthesized or activated. These enzymes break down the starchy endosperm and protein matrix, making nutrients available for the developing embryo and modifying the endosperm structure.

- This process usually takes 4-6 days.

- **3. Kilning:**
    - Once the desired level of modification is achieved (indicated by acrospire growth and enzyme activity), germination is halted by drying the malted grain with hot air in a kiln.
    - Kilning reduces moisture content (to about 3-5%), preserves the enzymes, and develops characteristic flavors and colors depending on the temperature profile.
    - Different kilning temperatures produce different types of malt (e.g., pale malt, roasted malt, crystal malt).

- **Uses of Malt:**
    - **Brewing (Beer Production):** This is the primary use. Malt provides fermentable sugars for yeast, contributes to the beer's color, flavor, and body, and supplies enzymes needed for starch conversion during mashing.
    - **Distilling (Whiskey/Whisky Production):** Malted barley is a key ingredient in malt whiskies, providing enzymes for fermentation and contributing flavor.
    - **Food Industry:**
        - **Malt Extracts:** Used as a natural sweetener, flavor enhancer, and nutrient source in various food products (e.g., malt beverages, cereals, confectionery, baby foods).
        - **Malt Flours:** Added to baked goods to improve crust color, texture, and flavor due to enzymatic activity.

- **Malt Vinegar:** Produced by fermenting malted barley.

- **Nutritional Supplements:** Malt is a source of B vitamins and enzymes, sometimes used in health supplements.

- **(b) Discuss the various methods used for tenderization of meat.**
  - Meat tenderization aims to break down the connective tissue (collagen and elastin) and/or muscle fibers to improve the tenderness and palatability of tougher cuts of meat.
  - **1. Mechanical Tenderization:**
    - **Pounding/Malleting:** Physically breaks down muscle fibers and connective tissue. Effective for thin cuts.
    - **Blade Tenderization (Needling):** Uses sharp blades or needles to cut through muscle fibers and connective tissue. Commonly done mechanically in meat processing plants.
    - **Grinding/Minced Meat:** Extensively breaks down structure, creating very tender ground products (e.g., hamburger patties).
    - **Scoring/Cubing:** Making shallow cuts across the surface of the meat can help sever some fibers and facilitate cooking and chewing.
  - **2. Enzymatic Tenderization:**
    - **Plant Enzymes:** Utilizes proteases from plant sources to break down proteins.
      - **Papain:** From papaya (e.g., in commercial meat tenderizers).
      - **Bromelain:** From pineapple.

- **Ficin:** From figs.
- These enzymes are typically sprinkled on the surface or injected and activated by heat during cooking. Overuse can lead to a mushy texture.

▪ **Fungal Enzymes:** Some commercial tenderizers use proteases derived from fungi (e.g., *Aspergillus*).

- **3. Chemical Tenderization:**
  - **Acids:** Acids (e.g., vinegar, lemon juice, yogurt, buttermilk, wine) in marinades can denature proteins and swell collagen, contributing to tenderness. They also add flavor.
  - **Salts:** Brining or salting can help tenderize meat by drawing out moisture and denaturing proteins, leading to a more tender and juicy product. Sodium bicarbonate (baking soda) can also raise pH and tenderize.

- **4. Thermal Tenderization (Slow Cooking):**
  - **Low and Slow Heat:** Cooking meat slowly at low temperatures (e.g., braising, stewing, slow roasting, sous vide) over extended periods is highly effective for tougher cuts.
  - **Collagen Conversion:** The moist heat and long cooking time convert tough collagen into gelatin, which melts into the meat, adding moisture and making it very tender.
- **5. Ageing (Ripening):**
  - **Dry Aging/Wet Aging:** After slaughter, meat undergoes a process called ageing (or ripening) where natural proteolytic enzymes (cathepsins, calpains) within the muscle tissue break down proteins and connective tissue.

    - **Results:** This process, either dry-aged (exposed to air) or wet-aged (in vacuum packaging), significantly improves tenderness, flavor, and juiciness.

- **(c) Briefly discuss composition of pulses.**
  - Pulses are the edible seeds of leguminous plants, such as lentils, chickpeas, common beans, peas, and various other beans. They are renowned for their high nutritional value.
  - **1. Carbohydrates (approximately 55-65%):**
    - The major component, primarily in the form of complex carbohydrates like starch.
    - They are a good source of dietary fiber (15-30%), both soluble and insoluble, which is beneficial for digestive health, blood sugar regulation, and cholesterol reduction.
    - Contain some oligosaccharides (e.g., raffinose, stachyose), which can cause flatulence in some individuals but are reduced by soaking and cooking.
  - **2. Protein (approximately 20-25%, can range from 17% to 30%):**
    - Pulses are an excellent source of plant-based protein, making them a crucial food source, especially for vegetarians and vegans.
    - While generally rich in lysine, they are typically deficient in sulfur-containing amino acids (methionine and cysteine).
    - Combining pulses with cereals (which are rich in methionine but deficient in lysine) provides a complete protein profile.
  - **3. Water (approximately 10-14% in dry pulses):**

    - Lower water content contributes to their long shelf life when stored dry.

- **4. Minerals (approximately 3-5%):**
    - Rich in essential minerals such as iron, zinc, magnesium, potassium, and phosphorus.
    - The bioavailability of some minerals can be affected by anti-nutritional factors like phytic acid.
- **5. Vitamins:**
    - Good source of B vitamins, especially folate (folic acid), thiamine (B1), riboflavin (B2), and niacin (B3).
    - They generally contain negligible amounts of fat-soluble vitamins (A, D, E, K) or vitamin C in their dry state, though vitamin C can increase significantly upon germination.
- **6. Fat (approximately 1-3%):**
    - Very low in fat, and the fat present is primarily unsaturated. Chickpeas and soybeans have slightly higher fat content compared to other pulses.
- **7. Anti-nutritional Factors:**
    - Pulses contain various anti-nutritional factors (ANFs) that can interfere with nutrient absorption or cause digestive discomfort. These include:
        - **Phytic acid:** Binds minerals.
        - **Trypsin inhibitors:** Interfere with protein digestion.
        - **Lectins (hemagglutinins):** Can cause digestive issues if not destroyed.
        - **Oligosaccharides:** Cause flatulence.

- However, these ANFs are significantly reduced or inactivated by proper processing methods such as soaking, germination, fermentation, and adequate cooking.

5. Discuss the following (any 3): (6x3=18). (a) Rigor Mortis. (b) Gelatinization of starch. (c) Milk pasteurization and its methods. (d) Gluten.

- **(a) Rigor Mortis.**
    - **Definition:** Rigor mortis is a temporary biochemical and physical change that occurs in muscles after an animal dies. It is characterized by the stiffening and contraction of muscles due to the depletion of adenosine triphosphate (ATP).
    - **Process:**
        - **Before Death:** In living muscle, ATP is essential for muscle relaxation. It binds to the myosin head, allowing the actin and myosin filaments to detach, and for calcium ions to be actively pumped back into the sarcoplasmic reticulum, leading to relaxation.
        - **After Death:**
            - **Oxygen Depletion:** Once an animal dies, the circulatory system stops, and oxygen supply to the muscle tissue ceases.
            - **Anaerobic Metabolism:** Muscle cells switch to anaerobic metabolism to produce ATP, using glycogen reserves. This leads to the accumulation of lactic acid, which lowers the muscle pH.
            - **ATP Depletion:** Glycogen reserves are eventually depleted, and the muscle can no longer produce ATP.

        - **Permanent Cross-Bridges:** Without ATP, the myosin heads cannot detach from the actin filaments, leading to the formation of permanent actomyosin cross-bridges. Calcium ions also remain in the sarcoplasm, further contributing to contraction.
        - **Muscle Stiffening:** This results in the stiffening and shortening of muscle fibers, making the carcass rigid.
    - **Timeline:** Rigor mortis typically sets in a few hours after death (e.g., 6-12 hours for beef, shorter for smaller animals) and can last for 24-72 hours, depending on factors like species, age, muscle type, temperature, and pre-slaughter stress.
    - **Resolution:** Rigor mortis eventually resolves due to the action of proteolytic enzymes (e.g., calpains, cathepsins) present naturally in the muscle. These enzymes begin to break down the muscle proteins and cross-bridges, leading to a gradual tenderization of the meat. This process is known as "ageing" or "conditioning" of meat.
    - **Significance in Meat Quality:** The onset and resolution of rigor mortis are critical for meat quality, particularly tenderness. Proper post-mortem handling and ageing allow for the resolution of rigor, ensuring that the meat is tender and palatable when consumed. Slaughtering and processing practices aim to manage this phase effectively to optimize meat quality.

- **(b) Gelatinization of Starch.**
    - **Definition:** Gelatinization is a crucial physicochemical process that occurs when starch granules are heated in the presence of water. It involves the irreversible swelling of starch granules, rupture of hydrogen bonds, and loss of crystalline structure.

- **Process:**
  - **1. Swelling:** When starch granules are heated in water, they begin to absorb water and swell. This is initially reversible.
  - **2. Disruption of Crystalline Structure:** As heating continues and temperature rises (specific for each starch type, e.g., $60 - 70°C$ for corn starch), the hydrogen bonds holding the starch molecules (amylose and amylopectin) in their ordered, crystalline arrangement begin to weaken and break.
  - **3. Amylose Leaching:** Amylose, the linear component of starch, is less tightly bound and begins to leach out of the granules into the surrounding water, increasing the viscosity of the solution.
  - **4. Granule Swelling and Rupture:** The granules continue to swell significantly, absorbing more water, and eventually, their structure can be disrupted, leading to the complete loss of their original birefringence (identifiable under polarized light).
  - **5. Peak Viscosity:** The suspension reaches a peak viscosity as granules swell and amylose leaches.
  - **6. Breakdown/Pasting (Continued Heating):** If heating continues beyond the peak, the swollen granules can begin to fragment and collapse, leading to a decrease in viscosity.
- **Factors Affecting Gelatinization:**
  - **Temperature:** Each starch has a specific gelatinization temperature range.
  - **Water Content:** Sufficient water is essential for swelling.

        - **pH:** Acidic conditions can lower gelatinization temperature and lead to granule breakdown.
        - **Sugar:** Sugars compete for water, raising the gelatinization temperature and reducing granule swelling.
        - **Fat/Protein:** Can coat starch granules, hindering water absorption and delaying gelatinization.
    - **Significance in Food:**
        - **Thickening:** Gelatinization is responsible for the thickening of sauces, gravies, puddings, and soups.
        - **Texture:** Contributes to the texture of baked goods (e.g., bread crumb structure), pasta, and rice.
        - **Digestibility:** Gelatinized starch is generally more digestible than raw starch.
        - **Gelling:** Upon cooling, the leached amylose molecules can re-associate and form a gel (retrogradation), which contributes to the texture of cooled starch products.

- **(c) Milk pasteurization and its methods.**
    - **Definition:** Pasteurization is a heat treatment process applied to milk (and other liquid foods) to destroy pathogenic microorganisms, thereby increasing its safety for consumption and extending its shelf life, without significantly altering its nutritional value or sensory qualities. It does not achieve sterility, meaning it doesn't destroy all microorganisms, only the harmful ones and a significant portion of spoilage organisms.
    - **Principles:**
        - **Time-Temperature Relationship:** Pasteurization relies on specific combinations of temperature and holding time to achieve the desired microbial destruction. Higher

temperatures require shorter holding times, and vice versa.

- **Target Organisms:** The process is designed to eliminate common milkborne pathogens like *Mycobacterium tuberculosis* (historically, a major concern), *Coxiella burnetii* (most heat-resistant non-spore-forming pathogen), *Salmonella*, *Listeria monocytogenes*, and *E. coli*.

- **Methods of Pasteurization:**
  - **1. LTLT (Low Temperature Long Time) or Holder Method:**
    - **Temperature/Time:** Milk is heated to $63^{\circ}C$ ($145^{\circ}F$) and held at that temperature for at least 30 minutes.
    - **Application:** Historically used for batch processing. Less common for large-scale fluid milk processing today, but still used for some specialty products or smaller dairies.
    - **Advantages:** Minimal effect on flavor and nutrient content.
    - **Disadvantages:** Longer processing time, less energy efficient for continuous flow.
  - **2. HTST (High Temperature Short Time) or Flash Pasteurization:**
    - **Temperature/Time:** Milk is heated to at least $72^{\circ}C$ ($161^{\circ}F$) and held for at least 15 seconds.
    - **Application:** The most common method for fluid milk processing worldwide. Uses plate heat exchangers for rapid heating and cooling.

- **Advantages:** Continuous flow process, very efficient, good retention of flavor and nutrients, relatively low cost, extends shelf life significantly.
- **Disadvantages:** Requires precise control of temperature and flow rates.

- **3. UHT (Ultra-High Temperature) Processing (often considered a form of sterilization rather than pasteurization, but relevant for comparison):**
  - **Temperature/Time:** Milk is heated to very high temperatures, typically $135-150^{\circ}C$ $(275-302^{\circ}F)$ for 2-5 seconds.
  - **Application:** Produces "shelf-stable" milk that does not require refrigeration until opened. Often packaged aseptically.
  - **Advantages:** Very long shelf life (several months) at ambient temperatures.
  - **Disadvantages:** Can impart a "cooked" flavor due to more intense heat treatment, some loss of heat-sensitive vitamins.

- **(d) Gluten.**
  - **Definition:** Gluten is a complex protein composite found primarily in wheat, barley, and rye. It is formed when two main storage proteins, glutenin and gliadin, interact and form a cohesive, elastic network upon hydration and mechanical mixing (kneading) of flour and water.
  - **Components:**
    - **Gliadin:** Provides extensibility and elasticity to the dough, allowing it to stretch. It is responsible for the stickiness and flow properties.

    - **Glutenin:** Provides strength and elasticity, contributing to the dough's ability to retain gas and maintain structure. It forms a strong, cross-linked network.

- **Formation:**
    - When wheat flour is mixed with water, gliadin and glutenin absorb water and begin to interact.
    - Mechanical energy (kneading) causes these proteins to align and form disulfide bonds, creating a complex, three-dimensional viscoelastic network.
- **Role in Food Products:**
    - **Bread Making:** Gluten is the primary reason wheat flour is ideal for making leavened bread. Its elastic and extensible network allows the dough to trap carbon dioxide gas produced by yeast during fermentation, causing the dough to rise and giving bread its characteristic light, airy texture and crumb structure.
    - **Texture:** Contributes to the chewiness of bread, pasta, and other baked goods.
    - **Viscoelasticity:** Provides dough with its unique properties of stretchability and resistance to deformation.
    - **Binding Agent:** Acts as a binding agent in various food products.
- **Health Considerations:**
    - **Celiac Disease:** For individuals with celiac disease, an autoimmune disorder, consuming gluten triggers an immune response that damages the small intestine, leading to nutrient malabsorption and other health issues.
    - **Non-Celiac Gluten Sensitivity:** Some individuals experience adverse symptoms (e.g., digestive issues,

fatigue) after consuming gluten, even without having celiac disease.

- **Gluten-Free Diet:** Due to these conditions, there is a growing demand for gluten-free products, which are made from alternative flours (e.g., rice, corn, potato, tapioca, almond) that do not form a gluten network.

6. Write briefly on (any 3): (6x3=18). (a) Toxic constituents of pulses. (b) Spoilage of fish. (c) Egg quality deterioration. (d) Refining of oils.

- **(a) Toxic constituents of pulses.**
  - Pulses are highly nutritious, but in their raw or improperly processed state, they contain various naturally occurring compounds known as anti-nutritional factors (ANFs) or toxic constituents. These compounds can interfere with nutrient digestion and absorption or cause adverse physiological effects if consumed in significant quantities. However, most of these are effectively reduced or eliminated by proper soaking, cooking, or processing.
  - **1. Trypsin Inhibitors:**
    - **Nature:** Proteins that inhibit the activity of digestive enzymes, particularly trypsin (a protease), in the small intestine.
    - **Effect:** Reduces protein digestion and amino acid absorption, potentially leading to pancreatic hypertrophy.
    - **Mitigation:** Heat treatment (e.g., boiling, pressure cooking) effectively denatures and inactivates trypsin inhibitors.
  - **2. Lectins (Phytohemagglutinins):**

- **Nature:** Carbohydrate-binding proteins that can agglutinate red blood cells and interfere with nutrient absorption by binding to the gut lining.
- **Effect:** Can cause nausea, vomiting, diarrhea, and reduced nutrient utilization. Raw kidney beans are notoriously high in phytohemagglutinin.
- **Mitigation:** Thorough cooking (boiling for at least 10 minutes) destroys most lectin activity. Soaking also helps.

- **3. Phytic Acid (Phytate):**
  - **Nature:** An organic phosphorus compound found in the bran and germ of pulses (and other seeds).
  - **Effect:** Acts as an anti-nutrient by chelating (binding) essential minerals like iron, zinc, calcium, and magnesium, making them less bioavailable for absorption.
  - **Mitigation:** Soaking, germination (sprouting), fermentation, and prolonged cooking can significantly reduce phytic acid content by activating the enzyme phytase.
- **4. Oligosaccharides:**
  - **Nature:** Complex sugars like raffinose, stachyose, and verbascose, which are not digestible by human enzymes in the small intestine.
  - **Effect:** They are fermented by gut bacteria in the large intestine, leading to gas production (flatulence, bloating, discomfort).
  - **Mitigation:** Soaking (and discarding soaking water), germination, and prolonged cooking can reduce their content. Alpha-galactosidase enzymes can also be used.

- **5. Saponins:**
  - **Nature:** Glycosides that produce a soapy foam when mixed with water.
  - **Effect:** While generally considered safe in dietary amounts, high levels might have some anti-nutritional effects or bitter taste. Some saponins are beneficial.
  - **Mitigation:** Soaking and washing can reduce some surface saponins.
- **6. Cyanogenic Glycosides:**
  - **Nature:** Compounds that can release hydrogen cyanide upon hydrolysis. Less common in common pulses but present in some varieties like lima beans (especially wild types).
  - **Effect:** High levels can be toxic.
  - **Mitigation:** Thorough soaking and boiling are effective.

- **(b) Spoilage of fish.**
  - Fish is highly perishable due to its unique biochemical composition, high water activity, neutral pH, and presence of specific enzymes and microorganisms. Spoilage begins almost immediately after harvest.
  - **1. Bacterial Spoilage:**
    - **Primary Cause:** The most significant factor in fish spoilage. Fish surfaces, gills, and intestines naturally harbor psychrotrophic (cold-loving) bacteria (e.g., *Pseudomonas, Shewanella, Moraxella, Acinetobacter*).
    - **Mechanism:** After death, the fish's natural defenses decline, and these bacteria multiply rapidly, invading the muscle tissue. They utilize non-protein nitrogenous

compounds (NPNs) like Trimethylamine Oxide (TMAO) as electron acceptors in anaerobic conditions.

- **Products:** Breakdown of TMAO to **Trimethylamine (TMA)** is a major contributor to the characteristic "fishy" odor. Other volatile compounds like putrescine, cadaverine, sulfur compounds (e.g., hydrogen sulfide) are also produced from protein breakdown, leading to offensive odors.

- **2. Enzymatic Autolysis:**
  - **Mechanism:** Intrinsic enzymes present in the fish muscle and gut continue to function after death, even under refrigeration. These proteases and lipases break down complex proteins and fats into simpler compounds.
  - **Effect:** Leads to the softening of muscle tissue, loss of texture, and release of substrates for bacterial growth. Histamine formation in scombroid fish (e.g., tuna, mackerel) is an enzymatic process that can cause scombroid poisoning if not properly handled.

- **3. Oxidative Rancidity (Fat Oxidation):**
  - **Mechanism:** Unsaturated fatty acids, particularly those in fatty fish (e.g., mackerel, salmon), are highly susceptible to oxidation when exposed to oxygen, light, and metal ions.
  - **Effect:** Leads to the development of undesirable "fishy" or "paint-like" off-flavors and odors (rancid) and discoloration. This is a major concern for frozen and processed fatty fish.
- **4. Physical Changes:**

        - **Loss of Rigor Mortis:** Fresh fish muscles are rigid after rigor mortis. As spoilage progresses, the muscles soften significantly due to enzymatic breakdown.
        - **Discoloration:** Gills turn from bright red to dull brown, and the flesh may lose its natural sheen.
        - **Slime Formation:** Bacterial growth on the surface leads to the development of a thick, cloudy slime.
        - **Sunken Eyes:** Eyes lose their clear, bulging appearance and become sunken and opaque.
    - **Prevention of Spoilage:** Rapid chilling immediately after catch, maintaining low temperatures, proper hygiene, gutting, packaging to limit oxygen exposure, and various preservation methods (salting, smoking, freezing).

- **(c) Egg quality deterioration.**
    - Egg quality, particularly for shell eggs, refers to a combination of external and internal characteristics that impact their freshness, culinary performance, and consumer acceptance. Deterioration begins immediately after the egg is laid and accelerates with time and improper storage.
    - **1. Increased Air Cell Size:**
        - **Cause:** Moisture and carbon dioxide are continuously lost from the egg through the porous shell via evaporation.
        - **Effect:** As water evaporates, the internal contents shrink, causing the air cell (located at the large end of the egg, between the shell membranes) to enlarge. A larger air cell indicates an older egg.
    - **2. Thinning of Albumen (Egg White):**
        - **Cause:** Breakdown of mucin fibers, particularly ovumucin, by proteolytic enzymes (like lysozyme) in the albumen.

The pH of the albumen also increases as carbon dioxide is lost.

- **Effect:** The thick, viscous albumen (gel-like) becomes thinner and more watery (liquefies). This reduces the egg's height and firmness when broken out, and affects its whipping properties (less foam stability).

- **3. Weakening of Yolk Membrane (Vitelline Membrane):**
  - **Cause:** Enzymatic degradation and weakening of the vitelline membrane, which surrounds and holds the yolk.
  - **Effect:** The yolk becomes flatter and more susceptible to breaking easily when the egg is cracked. In severe cases, the yolk may even mix with the albumen.
- **4. Flattening of Yolk:**
  - **Cause:** As the vitelline membrane weakens and the chalazae (which anchor the yolk) deteriorate, the yolk can no longer maintain its firm, rounded shape and tends to flatten.
- **5. Movement of Yolk from Center:**
  - **Cause:** Weakening of the chalazae.
  - **Effect:** The yolk tends to drift away from the center of the egg.
- **6. Increase in pH:**
  - **Cause:** Loss of carbon dioxide (which forms carbonic acid in solution) from the egg through the shell pores.
  - **Effect:** The pH of the albumen rises from an initial acidic value (around 7.6-7.9) in very fresh eggs to more alkaline values (up to 9.0-9.7) in older eggs. This pH change contributes to albumen thinning.

- **7. Development of Off-Flavors/Odors:**
  - **Cause:** Microbial spoilage (if bacteria enter the egg) or chemical changes in the egg components.
  - **Effect:** Can lead to undesirable flavors and odors, particularly if storage conditions are poor or if the egg is heavily contaminated.
- **Prevention of Deterioration:** Proper handling, storage at refrigeration temperatures ($0 - 4°C$), and maintaining high humidity significantly slow down the rate of quality deterioration.

- **(d) Refining of oils.**
  - Refining is a crucial multi-step process applied to crude edible oils (extracted from oilseeds, fruits, or animal fats) to remove undesirable impurities, contaminants, and components that negatively affect their quality, stability, appearance, flavor, and shelf life. The goal is to produce a clear, odorless, tasteless, and stable oil suitable for consumption or further processing.
  - **Common Steps in Oil Refining (Sequence can vary slightly):**
    - **1. Degumming (or Demucilagination):**
      - **Purpose:** Removes gums (phospholipids, mucilaginous substances, proteins, carbohydrates) that are soluble in oil but precipitate upon hydration. These gums cause haziness, foaming during frying, and reduce oil stability.
      - **Process:** Crude oil is treated with water, steam, or dilute acids (e.g., phosphoric acid). The gums hydrate, become insoluble, and settle out, allowing them to be separated (e.g., by centrifugation).
    - **2. Neutralization (Deacidification):**

- **Purpose:** Removes free fatty acids (FFAs), which contribute to undesirable flavors, smoke point reduction, and oxidative instability.
- **Process:** The oil is treated with an alkaline solution (e.g., caustic soda/sodium hydroxide, NaOH). FFAs react with the alkali to form soaps (soapstock), which are then separated from the oil. Alternatively, physical refining (steam distillation) can remove FFAs at high temperatures.

- **3. Bleaching (or Decolorization):**
  - **Purpose:** Removes colored pigments (e.g., chlorophylls, carotenoids), residual soap, and other impurities that impart color to the oil.
  - **Process:** The oil is treated with adsorbent materials like activated bleaching earths (clays) or activated carbon, typically under vacuum and at elevated temperatures. These adsorbents selectively bind the colored compounds, which are then filtered out.
- **4. Deodorization:**
  - **Purpose:** Removes volatile compounds responsible for undesirable odors and flavors, such as aldehydes, ketones, and other breakdown products from oxidation, as well as residual FFAs.
  - **Process:** The oil is subjected to high-temperature (e.g., $180 - 270°C$) steam distillation under high vacuum. The volatile compounds are stripped off by the steam. This step also reduces the content of some pesticides and polycyclic aromatic hydrocarbons (PAHs).
- **5. Winterization (Optional, for some oils):**

        - **Purpose:** Removes high melting point triglycerides and waxes that can make the oil cloudy at refrigeration temperatures.
        - **Process:** The oil is cooled slowly to a low temperature, allowing higher melting point components to crystallize. These crystals are then filtered out. This is typically done for oils like sunflower oil to maintain clarity in cold conditions.
    - **Outcome:** The refined oil is clear, bland (odorless and tasteless), stable against rancidity, and has a high smoke point, making it suitable for frying, cooking, and salad dressings.