**Chapter 13 Packaging of Livestock Products**

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**A. Refresher points/ Table**

* **Packaging** involves the act of enclosing products, items, or packages within various forms such as pouches, bags, boxes, cups, trays, cans, tubes, bottles, or other containers. This process serves multiple functions including containment, protection, preservation, communication, utility, and performance enhancement.
* **Package** refers to the tangible object that holds the product securely.
* **Packing** entails the act of enclosing individual items or groups of items within a package or container.
* The essential characteristics of any **food packaging material** involve fulfilling economic requirements by containing, safeguarding, and maintaining the product, as well as conveying information throughout the supply chain from manufacturing to consumer use. Additionally, they should offer convenience at various stages, all while considering legal and environmental limitations on their use.
* Plastic originates from the Greek term "plastikos," which translates to being malleable or capable of being easily deformed or shaped. Cellophane film is known for its environmentally friendly characteristics and suitability for packaging purposes.
* Polyethylene film exhibits chemical inertness, making it a favorable choice for various packaging applications.
* PVC film demonstrates brittleness in its natural state, influencing its handling and application in packaging.
* Food packaging regulations in the European Union are directly effective in all member states without the need for transposition by national parliaments.
* Flexible packaging materials can be folded in any manner as per packaging needs.
* PET bottles are virtually unbreakable and ideal for packaging pickled meat products.
* Moulded pulp containers are commonly used for packaging shell eggs.
* Bio-based plastics are more effective, safer for humans, and more eco-friendly compared to petroleum-based plastics.
* The biodegradation rate of biopolymers is influenced by factors such as temperature, humidity, and pH.
* MAP technology extends the shelf-life of meat by maintaining color, texture, and flavor.
* MAP involves altering the gas composition within the package.
* Carbon dioxide inhibits the growth of aerobic spoilage organisms in meat.
* **History of Packaging:**
* Early Developments:
  + Chemical understanding of polymers emerged in the mid-20th century.
  + Materials and industry existed before full comprehension.
  + Hard rubber, discovered by Charles Goodyear in 1839, marked an early example.
* Pioneering Materials:
  + Alexander Parkes presented "Parkesine" at the 1862 London Exhibition.
  + "Parkesine" derived from treating cotton waste with acids, leading to molded products.
  + Daniel Spill continued similar work with the Xylonite Company.
  + John Wesley Hyatt patented "Celluloid" in 1870, offering a substitute for ivory.
* Advancements:
  + Leo Hendrik Baekeland introduced phenol-formaldehyde resins (Bakelite) in 1907.
  + Hermann Staudinger's work in the 1920s established the concept of macromolecules.
  + Major breakthroughs led to the introduction of various plastics such as PVC and cellulose acetate.
* Significance in the 1930s-1940s:
  + Decade saw the development of major thermoplastics.
  + Continued growth despite setbacks like the oil crisis of the 1970s.
* Current Trends:
  + Global plastic consumption is around 250 million tonnes annually.
  + Approximately 30% of plastics are used in packaging.
  + Research focuses on sustainability, including biobased materials like biopolyethylene from sugar cane.
* India plastic production in 2019 was 16.5 MMT (only 9 % is recycling).
* India has a population of more than 1.4 billion and generates 26,000 tonnes of plastic waste – every day.
* Plastic processing in India was 8.3 Mt in the 2010 financial year and increased to 22 Mt in2020.
* While recycling the plastic, Plastic bottles are sorted into various categories, including transparent PET bottles for soft drinks, green PET bottles for soft drinks, translucent HDPE bottles for milk, water, and juice, colored HDPE bottles for detergent, PVC bottles for water, and containers like PP bottles for ketchup.
* Iron and steel scrap make up over a third of the total production of cast iron and steel. When recycling tinplate cans, it's necessary to eliminate tin, as even a small amount (0.01%) can create difficulties during rolling and result in hard spots in steel. Hence, only steel scrap with low levels of tin can be directly utilized in furnaces
* Glass occurs in the middle layer of the slurry formed by the mineral jig in recycler
* For every six tons of recycled container glass used, one less ton of carbon dioxide, a greenhouse gas, is reduced compared to manufacturing glass
* **Properties of packaging material**
* **Tensile strength**expressed in kg/15 mm
  + Laminates3-06 kg/ 15 mm
  + Elongation value200-500 (LDPE –300-500)
* **Bursting strength**expressed as kg/cm2 (Laminates 0.7 to 2.0kg/ cm2)
* **Puncture resistance**expressedOz/tear
* **Tearing resistance**
* **Addition polymerization** is the process where monomers combine to form polymers with repeating units containing the same atoms as the monomers, leading to the creation of thermoplastics.
* **Atactic:**Polymers with random spatial arrangements of branches under typical conditions and catalysts.
* **Isotactic polymers:**Certain processes result in products with branches arranged in an orderly manner.
* **Water activity** (*aw*) is a measure defined as the ratio between the vapor pressure of water in a substance and the vapor pressure of pure water at the identical temperature.
* Aerobic microorganisms require positive Eh values (oxidized) for growth and anaerobes require negative Eh values for growth.
* **Aseptic Packaging**Aseptic packaging involves filling sterile containers with commercially sterile products under aseptic conditions, ensuring hermetic sealing to prevent reinfection.
* Sterilization Methods\*\*:
  + HTST and Ultra-High Temperature (UHT) processes.
  + UHT involves continuous flow heating at ≥135°C for ≥1 second, suitable for various products based on viscosity.
* Ionizing Radiation:
  + Utilizes gamma rays or electron beams for sterilization.
  + Effective for materials unable to withstand thermal sterilization.
  + Dose of 25 kGy ensures sterility.
  + Electron beams used for surface sterilization of packaging materials.
* Pulsed Light:
  + Employs short pulses of broad-spectrum light for sterilization.
  + Duration1 μs to 0.1 s; flashes applied at 1–20 per second.
  + High intensity light in UV, visible, and infrared ranges.
  + Not yet commercialized due to complex surface topography influence.
* UV-C Radiation:
  + UV-C range (200–315 nm) most effective for microbial destruction.
  + Mercury vapor lamps emit UV-C at 253.7 nm.
  + UV (Excimer) lasers also used, particularly for carton interior sterilization.
  + Often used in combination with hydrogen peroxide.
* Plasma:
  + Nonthermal plasma (NTP) for surface decontamination of packaging.
  + Mixture of reactive gases generates UV photons and antimicrobial radicals.
  + Effective for PET bottle sterilization; commercialization underway.
* Heat Sterilization:
  + Involves steam (moist heat) or dry heat methods.
  + Steam more efficient than dry heat.
  + Steam sterilization at 121°C for 20 min equivalent to dry heat at 170°C for 60 min.
* Saturated Steam:
  + Steam under pressure used for sterilization.
  + Problems include air removal and condensation.
  + Effective for plastic container sterilization.
* Superheated Steam:
  + Historical method for can sterilization.
  + Cans passed through 220°C–226°C steam for 36–45 s.
* Hot Air:
  + Dry heat at atmospheric pressure.
  + Used for paperboard carton sterilization (pH < 4.5).
* Hot Air and Steam:
  + Mixture used for PP cup sterilization.
  + Uniform heating of cup base and walls.
* Extrusion:
  + Plastic granules subjected to high temperatures.
  + Results in partial spore reduction; suitable for acidic products (pH < 4.5).
  + Post-sterilization recommended for products with pH > 4.5.
* **Chemical Treatments for Sterilization of packaging materials**
* Hydrogen Peroxide (H2O2):
  + Known for its lethal effect on microorganisms, including spores.
  + Commercial use since 1961; often combined with heat.
  + Minimum conditions for sterilization70°C, 30% concentration, 6 seconds.FDA regulations limit H2O2 concentration in food packaging.
  + Used in dipping, spraying, rinsing processes, often combined with UV irradiation and heat.
* Peracetic Acid (PAA):
  + Liquid sterilant effective against spores, produced by oxidizing acetic acid with H2O2.
  + Effective even at 20°C, but can cause corrosion of metals.
  + Stored at concentrations around 40% to avoid explosive decomposition.
  + Utilized for sterilizing filling machine surfaces and PET bottles, followed by rinsing with sterile water.
* **Active Packaging** refers to packaging where additional components are intentionally added to the packaging material or inside the package itself. This is done to improve how well the packaging works.
* **Intelligent Packaging**, on the other hand, is packaging that includes either an internal or external indicator. This indicator gives information about the package's history or the quality of the food it contains.
* **Modified Atmosphere Packaging (MAP)** refers to the practice of enclosing food in a package where the atmosphere inside is adjusted or modified to create an ideal environment that extends shelf life and preserves the quality of the food (60 nitrogen in combination with 40carbon dioxide or 50 nitrogen + 50 carbon dioxide is ideal forMAP of poultry).
* **Controlled Atmosphere Packaging (CAP)** involves sealing food within a gas-impermeable package. Inside this package, the composition of gases, including O2, CO2 and N2, water vapor, and trace gases, is changed and selectively regulated to enhance shelf life.
* **Retortpouches**a composite film especially film/foil/film laminates are used in following ways;
* Outer layer films (polyamide, or oriented PP provide support and physical

strength

* Middlelayer foil (provide excellent barrier properties)
* Innerlayer films (PVC provide excellent sealing properties)
* Pigments like hemoglobin and myoglobin contribute to the characteristic color of fresh meat.
* Packaging of fresh meat aims to prevent moisture loss, bacterial contamination, and flavor alteration.
* In processed meats like cured meats, incorporating sodium nitrite during manufacturing serves as an antimicrobial agent, specifically targeting the inhibition of Clostridium botulinum growth
* Nitrate-based additives in cured meats likely stemmed from salting meats contaminated with saltpetre (KNO3), a common impurity in salt, enhancing preservation and imparting a red hue to the product.
* Top of Form
* Nitrite's interaction with secondary amines and amino acids in muscle proteins can lead to the formation of carcinogenic N-nitrosamines in cured products.
* Human lethal oral doses are set at 80–800 mg nitrate/kg body weight and 33–250 mg nitrite/kg body weight.
* Proper packaging controls oxygen transfer and prevents dehydration and oxidation.
* Relative humidity of 85% to 95% is required to prevent dehydration during storage.
* Temperature significantly influences meat spoilage, with ideal storage conditions at 0°C and 85-90% RH.
* Various packaging materials like LDPE, PVC, and polystyrene are used for fresh meat packaging.
* Different packaging techniques such as tray with over-wrap, shrink packaging, vacuum packaging, and skin packaging are employed.
* Modified atmosphere packaging (MAP) extends the shelf-life of meat by altering the gas composition within the package.
* In MAP Oxygen enhances the desirable formation of fresh red meat color and co2 extends shelf life, as it selectively inhibits microbial growth. Additionally, nitrogen can be utilized to preserve the final shape of the packaging.
* Typically, fresh red meats are stored in MAP containing 80% O 2 :20% CO 2. meat products stored in Modified Atmosphere Packaging (MAP) with high oxygen levels can lead to protein oxidation, potentially impacting the tenderness of the meat negatively.
* A **bag or pouch** serves as a container crafted from flexible packaging material, featuring a sealed end for containment.
* Bottles, characterized by a rounded neck narrower than their body, function as containers suitable for various liquids.
* Jars, distinguished by their wide mouth and lack of a distinct neck, are akin to bottles but offer greater accessibility for content removal
* **Elongation** denotes the extent to which a film can be stretched under a pulling force, expressed as a percentage of its original length.
* A **film** refers to an ultra-thin, pliable plastic sheeting commonly utilized in packaging applications.
* **Gas Transmission Rate** (GTR) signifies the quantity of any gas passing through a unit area of a film over a fixed time period under standard temperature and pressure conditions.
* **Plasticizer**, such as ATBC (acetyl tributyl citrate) used in Saran, is an additive incorporated during manufacturing to enhance the flexibility of packaging materials.
* **Tear resistance** measures a material's ability to resist the propagation of a minor tear, ensuring durability and integrity in flexible packaging.
* **Water Vapor Transmission Rate** (WVTR) quantifies the amount of water vapor permeating through a unit area of film in a 24-hour period at specific temperature and humidity conditions.
* The concept of Modified Atmosphere Packaging (MAP) was initially introduced by Killefer in 1930, who utilized 100% CO2 to preserve pork and lamb at temperatures ranging from 4 to 7°C.
* Vacuum packaging (VP) is widely employed for various products including prime cuts of fresh red meat (during storage, aging, transport, and retail frozen storage), cured meats (from manufacturing through to retail display), and processed meat products in chub format.
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* Typically, fresh red meats are stored in MAP containing 80% O 2 :20% CO 2. meat products stored in Modified Atmosphere Packaging (MAP) with high oxygen levels can lead to protein oxidation, potentially impacting the tenderness of the meat negatively.
* The respiration process of the meat rapidly utilizes most of the remaining oxygen (O2) within the package, leading to its replacement with carbon dioxide (CO2), which gradually accumulates to levels between 10% to 20% within the packaging.
* Vacuum-packaged fresh meat isn't suitable for retail due to oxygen absence causing a color change from red to purple and potential drip loss during prolonged storage. Vacuum skin packaging (VSP) addresses this issue by tightly adhering a film to the meat surface, minimizing fluid accumulation
* Active packaging systems may integrate oxygen scavengers, carbon dioxide scavengers, moisture control agents, and antimicrobial packaging technologies.
* Food materials in a package absorb or release moisture until reaching **moisture sorption equilibrium**, involving both moisture adsorption onto solid surfaces and absorption into solid or liquid materials.
* The production of bioplastics constitutes a significant portion of the total output, projected to reach 1.33 million tons by 2024 according to European bioplastics (2020).
* Plasma proteins, including those found in blood, have been harnessed to create biodegradable films. But lacks properties transparency and water resistance, which can achieved through methods like blending with chitosan or microencapsulation.

**Codex Alimentarius International Standards (FAO & WHO)**

* + This standard pertains to the labeling of all prepackaged foods intended for consumer consumption or catering purposes, including certain aspects of their presentation.

**Table no. 13.1 – General standard for prepackaged food labeling CXS 1-1985**

| **General Principles** |
| --- |
| Prepackaged food shall not be described or presented in a manner that is false, misleading, or deceptive, or likely to create an erroneous impression regarding its character. |
| Prepackaged food shall not be described or presented in a manner that refers to or suggests any other product, leading the purchaser to suppose a connection with such other product. |

| **Mandatory Labelling of Prepackaged Foods** |
| --- |
| 1. The name of the food |
| 2. List of ingredients |
| - Known allergens must always be declared: |
| - Cereals containing gluten (wheat, rye, barley, oats, spelt) |
| - Crustacea and products thereof |
| - Eggs and egg products |
| - Fish and fish products |
| - Peanuts, soybeans, and products thereof |
| - Milk and milk products (including lactose) |
| - Tree nuts and nut products |
| - Sulphite in concentrations of 10 mg/kg or more |
| 3. Net contents and drained weight |
| - Declared in metric units |
| - Liquid foods by volume |
| - Solid foods by weight |
| - Semi-solid or viscous foods by weight or volume |
| 4. Name and address |
| - Manufacturer, packer, distributor, importer, exporter, or vendor |
| 5. Country of origin |
| 6. Lot identification |
| 7. Date marking and storage instructions |
| 8. Instructions for use |

| Additional Mandatory Requirements |
| --- |
| - Quantitative ingredients declaration |
| - Irradiated foodsLabel must indicate treatment with ionizing radiation, with the option to use the international food irradiation symbol. |

* **Food Packaging Regulations in the US**
  + Enforced by the FDA (Food and Drug Administration).
  + FDA conducts risk assessment and management for food safety and packaging.
  + Food, Drug, and Cosmetic Act 1958, enforced by the FDA, is the fundamental regulation for Food Contact Materials (FCM).

**Food Packaging Regulations in the European Union (EU)**

* Coexistence of national and community-level legislation.
* Regulations are directly effective in member states but may need to be transposed by national parliaments for enhanced effectiveness.
* EU Framework Regulation EC 1935/2004 is used for regulating food contact materials at the Union level.

**Food Packaging Regulations in the Middle East Region**

* Gulf Cooperation Council (GCC) includes member nations such as the UAE, Bahrain, Kuwait, Oman, Qatar, and Saudi Arabia.
* Standards and technical regulations for food packaging in GCC nations fall under the GCC Standardization Organization (GSO).
* Yemen also follows these standards and regulations.
* Various standards developed by GSO must be implemented voluntarily by GCC nations.
* To have legal effect, these standards must be adopted into national law in Member States and Yemen.

**Food Packaging Regulations in India**

Regulatory Authority:  
The Food Safety and Standards Authority of India (FSSAI) is an autonomous body under the Ministry of Health & Family Welfare, responsible for setting standards and regulations pertaining to food safety in India.

Key Regulations:Food Safety and Standards (Packaging) Regulations, 2018

General Requirements:Packaging materials must comply with these regulations; in the absence of Indian Standards, relevant International Standards may be followed.

* All materials in direct contact with food or likely to come in contact must be of food-grade quality.
* Packaging materials should be suitable for the type of product, storage conditions, and transportation.
* They must withstand mechanical, chemical, or thermal stresses during transportation.
* Products must be packed in clean, hygienic, and tamper-proof packages.
* Sealing materials should be compatible with the product and containers.
* Tin containers should not be reused for food packaging.
* Plastic containers (5 liters and above) and glass bottles, if reused, must be durable and easy to clean.
* Printing inks used on food packages must conform to IS15495.
* Printed surfaces of packaging materials should not directly contact food products.
* Newspaper or similar materials should not be used for storing or wrapping food.

**Specific Requirements for Multilayer Packaging:**

* Layers in direct contact with food or likely to come in contact must meet the packaging material requirements specified in Schedule I, II, and III of the regulations.
* Materials listed in these schedules must be compatible with their intended use as packaging material to maintain the quality and safety of the food product.
* Food business operators must obtain a certificate of conformity from an NABL accredited laboratory against these regulations for packaging materials in direct contact with food or layers likely to come in contact.

**Migration limits for plastic packaging materials**

* Plastic packaging materials must adhere to the specified overall migration limit of either 60 mg/kg or 10 mg/dm², as assessed according to IS 9845, without any discernible color migration.
* Colorants or pigments utilized in plastics that come into contact with food items and drinking water must comply with IS9833.
* food packaging, storage, carrying, or dispensing products made from recycled plastics, including carry bags, can be utilized once the Food Authority establishes standards and guidelines.
* Plastic materials and articles must not release substances in quantities that surpass the specified migration limits outlined below.

**Table no. 13.2 –** specified migration limits for plastic materials and articles

|  |  |
| --- | --- |
| **Barium** | **1.0** |
| **Cobalt** | **0.05** |
| **Copper** | **5.0** |
| **Iron** | **48.0** |
| **Lithium** | **0.6** |
| **Manganese** | **0.6** |
| **Zinc** | **25.0** |
| **Antimony Phthalic acid, bis (2-ethylhexyl) ester (DEHP)** | **1.5** |

**List of suggestive packaging materials Fish and fish products or Seafood**

* Glass jars with plastic (PP or High-density polyethylene (HDPE)
* caps o Metal Containers with metal lid (lacquered tin containers)
* Polyethylene terephthalate (PET) punnets or containers with plastic caps
* Plastic-based multi-layered flexible laminates heat sealed pouches
* Plastic tray with overwrap

**Food safety and standards (labelling and display) regulations, 2020**

Labelling of pre-packaged foods:

* All pre-packaged foods must bear the required information on labels, as per these regulations, unless specified otherwise.
* When sold via e-commerce or direct selling, the mandatory label requirements outlined in these regulations must be provided to consumers prior to purchase.
* Labels must not convey false, misleading, or deceptive information about the food product.
* Any information or imagery displayed on the label must not conflict with the regulations.
* Label particulars must be in English or Hindi and applied securely to prevent detachment.
* Labels must be clear, easily readable, and durable under normal conditions of use.
* When an outer container is used for retail display, it should include all required label information unless transparent and easily readable through the outer container.

**Labelling Requirements:**

* Food name, reflecting its true nature, must be prominently displayed on the front of the package.
* Ingredients list, except for single-ingredient foods, must be provided.
* Nutritional information per serving and as a percentage of the recommended dietary allowance must be included.
* Declaration of vegetarian or non-vegetarian status with specified symbols.
* Declaration of food additives.
* Name and full address of the manufacturer or vendor.
* Display of FSSAI logo and license number in contrast to the background.
* Net quantity, retail price, and consumer care details.
* Lot or batch identification.
* Date of manufacture or packaging and expiry/use by date.
* Labelling requirements for imported foods, including country of origin.
* Instructions for use.
* Declaration of food allergens.
* Symbol declaration for non-human consumption food materials. Principal display panel:

**Table no. 13.3- Different methods of integrating nanomaterials into packaging**

|  |  |
| --- | --- |
| **Method** | **Description** |
| Nanocomposites | Incorporation of nanomaterials within the packaging material to enhance its physical properties, durability, barrier characteristics, and biodegradability. |
| Nano coatings | Application of nanomaterials onto the packaging surface to primarily enhance its barrier properties, particularly against external factors. |
| Surface biocides | Integration of nanomaterials with antimicrobial properties onto the packaging surface to inhibit microbial growth, ensuring food safety and preservation. |
| Active packaging | Incorporation of nanomaterials with antimicrobial or other beneficial properties into the packaging, aiming for intentional release to extend the shelf life and improve the safety of packaged food items. |
| Intelligent packaging | Implementation of nanosensors within the packaging to actively monitor and report on various aspects of food condition, such as freshness, temperature, and spoilage, offering real-time insights for consumers and producers. |

**Table mo. 13.4 Collagen films developed from different animal by-product sources**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source | Objectives | Plasticizers | Method | Findings | Refrence |
| Hidrogel® B50 | Produce edible films using collagen, sucrose, and cocoa butter | Sucrose | Solvent casting | Sucrose and cocoa butter reduce tensile strength (TS). Plasticizer enhances film elongation. Sucrose improves transparency; films with over 17.5% collagen display homogeneous surfaces. | [Fadin et al., 2013] |
| Bovine hides | Create collagen films with Laponite® nanoparticles | Glycerol | Casting | Laponite increases surface roughness without altering film properties. Nano-bio-composite films exhibit lower melting enthalpy. | [Valencia et al., 2019] |
| Fish skin | Scale up collagen and sodium alginate blended films | Glycerol | Casting machine | Sodium alginate enhances viscosity, thermal stability, and TS; film properties remain unaffected. Optimal ratiocollagen to sodium alginate is 10:2. Successful upscaling achieved. | [Wang et al., 2017] |
| Bligon Goatskin | Develop edible films from collagen extracts and glycerol | Glycerol | Solvent casting | Varying plasticizer concentrations affect film thickness, TS, and elongation. Films with 80% glycerol (based on collagen) exhibit superior mechanical and physical properties. | [Said et al., 2016] |
| Bovine connective tissue | Assess cross-linkers' impact on collagen film barrier properties | Lecithin | Solvent casting, extrusion | Thermal cross-linking enhances water resistance. Chemical cross-linking with glutaraldehyde, glyoxal, or formaldehyde improves water resistance and reduces degradation rate. | [Sommer et al.,2012] |
| Cow’s hide | Investigate apatite reinforcement in collagen films | Glycerol | Solvent casting | Apatite enhances film compactness, TS, reduces WVP and solubility, and improves thermal stability | [wang et al., 2016] |
| Tilapia skin collagen | Develop blended collagen films with Pachyrhizus starch or rambutan peel phenolics | Glycerol | Solvent casting | Addition of starch and phenolics increases opacity and thickness, reduces water solubility, EAB, and WVP. Optimal blend10% starch and 0.5% phenolics. Improved thermal stability. Smooth, uniform surface. | [Zhuang et al., 2019] |
| Trimmed skin waste from leather industry | Produce blended films from collagen, starch, and soy protein | - | Solvent casting | Increasing starch concentration enhances film tensile strength (TS), while soy protein boosts elongation at break (EAB). Moderate increase in thermal stability. Hybrid films exhibit higher swelling and biodegradation. | [Murali et al., 2011] |
|  | Develop blended films from collagen, methylcellulose, and whey protein | Glycerol | Solvent casting | Collagen films exhibit highest elongation at break (EAB). Methylcellulose improves tensile strength (TS), barrier, and thermal properties. | [Filipini et al., 2020] |
| Bovine hides | Prepare collagen-2 hydroxyethyl cellulose hybrid films | - | Solvent casting | Cross-linking with cellulose derivatives enhances dry film TS (from 22 to 58.9 MPa). Improved thermal stability. Enhanced bio-stability and biocompatibility. | [Anumary et al., 2013] |
| Bovine skin splits | Manufacture collagen films incorporated with carboxylated cellulose nanofibers (CNF) | Glycerol | Solvent casting | CNF increases collagen fiber suspensions and film TS, while reducing EAB. Improved WVP and oxygen permeability. Homogeneous embedding of CNF enhances thickness, opacity, and swelling. | [Wang et al., 2017] |

**Table 13.5-TYPES OF PACKAGING -**

| Type | Examples |
| --- | --- |
| Flexible Packaging | Plastic films, Paper, Aluminum foil |
| Semi-Rigid Packaging | Paperboard/cardboard/containers, PET and PVC containers, Aluminum containers, Molded containers |
| Rigid Packaging Containers | Glass containers, Metal cans, Fiberboard containers, Wooden boxes/crates/barrels |

**Table 13.6 -TYPES OF PACKAGING MATERIALS-**

|  |  |
| --- | --- |
| **Material** | **Description** |
| Polyester | Inert film with excellent strength, commonly used in lamination for outer, abrasion-resistant layers. |
| Polyvinyl Chloride (PVC) | Plasticized film for packaging with low folding endurance, but clear, non-toxic, and almost impervious to gas transmission. |
| Saran | Produced with vinyl chloride, clear, non-toxic, and almost impervious to gas transmission, suitable for meat packaging. |
| Ionomer | Ideal bonding agent between packaging films, offering good seal property and resistance to oil and grease. |
| Shrink Films | Thermoplastic films such as PE and PP act as shrink film, providing neat appearance and tight package contour when wrapped around meat cuts. |
| Laminate | Combination of different flexible packaging materials bonded together to provide functional properties and improve barrier properties. |
| Glassine | Smooth, dense, transparent or semi-transparent paper with good resistance to grease and air, suitable for wrapping fatty cuts and bacon. |
| Parchment Paper | Paper with good grease resistance and high wet strength, used for wrapping bacon and other fatty cuts of meat. |
| Frozen Foods Paper | High moisture and water vapor resistant paper used for inner liners in frozen food packaging, resistant to cracking at freezing temperatures and high wet strength. |
| Meat Wrapping Paper | Odorless and tasteless paper that resists meat juices, fat, and greases, easy to remove from any kind of meat. |
| Delicatessen Paper | Used as an inner wrap for meats and soft foods to retain moisture and prevent outer wrappers from becoming water or grease soaked. |
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| Delicatessen Paper | Used as an inner wrap for meats and soft foods to retain moisture and prevent outer wrappers from becoming water or grease soaked. |
| Glass Containers | Versatile packaging option for food, chemically inert with excellent barrier properties to solids, liquids, and gases. Allows molding into various shapes/sizes and provides excellent product visibility. Commonly used for packaging meat pickles. Drawbacks include breakage risk and heavy weight. |
| Metal Cans | Primarily used for commercially sterilized food products. Made from iron sheet with thin tin coating to prevent rusting; further coated with enamel or lacquer for food safety. Preferable to use sulphur-resistant lacquer for canning meat products to prevent black discoloration. Hermatically sealed to preserve product. |
| Rigid Thermoformed Plastic Containers | Created by heating plastic sheet and forming into various shapes, including individual pieces or combinations. Utilizes high-density polyethylene, polypropylene, or polyvinyl chloride. Polystyrene foam trays are also used in developed countries for fresh meat packaging. |
| Fibreboard Containers, Wooden Boxes, Plastic Crates | Wholesale or shipping containers made from fibreboard, wood, or plastic, commonly used for transporting goods. More details will be covered in the subsequent unit. |

**Table 13.7-Individual polymer materials, common abbreviation and associated properties**

|  |  |  |
| --- | --- | --- |
| **Polymermaterials Associated** | **Abbreviations** | **properties** |
| Lowdensity polyethylene | LDPE | Sealability, formability, moisture barrier, low cost |
| Polyethylene | PP | Moisture barrier, thermal resistance, dimensional stability |
| Polyesters | PET | Mechanical resistance, heat resistance, medium 02, barrier |
| Polyamides | PA | Mechanical strength, 02, barrier (moisture sensitive), formability |
| Polyvinylidene chloride | PVDC | High 02, barrier; (moisture stable), grease and fat barrier |
| High density polyethylene | HDPE | More gas impermeable than LDPE, low cost, strong, reduced clarity |
| Polyvinyl chloride | PVC | Versatile, shrink properties, sparkling clear, |
| Low-cost Polystyrene | PS | Excellent clarity, low cost, readily thermoformed and injection moulded |
| Ionomer |  | Heat sealability, produce films of unusual toughness and clarity |

(SourceWalsh, H.M. and Keny S.P. Meat Packaging in Meat Processing- improving quality)

* Top of Form

**Table 13.8- Functions of packaging**

|  |  |  |  |
| --- | --- | --- | --- |
| **Function** | **Physical** | **Environments**  **Ambient** | **Human** |
| **Description** | | |
| Containment | Essential for transporting products. | | |
| Prevents product loss and environmental pollution. | | |
| Faulty packaging can lead to environmental damage. | | |
| Protection | Shields contents from environmental factors. | | |
| Crucial for preserving food and extending shelf life. | | |
| Preserves energy expended during production and processing. | | |
| Convenience | Addresses changes in lifestyles and household dynamics. | | |
| Offers pre-prepared, easy-to-use products. | | |
| Facilitates portion control and efficient packaging for storage and transportation. | | |
| Communication | Acts as a "silent salesman," aiding consumer recognition. | | |
| Provides essential information like universal product code (UPC) and nutritional facts. | | |
| Vital for efficient stock management and international trade. | | |

**Table 13.9 Classification, properties and importance of Polymers in food packaging**

|  |  |
| --- | --- |
| **Classification of Polymers** | |
| **Types of Polymers** | **Description** |
| Homopolymers | Consist of the same repeating building-block unit throughout their molecules. |
| Heteropolymers | Contain two or more different building-block units distributed throughout their length. |
| Copolymers | Formed when two different monomers are polymerized together. |
| Terpolymers | Formed when three different monomers are used in polymerization. |
| Linear Polymers | Have a backbone of carbon atoms with side groups varying from polymer to polymer. |
| Examples include polyethylene (PE), which is a common food packaging film. |
| Copolymers | Can exhibit regular, random, or block copolymer structures. |
| Branched Polymers | Have additional side chains branching off from the main molecular chain. |
| Cross-linked Polymers | Form a network structure with links between chains, making the material a single giant molecule. |
| Thermosetting polymers that do not soften or melt upon heating. |
| Examples include epoxy resins and unsaturated polyesters. |
| **Properties and Applications of polymer** | |
| Thermoplastic Polymers | Gradually soften with increasing temperature and can be remolded. |
| Exhibit temperature-sensitive mechanical properties. |
| Account for more than two-thirds of all polymers used globally. |
| Thermosetting Polymers | Set into a fixed network during manufacturing and cannot be remolded. |
| Do not melt upon heating; may blister and char instead. |
| Examples include epoxy resins, used as enamels for metal cans. |
| **Importance of polymers in Food Packaging** | |
| Thermoplastic Polymers | Widely used in food packaging due to their moldability and flexibility. |
| Allows for easy molding and extrusion processes. |
| Thermosetting Polymers | Minimal importance in food packaging, except for epoxy resins used as enamels for metal cans. |

**Table 13.10- Properties of different polyethylene films**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Type of Polyethylene** | **Tensile Strength (MPa)** | **Gas Transmission** | | **Water Vapor Transmission** |
| **O2** | CO2 |
| High density (960 kg m−3) | 28 | 125 | 350 | 0.3 |
| Medium density (940 kg m−3) | 21 | 225 | 500 | 0.6 |
| Low density (920 kg m−3) | 9–15 | 500 | 1350 | 1.4 |

**Table 13.11- Classification of biodegradable/ biobased packaging materials**

|  |  |  |
| --- | --- | --- |
| **Category** | **Description** | **Example** |
| Category 1 | Polymers derived directly from natural sources such as plants and animals | Starch, Cellulose, Chitin |
| Category 2 | Polymers synthesized through traditional chemical methods using renewable biomass-derived monomers | Polylactic acid (PLA), Biopolyethylene (bioPE) |
| Category 3 | Polymers created through direct biological processes or genetic modification of organisms | Polyhydroxyalkanoates (PHA) |
| Category 4 | Polymers derived from petrochemical-based monomers, although they may have biodegradable properties | Poly(caprolactone) (PCL), PBSA |

**Table 13.12 Lowest limits of temperature, ph and water activity for growth microorganisms**

|  |  |  |  |
| --- | --- | --- | --- |
| **Bacteria/Organisms** | **Lowest Temperature Limit (°C)** | **Lowest pH Limit** | **Lowest aw Limit** |
| Staphylococcus aureus | 7 | 4 | 0.86 |
| Listeria monocytogenes | 0 | 4.3 | 0.92 |
| B. cereus (psychrotrophic) | 5 | 4.9 | 0.93 |
| Bacillus cereus (mesophilic) | 10 | 4.9 | 0.93 |
| Lactobacillus spp. | 4 | 3 | 0.93 |
| Brochothrixthermosphacta | 0 | 4.6 | 0.94 |
| Clostridium botulinum (proteolytic) | 10 | 4.6 | 0.94 |
| Escherichia coli | 7 | 4.4 | 0.95 |
| Most lactic acid bacteria | 5 | 3.5 | 0.95 |
| Salmonella spp. | 5 | 4 | 0.95 |
| Clostridium perfringens | 5 | 4.5 | 0.96 |
| Clostridium botulinum (nonproteolytic) | 3.3 | 5 | 0.97 |
| Pseudomonas spp. | -2 | 5 | 0.97 |
| Campylobacter spp. | 30 | 4.9 | 0.98 |
| Moulds | | | |
| Aspergillus flavus | 3 | 2 | 0.78 |
| Most moulds | <0 | 1.5 | 0.8 |
| Yeasts | | | |
| Most yeasts | -5 | 1.5 | 0.87 |
| Saccharomyces cerevisiae | 0 | 2.3 | 0.9 |

**Table 13.13- Influence of water activity on microbial growth in food across various water activity levels (*aw*)**

|  |  |  |
| --- | --- | --- |
| **Range** | **Microorganisms Generally Inhibited by Lowest aw of the Range Foods** | **Generally, within This Range of aw** |
| 0.30–0.20 | No microbial proliferation | Whole milk powder of 2%–3% moisture content, dried vegetables of 5% moisture content; corn flakes of 5% moisture content |
| 0.40–0.30 | No microbial proliferation | Cookies, crackers, bread crusts, and so forth of 3%–5% moisture content |
| 0.50–0.40 | No microbial proliferation | Whole egg powder of 5% moisture content |
| 0.60–0.50 | No microbial proliferation | Pasta of 12% moisture content; spices of 10% moisture content |
| 0.65–0.60 | Osmophilic yeasts (Saccharomyces rouxii), few molds (Aspergillus echinulatus, Monascusbisporus) | Dried fruits containing 15–20% moisture content, some toffees and caramels; honey |
| 0.75–0.65 | Xerophilic molds (Aspergillus chevalieri, A. candidus, Wallemia sebi), Saccharomyces bisporus | Rolled oats of 10% moisture content, grained nougats, fudge, marshmallows, jelly, molasses, raw cane sugar, some dried fruits, nuts |
| 0.80–0.75 | Most halophilic bacteria, mycotoxigenic aspergilli | Jam, marmalade, marzipan, glacéd fruits, some marsh mellows |
| 0.87–0.80 | Most molds (mycotoxigenic penicillia), Staphylococcus aureus, most Saccharomyces (bailii) spp., Debaryomyces | Most fruit juice concentrates, sweetened condensed milk, chocolate, syrup, maple and fruit syrups; flour, rice, pulses of 15%–17% moisture content; fruit cake, country-style ham, fondants, high-ratio cakes |
| 0.91–0.87 | Many yeasts (Candida, Torulopsis, Hansenula), Micrococcus | Fermented sausages (salami), sponge cakes, dry cheeses, margarine; foods containing up to 65% (w/w) sucrose (saturated) or 15% sodium chloride |
| 0.95–0.91 | Salmonella, Vibrio parahaemolyticus, C. botulinum, Serratia, Lactobacillus, Pediococcus, some molds, yeasts | Some cheeses (Cheddar, Swiss, Muenster, Provolone), cured meats (ham), some fruit juice concentrates; foods containing 55% (w/w) sucrose or 12% sodium chloride |
| 1.00–0.95 | Pseudomonas, Escherichia, Proteus, Shigella, Klebsiella, Bacillus, Clostrium perfringens, some yeasts | Highly perishable (fresh) foods and canned fruits, vegetables, meat, fish and milk; cooked sausages and breads; foods containing up to approximately 40% (w/w) sucrose or 7% sodium chloride |
| SourceBeuchat, L., Cereal Foods World, 26, 345, 1981. | | |

**Table 13.14- Commonly used active packaging systems in meat and dairy products**

|  |  |  |
| --- | --- | --- |
| **Active Packaging System** | **Mechanisms** | **Food Applications** |
| Anti-microbial packaging | Organic acids, chlorine dioxide and sulfur dioxide silver zeolite, vitamin E antioxidant, spice and herb extracts, BHA/BHT antioxidants, | Meats, fish and cheese |
| Carbon dioxide absorbers/emitters | calcium oxide/Iron oxide/activated charcoal and ascorbate/ calcium hydroxide, ferrous carbonate/sodium bicarbonate/metal halide | fresh meats and fish |
| Ethanol emitters | Encapsulated ethanol | fish and bakery products |
| Flavor/odor adsorbers | ascorbate and activated carbon/clays/Cellulose triacetate, ferrous salt/zeolites, acetylated paper, citric acid, | dairy products, fish, and poultry |
| Moisture absorbers | activated clays and minerals, Poly(vinyl acetate) blanket, and silica gel | poultry, meats and Fish |
| Oxygen absorbers | enzyme-based and nylon MXD6, Iron-based, metal/acid, ascorbate/metallic salts and metal (e.g., platinum) catalyst | Bread, cakes, cheese, cured meats and fish |

**Table 13.15- Phyico-chemical properties of packaging materials**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Film** | **Density/Specific Gravity** | **GTR (O2) (cc/100 gauge/m² hr at NTP)** | **WVTR (g/m²/ 24 hr at 38 oC and 90% RH)** | **Elongation (%)** | **Tensile Strength (Kg/cm²)** | **Tear resistant (g/100 gauge)** | **Heat Seal Range (°C)** |
| Cellophane (Polycoated) | 1.25 | 05-10 | >20 | 15.15 |  | 2-10 | 100-150 |
| Cellulose acetate | 1.25-1.35 | 1500-3000 | very high | 15-50 |  | 2-10 | 175-230 |
| Polyamide (Nylon) | 1.13 - 1.14 | 25-100 | very high | 250-500 | 700 - 1000 | 50-150 | 175-250 |
| Polyester | 1.15-1.39 | 50-125 | 15 | 70-120 | 750 - 1500 | 15-75 | 135-200 |
| Polyethylene (High density) | 0.941 - 0.965 | 500-4000 | 05-10 | 50-400 | 200 - 350 | 50-300 | 138-155 |
| Polyethylene (Low density) | 0.910 - 0.925 | 4000-12500 | 20 | 220-600 | 80 - 240 | 100-400 | 120-175 |
| Polypropylene | 0.88 - 0.90 | 1200-650 | 07-Oct | 200-500 | 300 - 400 | 40-300 | 160-200 |
| PVDC/Saran | 1.65 - 1.70 | 10-25 | 02-05 | 40-80 | 500 - 800 | 10-20 | 135-150 |
| polystyrene | 1.05 | 2500-7500 | >100 | 10-50 | 350-500 | 5-20 | 120-160 |
| SourceB. D. Sharma and Kinshukisharma. 2011. Outlines of meat science and technology (ed), Jaypee publictions. | | | | | | | |

**Table 13.16- Typical Gas Mixtures used for some of the Meat Products**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Product** | **Temperature (°C)** | **O2 (%)** | **CO2 (%)** | **N2 (%)** |
| Fresh Meat | 0 – 2 | 70 | 20 | 10 |
| Cured Meat | 1 – 2 | 0 | 30 | 70 |
| Pork | 0 – 2 | 80 | 20 | 0 |
| Poultry | 0 – 2 | 0 | 20 - 40 | 80 - 60 |

* **Abbreviations**

CAP -Controlled atmosphere packaging

CDTR - Carbon dioxide transmission rate

CFSAN - Centre for Food Safety and Applied Nutrition

EFSA - European Food Safety Authority

MAP - Modified atmosphere packaging

EPA -Environmental Protection Agency

GRAS - Generally Recognized as Safe

GTR - Gas transmission rate

WVTR - Water vapor transmission rate

**A. Fill in the blanks**

1. Many C2H4-absorbing substances have been described in the patent literature but those that have been commercialized are based on \_\_\_\_\_\_\_\_\_\_\_\_\_.
2. \_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are examples of superabsorbent polymers commonly used in moisture absorbers.
3. Drip-absorbent pads consist of two layers of a \_\_\_\_\_\_\_\_\_\_ or\_\_\_\_\_\_\_\_\_\_ film, such as LDPE or PP, between which is placed a superabsorbent polymer that is capable of absorbing up to 500 times its own weight of water.
4. Polyethylene can be safely used upto a temperature of\_\_\_\_\_\_\_\_\_\_°C.
5. Aluminum foil provides a good base for \_\_\_\_\_\_\_\_\_\_to enhance marketing prospects of a product.
6. Polyamide film is called\_\_\_\_\_\_\_\_\_\_ in the packaging trade
7. Parchment paper wrapping is especially suitable for meat cuts with more\_\_\_\_\_\_\_\_\_\_.
8. PET bottles are extensively used for packaging of\_\_\_\_\_\_\_\_\_\_.
9. \_\_\_\_\_\_\_\_\_\_\_\_ involve incorporating nanomaterials into packaging to improve its physicalproperties, durability, barrier properties, and biodegradation.
10. Nano-coatings are applied onto the \_\_\_\_\_\_\_\_\_\_\_\_ to primarily enhance its barrier properties, particularly against external factors.
11. Surface biocides incorporate nanomaterials with \_\_\_\_\_\_\_\_\_\_\_\_ properties onto the packaging surface to inhibit microbial growth.
12. \_\_\_\_\_\_\_\_\_\_\_\_ involves incorporating nanomaterials with antimicrobial or other properties with intentional release into the packaged food.
13. Intelligent packaging incorporates \_\_\_\_\_\_\_\_\_\_\_\_ to monitor and report on the conditionof the food.
14. Packaging is the art and science of encasing food products to safeguard them during distribution \_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_.
15. According to \_\_\_\_\_\_\_\_ International Standards, prepackaged food shall not be described or presented in a manner that is false, misleading, or deceptive.
16. The FSSAI logo and \_\_\_\_\_\_\_\_ must be displayed on the label of prepackaged foods in English or Hindi.
17. Every package of food material sold in retail, but which is not meant for human consumption, shall bear a declaration to this effect by a \_\_\_\_\_\_\_\_.
18. Cellophanefilm is derived from\_\_\_\_\_\_\_\_ and is treated with acid and alkali to get cellophane.
19. Low density polyethylene (LDPE) film is transparent to translucent and has comparatively \_\_\_\_\_\_\_\_permeability to water vapors.
20. Polyamide, also known as\_\_\_\_\_\_\_\_, is inert, heat resistant, and has excellent mechanical properties.
21. Polyester film is also called as\_\_\_\_\_\_\_\_, is highly resistant to high temperatures.
22. \_\_\_\_\_\_\_\_are used primarily for commercially sterilized food products.
23. Fibreboard containers, \_\_\_\_\_\_\_\_, and plastic crates are used as wholesale or shipping containers.
24. Petroleum-based plastics have gained interest for a wide variety of applications due to their\_\_\_\_\_\_\_ and low production costs.
25. Use of plasticswhich aregenerally used in \_\_\_\_\_\_\_ applications, contributing significantly to plastic waste.
26. Biodegradable packaging materials can be degraded by \_\_\_\_\_\_\_ present in soil or water.
27. \_\_\_\_\_\_\_ of biopolymers helps elucidate the Environmental impact of biodegradable materials.
28. Sealing is a commonly used technique in the packaging industry for forming a \_\_\_\_\_\_\_ Firmseal.
29. In \_\_\_\_\_\_, negative pressure inside and positive pressure outside push the film against the product in all directions.
30. Packaging for fresh meat should allow permeability to \_\_\_\_\_\_\_ to enhance color.
31. Gas packing with \_\_\_\_\_\_\_ offers better color in meat than nitrogen.
32. Large quantities of meat are usually packaged in \_\_\_\_\_\_\_ boxes.
33. Egg powder is highly sensitive to \_\_\_\_\_\_\_ and needs protection.
34. Butter packaging must prevent \_\_\_\_\_\_\_ to avoid color changes.
35. Aluminium foil and various paper laminates provide opacity and good \_\_\_\_\_\_\_ essential for butter packaging.
36. Most natural cheeses require minimal permeability to \_\_\_\_\_\_\_ to maintain quality.
37. Ideal tray size for packaging chicken cut up parts is \_\_\_\_\_\_\_.
38. Large whole \_\_\_\_\_\_\_ poultry is typically packed in copolymer film with exceptional tensile strength.
39. Lard is commonly packed in \_\_\_\_\_\_\_ containers.
40. Coatings inside meat cans are called \_\_\_\_\_\_\_.
41. Meal pies degrade in \_\_\_\_\_\_\_ environments, so films should be used for packaging.
42. To delay meat oxidation at room temperature, \_\_\_\_\_\_\_ packaging is recommended.
43. Rigid polyvinyl chloride is used for packaging due to its property of \_\_\_\_\_\_\_.
44. \_\_\_\_\_\_\_ is widely used in vacuum packages because of its commonality.
45. Fresh sausages are predominantly sold in \_\_\_\_\_\_\_ casings.
46. Frozen meat is susceptible to dehydration and loss of tone; packaging should prevent \_\_\_\_\_\_\_.
47. Packaging acts as a bridge between the \_\_\_\_\_\_\_ and the manufacturer.
48. Polyethylene bags cannot be \_\_\_\_\_\_\_ at 110°C.
49. \_\_\_\_\_\_\_ gives a blue color in glass.
50. Blister packaging emerged in \_\_\_\_\_\_\_.
51. \_\_\_\_\_\_\_ slugs are used for collapsible tubes.
52. Copolymerization of PVDC with PVC increases its flexibility but decreases its \_\_\_\_\_\_\_ point.
53. Polyester film, primarily used as shrink wrap, is known for being \_\_\_\_\_\_\_.
54. Polyethylene glycol and terephthalate is synthesized from \_\_\_\_\_\_\_.
55. Trays used to pack cut-up parts of birds are made from \_\_\_\_\_\_\_.
56. Tetra packs used for packaging milk are \_\_\_\_\_\_\_ shaped.
57. \_\_\_\_\_\_\_ film is commonly used for frozen meat, while \_\_\_\_\_\_\_ films are useful for light protection.
58. Fresh meat quality is affected by factors such as microorganisms, enzyme activity, and \_\_\_\_\_\_\_\_\_\_\_\_.
59. Packaging of fresh meat aims to prevent \_\_\_\_\_\_\_\_\_\_\_\_ loss, bacterial contamination, and alteration of flavor.
60. Proper packaging controls oxygen transfer and prevents dehydration and \_\_\_\_\_\_\_\_\_\_\_\_.
61. Relative humidity of \_\_\_\_\_\_\_\_\_\_\_\_ is required to prevent dehydration during storage.
62. Various packaging materials like LDPE, PVC, and \_\_\_\_\_\_\_\_\_\_\_\_ are used for fresh meat packaging.
63. Modified atmosphere packaging (MAP) extends the shelf-life of meat by altering the \_\_\_\_\_\_\_\_\_\_\_\_ within the package.
64. Shrink packaging used for wrapping\_\_\_\_\_\_\_\_\_\_\_\_ of meat with heat-shrinkable polymer film.
65. Vacuum packaging ensures a longer shelf-life for meat by removing \_\_\_\_\_\_\_\_\_\_\_\_ from the package.

**C. MCQs**

1. Which of the following statements are true regarding the standard ISO 11156?

a) ISO 11156 provides a framework for the design and evaluation of packages.

b) ISO 11156 does not cover dimensions, materials, manufacturing methods, or evaluation methods of individual packages.

a. Only a

b. Only b

c. Both a and b

d. None

2. Which of the following statements are true regarding the formation of thermoplastic and thermosetting polymers?

a) Thermoplastic polymers can be produced through either addition or condensation polymerization.

b) Thermosetting plastics are exclusively formed through condensation polymerization.

a. Only a

b. Only b

c. Both a and b

d. None

3. What is the density of polymers containing chlorine, such as PVC?

a) 1.0 g/cm³

b) 0.5 g/cm³

c) 2.0 g/cm³

d) 1.4 g/cm³

4. What is the typical range of crystallinity for LDPE (low density polyethylene) compared to HDPE (high density polyethylene)?

a) LDPE75%-90%; HDPE55%-70%

b) LDPE55%-70%; HDPE75%-90%

c) LDPE40%-60%; HDPE70%-85%

d) LDPE90%-100%; HDPE50%-60%

5. What is the melting temperature (Tm) of Polypropylene?

a) 76°C

b) 176°C

c) 276°C

d) 106°C

6. Which of the following are true regarding edible films over traditional petrochemical-based polymeric packaging materials?

a) They can be consumed with the packaged product, leaving no residual packaging to be disposed of.

b) They are likely to degrade more readily than petrochemical-based polymers.

c) They can enhance the organoleptic properties of packaged foods.

d) They are produced exclusively from non-renewable ingredients.

a) a, b and c

b) a, b and d

c) b, c and d

d) a, b, c, and d

7. What are polysaccharides primarily composed of?

a) Amino acids

b) Nucleotides

c) Monosaccharides

d) Lipids

8. Which polysaccharide is the main energy storage material in the plant kingdom?

a) Cellulose

b) Chitin

c) Starch

d) Glycogen

9. What is the main difference between amylose and amylopectin?

a) Amylose is linear while amylopectin is highly branched.

b) Amylose is highly branched while amylopectin is linear.

c) Amylose contains only glucose monomers while amylopectin contains other monosaccharides.

d) Amylose contains α-(1→6) glycosidic bonds while amylopectin contains α-(1→4) glycosidic bonds.

10. How does partial etherification affect the properties of high-amylose starch?

a) It decreases water solubility.

b) It increases brittleness.

c) It enhances water solubility.

d) It reduces film formation properties.

11. Which polysaccharide derivative is commonly used as an edible coating on foods and encapsulating agent?

a) Amylopectin

b) Hydroxypropylated high-amylose starch

c) Dextrins

d) Cellulose

12. What is the traditional method of manufacturing dextrins?

a) Hydrolysis in a dry, heated environment

b) Polymerization in a wet, cold environment

c) Hydrolysis in a wet, cold environment

d) Polymerization in a dry, heated environment

13. How are dextrins commonly used in confectionery products?

a) As chocolate fillings

b) As edible coatings on chocolate

c) As sealants for packaging

d) As glues for confections

14. What is the primary chemical linkage found in cellulose?

a) α-(1→4) glycosidic bonds

b) β-(1→4) glycosidic bonds

c) α-(1→6) glycosidic bonds

d) β-(1→6) glycosidic bonds

15. How do the hydroxyl functions in cellulose contribute to its properties?

a) They decrease hydrogen bonding.

b) They make the material fusible.

c) They create a physical network via strong hydrogen bonds.

d) They increase solubility in aqueous solution.

16. What is the purpose of chemical modification of cellulose, such as etherification?

a) To increase hydrogen bonding intensity

b) To decrease permeability

c) To decrease the intensity of hydrogen bonds

d) To increase solubility in aqueous solution

17. Which of the following cellulose ethers is known for its excellent film-making properties and efficient barrier properties against oxygen and lipids?

a) Methylcellulose (MC)

b) Hydroxypropyl cellulose (HPC)

c) Hydroxypropyl methylcellulose (HPMC)

d) Carboxymethylcellulose (CMC)

18. How are MC and HPMC commonly used in food applications?

a) As structural components in plant exoskeletons

b) As energy storage materials in plants

c) As batter ingredients to reduce oil uptake and moisture loss during frying

d) As sources of lignin in plant materials

19. What is the purpose of using water-soluble, edible pouches made from MC and HPMC in food delivery?

a) To increase oil uptake in fried foods

b) To provide barriers to oxygen, oil, and moisture

c) To enhance hydrogen bonding in food matrices

d) To decrease solubility in aqueous solution

20. Approximately what percentage of plant biomass does hemicellulose typically comprise?

a) 5%

b) 10%

c) 20%

d) 30%

21. Which of the following sugars is NOT typically found in hemicellulose?

a) Glucose

b) Xylose

c) Sucrose

d) Arabinose

22. How many main groups of hemicelluloses are defined based on their primary structure?

a) Two

b) Three

c) Four

d) Five

23. Which of the following is NOT a main group of hemicelluloses?

a) Xyloglycans (xylans)

b) Mannoglycans (mannans)

c) Celluloglycans (cellulans)

d) β-glucans

24. What type of edible food coatings have been studied using β-glucan extracts from various sources?

a) Coatings for fruits only

b) Coatings for vegetables only

c) Coatings for grains and cereals

d) Coatings for meats only

25. Which of the following has NOT been used as an additive in wheat gluten to form potentially edible composite films?

a) Xylans from birchwood

b) Grass

c) Rice bran

d) Corncob

26. What is the purpose of using hemicellulose additives in composite films with wheat gluten?

a) To increase brittleness

b) To decrease solubility

c) To improve film-forming properties

d) To reduce shelf life

27. What is the typical degree of deacetylation for commercial chitosan?

a) 50%

b) 65%

c) 75%

d) 85%

28.Which property of chitosan makes it a potential antimicrobial agent?

a) Hydrophobicity

b) High water solubility

c) Nonreactivity with microorganisms

d) Broad antimicrobial spectrum

29.What has the antimicrobial performance of chitosan been related to?

a) Release of glucosamine fractions

b) Release of acetyl groups

c) Release of methyl groups

d) Release of glucose monomers

30. At what pH range are low molecular weight chitosans most effective for achieving antimicrobial and antioxidative–preservative effects in foods?

a) Below pH 4

b) Below pH 6

c) Above pH 8

d) Above pH 10

31. What is the main polymer found in alginates?

a) Cellulose

b) Xylan

c) Alginate

d) Chitosan

32. How are calcium ions utilized in alginate coatings?

a) To decrease water vapor permeability

b) To decrease O2 barrier properties

c) To bridge alginate chains together via ionic interactions

d) To increase desiccation in enrobed meats

33. Which red seaweed species is most well-known for producing carrageenan?

a) Irish moss

b) Dulse

c) Nori

d) Kombu

34. What is the main function of pectin coatings on foods?

a) To increase moisture loss

b) To increase lipid migration

c) To retard water loss

d) To decrease handling and appearance of foods

35. What property of agar makes it suitable for forming strong gels?

a) Low viscosity

b) Low melting point

c) High gelation temperature

d) High melting point

37. What is the primary function of lipid compounds when used as protective coatings?

a) Forming coherent, stand-alone films

b) Providing gloss

c) Increasing polarity

d) Enhancing polymerization

38. Which of the following is NOT a type of wax commonly used as a protective coating for fresh fruits and vegetables?

a) Carnauba wax

b) Candelilla wax

c) Soy wax

d) Beeswax

39. Why can wax-, fat-, and oil-based coatings be difficult to apply?

a) Due to their low viscosity

b) Due to their high polarity

c) Due to their thickness and greasy surface

d) Due to their high water solubility

40. Which of the following is NOT a type of lipid coating mentioned in the text?

a) Mono-, di-, and triglycerides

b) Acetylated glycerol monostearate

c) Sucrose fatty acid esters

d) Cellulose derivatives

41. What problem has been reported with acetylated monoglyceride edible coatings?

a) Cracking and flaking during refrigerated or frozen storage

b) Resistance to foreign odors

c) Lack of permeability to water vapor

d) Sweet aftertaste

42. Which edible resin is commonly used to impart gloss to food commodities?

a) Shellac

b) Silicone

c) Polyester

d) Epoxy

43. What is the primary reason for using shellac as an edible coating for confectionary and fresh produce?

a) To decrease gloss

b) To provide moisture barrier

c) To enhance flavor

d) To impart gloss

44. Which lipid compound is particularly susceptible to oxidation?

a) Fatty acids

b) Glycerol

c) Paraffin wax

d) Shellac

45. What is the primary limitation of protein-based films and coatings?

a) Limited mechanical properties

b) Limited optical properties

c) Limited resistance to water vapor

d) Limited barrier against O2 and CO2

46. How are protein-based films typically made flexible?

a) By incorporating hydrophobic plasticizers

b) By incorporating hydrophilic plasticizers

c) By increasing protein content

d) By decreasing protein content

47. Which protein is commonly used for making sausage casings?

a) Gelatin

b) Casein

c) Collagen

d) Whey protein

48. What is gelatin commonly used for in food applications?

a) Increasing water vapor permeability

b) Reducing O2 uptake and rancidity

c) Enhancing protein cross-linking

d) Improving mechanical properties

49. Which protein is widely used as an encapsulating agent in hard and soft gel capsules?

a) Collagen

b) Casein

c) Gelatin

d) Whey protein

50. How does incorporating ascorbic acid into whey protein films help in food packaging?

a) It increases water vapor permeability

b) It decreases mechanical properties

c) It reduces oxygen transmission rate and retards lipid oxidation

d) It increases fat uptake

51. Which cereal protein is insoluble in water except at very low or high pH and is used as a finishing agent for nuts, candies, and confectionery products?

a) Wheat gluten

b) Corn zein

c) Rice protein

d) Sorghum protein

52. Apart from corn zein, which other cereal protein is commonly used to form edible films?

a) Wheat gluten

b) Rice protein

c) Sorghum protein

d) Pea protein

53. Why do edible films based on polar biopolymers (polysaccharides and proteins) degrade at high relative humidity (RH)?

a) Due to increased gas barrier efficiency

b) Due to decreased mechanical properties

c) Due to decreased moisture-barrier performance

d) Due to increased water-sensitive films

54. What is the primary role of lipid components in composite films?

a) Providing strength and structural integrity

b) Decreasing gas barrier efficiency

c) Increasing moisture-barrier performance

d) Decreasing water transmission

55. What are the two basic techniques used to form multicomponent films?

a) Emulsion technique and extrusion technique

b) Coating technique and extrusion technique

c) Coating technique and emulsion technique

d) Casting technique and extrusion technique

56. What is the primary purpose of adding plasticizers to edible films?

a) To increase film flexibility

b) To increase film durability

c) To increase film stiffness

d) To improve film flexibility and durability

57. Which of the following is NOT a type of plasticizer commonly added to edible films?

a) Mono- and oligosaccharides

b) Polyethylene terephthalate

c) Polyols

d) Lipids and derivatives

58. Which polyol is commonly used as a plasticizer in edible films?

a) Glucose

b) Sucrose

c) Glycerol

d) Phospholipids

59. Which of the following is NOT a type of lipid-based plasticizer?

a) Fatty acids

b) Glycerol

c) Phospholipids

d) Surfactants

60.What is the primary role of emulsifiers in coating applications?

a) Enhancing film flexibility

b) Increasing film durability

c) Achieving surface wettability and proper surface coverage

d) Decreasing film adhesion

61. Which property of emulsifiers is essential for the formation and stabilization of well-dispersed lipid particles in composite emulsion films?

a) Hydrophilicity

b) Hydrophobicity

c) Amphiphilicity

d) Viscosity

62. Which of the following is NOT a common emulsifier used in coating applications?

a) Sodium lauryl sulfate

b) Polysorbate 60

c) Sodium chloride

d) Lecithin

63. Which type of antioxidants delay the initiation or propagation step of autoxidation by accepting free radicals?

a) Primary antioxidants

b) Secondary antioxidants

c) Tertiary antioxidants

d) Preventive antioxidants

64. Which of the following is NOT an example of a primary antioxidant?

a) Butylated hydroxyanisole (BHA)

b) Butylated hydroxytoluene (BHT)

c) Citric acid

d) Propyl gallate

65. What are the two key steps involved in the biodegradation of polymers?

a) Hydrolysis and polymerization

b) Chain cleavage and mineralization

c) Oxidation and carbonization

d) Photosynthesis and respiration

66. Which factors influence the biodegradability of polymers?

a) Temperature and humidity

b) Crystallinity and molecular weight

c) pH and oxygen levels

d) All of the above

67. What are the main mineralization products of biopolymers during biodegradation?

a) Biomass and salts

b) Water and minerals

c) CO2 and CH4

d) Hydrocarbons and nitrogen compounds

68. Which standard test method is commonly used to determine the biodegradation of packaging materials under controlled composting conditions?

a) ASTM D5338

b) ISO 14852

c) ASTM D5988

d) ISO 14855

69. What is the purpose of using cellulose as a positive control in biodegradation tests?

a) To provide a reference for carbon conversion

b) To act as a catalyst for biodegradation

c) To mimic the natural environment

d) To provide nutrients for microbial growth

70. Which transition metal ions are commonly used as pro-degradant additives in oxo-biodegradable (OBD) plastics?

a) Nickel and copper

b) Zinc and aluminum

c) Iron, cobalt, and manganese

d) Silver and gold

71. At what temperature range can starch be converted into a plastic-like material known as "thermoplastic starch" (TPS)?

a) 50°C–90°C

b) 90°C–180°C

c) 180°C–250°C

d) 250°C–300°C

72. Which commercial water-resistant, starch-based bioplastics are produced using blends of starch and petroleum-based biodegradable polymers?

a) Bioplast® (starch/PCL)

b) Mater-Bi® (starch/PVOH)

c) Bionolle™-Starch (starch/PBSA)

d) Plantic™ (starch/PBAT)

73. How is cellulose acetate (CA) produced?

a) By subjecting to a mixture of sulfuric and acetic acids

b) By acetylating cellulose using acetic anhydride

c) By hydrolyzing cellulose triacetate in acetone

d) By blending cellulose with nitrocellulose

74. Which of the following statements best describes the characteristics of poly(vinyl chloride-co-vinyl acetate) copolymer coating?

a) It provides a heat-resistant film with high barrier properties against moisture, gases, and odors.

b) It offers a non-sealable film with limited barrier properties against water vapor and gases.

c) It is commonly known as copolymer-coated polyethylene and is not suitable for use in ovens or microwaves.

d) It serves as a barrier to water vapor, gases, and aromas while providing a heat-sealable film, and certain grades are approved for use in ovens and microwaves up to 200°C.

75. Which method has been proposed for producing hydrophobic films using arabinoxylan for potential use in food packaging?

a) Surface oxidation

b) Surface fluorination

c) Surface polymerization

d) Surface hydrolysis

76. What property makes chitosan particularly useful in food packaging applications?

a) High water resistance

b) Excellent mechanical strength

c) Antimicrobial activity

d) Transparency and clarity

77. What is the family of fibrous structural proteins found in chicken feathers?

a) Collagen

b) Elastins

c) Keratins

d) Actins

78. Which of the following are common plant proteins used in the production of biodegradable plastic films?

a) Casein and albumin

b) Chickpea and soy protein isolates

c) Fibrinogen and silks

d) Wheat and sunflower extracts

79. Why have proteins like casein, albumin, and fibrinogen not found widespread use as food packaging materials?

a) They are difficult to extract from plants

b) They are highly expensive

c) They lack biodegradability

d) They are difficult to process and blend with other polymers

80. What is the main drawback of soy protein isolate films?

a) Low thermal stability

b) High cost

c) High moisture sensitivity

d) Low biodegradability

81. What improvement in properties can be achieved by adding stearic acid to soy protein isolate films?

a) Increased moisture sensitivity

b) Decreased tensile and thermal properties

c) Improved tensile and thermal properties

d) Enhanced moisture sensitivity

82. Which catalyst is commonly used in the ring-opening polymerization (ROP) of lactide to produce PLA?

a) Nickel

b) Palladium

c) Zinc and tin oxides or chlorides

d) Iron

83. How does the degradation of PLA primarily occur?

a) Oxidation

b) Photolysis

c) Hydrolysis of ester linkages

d) Thermal decomposition

84. What is the primary advantage of adding plasticizers to PLA?

a) Decreased water permeability

b) Increased glass transition temperature (Tg)

c) Improved flexibility

d) Enhanced crystallinity

85. Which countries are known for being the two largest bioethanol producers from sugarcane?

a) United States and China

b) Brazil and Argentina

c) Brazil and India

d) Brazil and Australia

86. What is the primary advantage of using bioPE over conventional polyethylene?

a) Higher tensile strength

b) Lower production cost

c) Longer shelf life

d) Reduced carbon footprint

87. What is the feedstock used for the production ofbioethylene?

a) Sugarcane

b) Corn

c) Soybean

d) Wheat grain

88. What are PHAs primarily composed of?

A) Polyethylene

B) Polypropylene

C) Microbial polyesters

D) Polylactic acid

89. How do microorganisms accumulate PHAs?

A) By consuming excess carbon

B) Through photosynthesis

C) By metabolizing proteins

D)Through respiration

90. Which crop is being genetically modified for direct PHA production?

A) Wheat

B) Rice

C) Switchgrass

D) Corn

91. What is the primary degradation product of PHAs in aerobic environments?

A) Methane (CH4)

B) Carbon monoxide (CO)

C) Carbon dioxide (CO2)

D) Ethylene (C2H4)

92. Bacterial cellulose (BC) is primarily produced by bacteria belonging to which of the following genera?

A) Escherichia

B) Acetobacter

C) Bacillus

D) Lactobacillus

93. What advantage does bacterial cellulose (BC) possess over plant cellulose in terms of extraction?

A) Higher crystallinity

B) Lower water-holding capacity

C) Not combined with lignin, hemicelluloses, and pectin

D) Requires harsh chemical treatment for extraction

94. Compared to cellulose from plants, bacterial cellulose (BC) exhibits which of the following properties?

A) Lower water-holding capacity

B) Lower crystallinity

C) Higher tensile strength

D) Lower Young's modulus

95. The rate of enzyme activity is dependent on:

A) Oxygen concentration

B) Water availability

C) pH level

D) Sugar content

96. Which phenomenon is primarily responsible for microwave heating effects in moist foods?

A) Conduction

B) Convection

C) Radiation

D) Dipole polarization

97. Why does the effect of ionic conductivity become stronger at higher temperatures?

A) Due to reduced salt concentration

B) Due to increased hydrogen bonding

C) Due to increased collision frequency between ions

D) Due to decreased kinetic energy

98. What is the primary focus area of nanotechnology in the food sector according to the provided text?

A) Food production

B) Food packaging

C) Food preservation

D) Food processing

99. Which of the following is NOT a method of incorporating nanomaterials into food packaging?

A) Nanocomposites

B) Nano coatings

C) Surface biocides

D) Nano fillers

100. What is the primary function of active packaging in the food industry?

A) Enhancing the physical appearance of food products

B) Increasing the shelf life of packaged foods

C) Improving the taste and flavor of food items

D) Reducing the packaging material required for food products

101. Which type of nanomaterial is commonly used for its antimicrobial properties in food packaging?

A) Metal nanoparticles

B) Organic nanofibers

C) Natural biopolymers

D) Clay nanocomposites

102. What is the aim of intelligent packaging systems in the food industry?

A) To extend the shelf life of packaged foods

B) To reduce the environmental impact of food packaging

C) To monitor and report on the condition of packaged foods

D) To enhance the visual appeal of food packaging

103. Which international organization sets general standards for food labeling?

A) UNICEF

B) FAO & WHO

C) WTO

D) UNESCO

**FAO & WHO**

104. which of the following is NOT listed as a flexible packaging material?

A) Plastic film

B) Foil

C) Glass

D) Textiles

**Glass**

105. What is the purpose of a Time-Temperature Indicator (TTI) in food packaging?

A) To indicate the expiry date

B) To show the manufacturing date

C) To predict microbial concentrations and monitor food quality during shipping and storage

D) To display nutritional information

**To predict microbial concentrations and monitor food quality during shipping and storage**

106. In India, which authority is responsible for setting standards for food packaging?

A) Food and Drug Administration (FDA)

B) European Food Safety Authority (EFSA)

C) Food Safety and Standards Authority of India (FSSAI)

D) Gulf Cooperation Council (GCC)

**Food Safety and Standards Authority of India (FSSAI)**

107. Which of the following materials is considered flexible packaging?

A) Glass

B) PET

C) Aluminum Foil

D) Paper

**PET**

108. What is the primary advantage of using polyethylene (PE) film for food packaging?

A) High cost

B) Low flexibility

C) Resistance to odors and toxins

D) Poor sealability

**Resistance to odors and toxins**

109. Which of the following packaging materials is translucent to opaque and less permeable to water vapors and gases?

A) Polypropylene (PP)

B) Polyethylene terephthalate (PET)

C) Cellophane

D) Polyamide (Nylon)

**) Polypropylene (PP)**

110. Saran film is primarily used for packaging which type of food products?

A) Fruits

B) Vegetables

C) Meat and meat products

D) Dairy products

**) Meat and meat products**

111.What is the main drawback of glass containers for food packaging?

A) Poor barrier properties

B) Lightweight

C) Resistance to breakage

D) Risk of breakage and heavy weight

**) Risk of breakage and heavy weight**

112. Moulded pulp containers are commonly used for the packaging of which food product?

A) Fresh meat

B) Frozen seafood

C) Shell eggs

D) Dairy products

**) Shell eggs**

113. What significant revolution occurred in the plastic industry during the 19th century?

A) Introduction of bio-based plastics

B) Development of petroleum-based thermoplastics

C) Discovery of microbial fermentation

D) Invention of synthetic polymers

**) Development of petroleum-based thermoplastics**

114.Packaging sector has seen a significant increase in the usage of which plastics due to their properties in recent years?

A) synthetic polymers

B) polyethen

C) petroleum-based

D) none of them

**) petroleum-based**

115. What percentage of plastic waste in India is recovered for recycling?

A) Around 8%

B) Around 30%

C) Over 50%

D) None

**) Around 8%**

116. Which international strategies have accelerated the demand for bio-based plastics?

A) European Union Sustainable Development Strategy

B) United Nations 2030 Sustainable Development Goals

C) Both A and B

D) None of the above

**) Both A and B**

117. What is one of the drawbacks associated with the industrial production of PLA?

A) High water footprint

B) Fast degradation rate

C) Low mechanical strength

D) Limited availability of raw materials

**) High water footprint**

118. Which modification technique improves the properties of porcine plasma films?

A) Glycerol addition

B) pH modification

C) Cross-linking with caffeic acid

D) Heating without homogenization

**)**

119. What is a notable challenge in the application of blood proteins for bioplastics?

A) Low water solubility

B) High thermal stability

C) Limited foaming capacity

D) High solubility in water

**)**

120. Which material accounts for the highest percentage of recycled packaging materials in the United Kingdom?

A) Plastic

B) Paper and board

C) Glass

D) PET (polyethylene terephthalate )

**) PET**

121. What is the primary concern associated with plastics in the environment?

A) Forest exhaustion

B) Greenhouse gas emissions

C) Harmful effects on animal life

D) Landfill disposal costs

**) Harmful effects on animal life**

122. How much of the plastic waste generated in the country is recycled and used in the manufacture of various plastic products?

A) Less than 10%

B) Around 55%

C) Less than 30%

D) Approximately 75%

**) Less than 30%**

123. Which one of the following the is the largest nonferrous metal recycled

A) Aluminium

B) Copper

C) Steel

D) tin

**) Aluminium**

124. Glass packaging accounts for what % of the volume of municipal solid waste

A) 10 %

B) 2 %

C) 30%

D) 25%

**) 2 %**

125. What is the primary role of an antiblock agent in plastic packaging materials?

A) To prevent microbial growth

B) To enhance durability

C) To reduce friction between plastic layers

D) To provide coloration

) **To reduce friction between plastic layers**

126. Which type of packaging material is recommended for long-term storage of frozen meat products?

A) Polyester film/MDPE laminates

B) LDPE bags

C) HDPE containers

D) Polystyrene packaging

**A**) **Polyester film/MDPE laminates**

127. What components make up a retortable flexible package?

A) Polystyrene film, aluminium foil, and polyolefin laminate

B) Cellophane, LDPE, and paper laminate

C) Cellophane, HDPE, and LDPE laminate

D) LDPE, MDPE, and polystyrene laminate

) **Polystyrene film, aluminium foil, and polyolefin laminate**

128. In India, what material are butter containers commonly made of?

A) LDPE

B) Aluminium foil

C) Tinplate

D) Polystyrene

) **Polystyrene**

129. Among LDPE, polyvinyl chloride, polyester, and polyvinylidene chloride, which plastic film has the lowest permeability to oxygen and carbon dioxide?

A) LDPE

B) Polyvinyl chloride

C) Polyester

D) Polyvinylidene chloride

**) Polyvinylidene chloride**

130. What is the main purpose of Cryovac packaging?

A) To extend product shelf life

B) To enhance product aesthetics

C) To provide structural support

D) To reduce packaging costs

**) To extend product shelf life**

131. How can Irish moss extract be utilized in poultry packaging?

A) As a plasticizer

B) As a lubricant

C) As an edible coating

D) As an antioxidant

**) As an edible coating**

132. What does sanitary protection primarily protect against in food packaging?

A) To prevent contamination and loss

B) To enhance product flavor

C) To improve product appearance

D) To reduce packaging waste

**. To prevent contamination and loss**

133. Apart from protection, what is another primary purpose of food packaging?

A) To increase market share

B) To attract customer attention

C) To provide usage instructions

D) To regulate product temperature

**. To regulate product temperature**

134. What distinguishes the "Flash-18" process in the realm of packaging methods?

A) It involves sterilization of both product and container

B) It requires vacuum sealing

C) It utilizes a specific temperature and pressure combination

D) It focuses on reducing packaging material waste

**. It utilizes a specific temperature and pressure combination**

135. Souring of cured meats on storage is caused by:

A) Streptococcus

B) Micrococcus

C) Both of the above

D) None of the above

**. None of the above**

136. Dehydrated meats require protection from:

A) Oxygen

B) Moisture

C) Both of the above

D) All of the above

**. All of the above**

136. Indicate the method used for measuring the moisture protection qualities of a package:

A) Weight gain loss

B) Half value period

C) Break down

D) All of the above

**D. All of the above**

137. Frozen burn refers to:

A) Desiccation

B) Frozen burn

C) None of the above.

D) Both of the above

**. None of the above**

138. MSAT cellophane means

A) Moisture proof

B) Sealable

C) Anchored and transparent

**. All of the above**

**D. All of the above**

139. Which factor contributes to the characteristic color of fresh meat?

A) Hemoglobin

B) Oxygen

C)Moisture

D) Carbon dioxide

**) Hemoglobin**

140. What is the primary role of fresh meat packaging?

A) Enhancing flavor

B) Preventing moisture loss

C) Increasing oxygen transfer

D) Promoting microbial growth

**) Preventing moisture loss**

141. What is the recommended relative humidity for preventing dehydration during meat storage?

A) 50-60%

B) 70-80%

C) 85-95%

D) 100%

**) 85-95%**

142. Which packaging material is commonly used for fresh meat?

A) Glass

B) Aluminum

C) Polyethylene

D) Steel

**) Polyethylene**

143. Which packaging technique involves wrapping large cuts of meat with heat-shrinkable polymer film?

A) Vacuum packaging

B) Skin packaging

C) Modified atmosphere packaging

D) Shrink packaging

**) Shrink packaging**

144. What does MAP stand for in meat packaging?

A) Modified Aerobic Packaging

B) Maximum Air Permeability

C) Modified Atmosphere Packaging

D) Meat Assurance Protocol

**) Modified Atmosphere Packaging**

145. Which gas inhibits the growth of aerobic spoilage organisms in MAP?

A) Oxygen

B) Carbon dioxide

C) Nitrogen

D) Hydrogen

**) Carbon dioxide**

146. What is the ideal temperature for storing fresh meat in vacuum packs?

A) -18°C

B) 0°C

C) 4°C

D) 25°C

**) 0°C**

147. Which packaging technique conforms the packaging film exactly to the profile of the meat product?

A) Vacuum packaging

B) Skin packaging

C) Shrink packaging

D) Modified atmosphere packaging

**) Skin packaging**

148. What is the primary disadvantage of vacuum packaging?

A) Loss of moisture

B) Increased oxygen exposure

C) Unattractive meat color

D) Fragile packaging material

**) Unattractive meat color**

**D. Match the following**

1.

|  |  |
| --- | --- |
| i.Nanocomposites | 1. Enhance barrier properties of packaging surface |
| ii. Nano coatings | 2. Inhibit microbial growth on packaging surface |
| iii. Active packaging | 3. Release antimicrobial properties into packaged food |
| iv. Intelligent packaging | 4. Incorporate nanomaterials into packaging for improved physical properties |
| v. Surface biocides | 5. Monitor and report on food condition through nanosensors |

2.

|  |  |
| --- | --- |
| i. Plastic film | 1. Often used for storing frozen foods . |
| ii. Glass containers | 2. Suitable for rigid packaging |
| iii. Metal Containers | 3. Typically used for storing liquids |
| iv. PET punnets | 4.Flexible laminates heat-sealed pouches |
| v. Plastic tray with overwrap | 5.Commonly used for packing fruits |

3.

|  |  |
| --- | --- |
| i.LDPE | 1. Excellent clarity |
| ii. Polypropylene | 2. Moisture barrier |
| iii. PET | 3. Thermal resistance |
| iv. PVC | 4. Low cost, strong |
| v. Polystyrene | 5. Resistance to odors and toxins |
| ⅴⅰ. Ionomer | 6. Shrink properties |

4.

|  |  |
| --- | --- |
| i.Green colour of packaging material | 1. Tranquility |
| ii.Orange colour of packaging material | 2. Alpine tribes |
| iii.Blue colour of packaging material | 3. Glass packaging |
| iv.Glass packaging | 4. Plasticization |
| ⅴ. Yellow colour of packaging material | 5. Cellophane/PVDCI |

**B. Fill in the blanks.**

|  |  |
| --- | --- |
| 1 | Potassium permanganate (KMnO4) |
| 2 | Polyacrylate salts, carboxymethyl cellulose (CMC), and graft copolymers of starch. |
| 3 | Microporous; nonwoven plastic |
| 4 | **70°C** |
| 5 | **decorative printing** |
| 6 | **Nylon** |
| 7 | **fat** |
| 8 | **meat pickles** |
| 9 | **Nanocomposites** |
| 10 | **packaging surface** |
| 11 | **Antimicrobial** |
| 12 | **Active packaging** |
| 13 | **Nanosensors** |
| 14 | **sale, storage** |
| 15 | **Codex Alimentarius** |
| 16 | **license number** |
| 17 | **Cross mark symbol** |
| 18 | **bleached pulp** |
| 19 | **low** |
| 20 | **Nylon film** |
| 21 | **Mylar** |
| 22 | **Metal cans** |
| 23 | **wooden boxes** |
| 24 | **light weight** |
| 25 | **Single-use** |
| 26 | **Microorganisms** |
| 27 | **The life cycle assessment (LCA)** |
| 28 | **Thermal** |
| 29 | vacuum-sealing |
| 30 | **Oxygen** |
| 31 | **carbon dioxide** |
| 32 | **corrugated** |
| 33 | **moisture** |
| 34 | **moisture loss** |
| 35 | **barrier properties** |
| 36 | **oxygen** |
| 37 | **18”x10”x3”** |
| 38 | **frozen** |
| 39 | **carton** |
| 40 | **lacquers** |
| 41 | **high-moisture** |
| 42 | **vacuum** |
| 43 | **strong protection** |
| 44 | **Nylon** |
| 45 | **plastic** |
| 46 | **freezer burn** |
| 47 | **consumer** |
| 48 | **sterilized** |
| 49 | **Iron** |
| 50 | **1960** |
| 51 | **Aluminium** |
| 52 | **melting** |
| 53 | **non-breathable** |
| 54 | **ethylene glycol and terephthalic acid** |
| 55 | **polystyrene** |
| 56 | **rectangular** |
| 57 | **Polyethylene; aluminum foil** |
| 58 | **Oxidation** |
| 59 | **moisture** |
| 60 | **Lipid oxidation** |
| 61 | **85% to 95%** |
| 62 | **polystyrene** |
| 63 | **gas composition** |
| 64 | **large cuts** |
| 65 | **air** |

**C. MCQs**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1.a | 2.c | 3.d | 4.b | 5.b | 6.d | 7.c | 8.c | 9.a | 10.c |
| 11.b | 12.a | 13.b | 14.b | 15.c | 16.c | 17.a | 18.c | 19.b | 20.c |
| 21.c | 22.c | 23.c | 24.c | 25.c | 26.c | 27.d | 28.d | 29.d | 30.a |
| 31.b | 32.c | 33.c | 34.a | 35.c | 36.d | 37.b | 38.c | 39.c | 40.d |
| 41.a | 42.a | 43.d | 44.a | 45.c | 46.b | 47.c | 48.b | 49.c | 50.c |
| 51.b | 52.a | 53.d | 54.a | 55.c | 56.d | 57.b | 58.c | 59.b | 60.c |
| 61.c | 62.c | 63.a | 64.c | 65.b | 66.d | 67.c | 68.d | 69.a | 70.c |
| 71.b | 72.c | 73.a | 74.d | 75.b | 76.c | 77.c | 78.b | 79.d | 80.c |
| 81.c | 82.c | 83.c | 84.c | 85.b | 86.d | 87.a | 88.c | 89.a | 90.c |
| 91.c | 92.b | 93.c | 94.c | 95.b | 96.d | 97.c | 98. | 99. | 100. |
| 101. | 102. | 103. b | 104. c | 105. c | 106. c | 107. b | 108. c | 109. a | 110. c |
| 111.d | 112.c | 113. b | 114.c | 115. b | 116.c | 117.a | 118. d | 119. a | 120. d |
| 121.c | 122.c | 123.a | 124. b | 125.c | 126.a | 127.a | 128. d | 129. d | 130. a |
| 131.c | 132.a | 133.d | 134.c | 135.d | 136.d | 137.c | 138. d | 139. a | 140. b |
| 141.c | 142.c | 143.d | 144.c | 145. b | 146. b | 147. b | 148. c | 149. | 150. |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |

**D. Match the following.**

1. **ⅰ- 4 ⅱ-1 ⅲ- 3 ⅳ- 5 ⅴ- 2**

2. **ⅰ- 4 ⅱ-3 ⅲ- 2 ⅳ- 5 ⅴ- 1**

3.**ⅰ- 4 ⅱ-3 ⅲ- 2 ⅳ- 6 ⅴ- 1 ⅴⅰ-5**

**4. ⅰ- 4 ⅱ- 2ⅲ- 3 ⅳ-1 ⅴ-5**

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**References:**

Lee, D.S., Packaging and the microbial shelf life of food, inFood Packaging and Shelf Life,Robertson, G.L. (Ed.), CRC Press, Boca Raton, FL, pp. 55–79, 2010.

Robertson, G.L. (Ed.), (2010). CRC Press, Boca Raton, FL.

Beuchat, L., Cereal Foods World, 26, 345, 1981.

B. D. Sharma and Kinshukisharma. 2011. Outlines of meat science and technology (ed), Jaypee publictions.

Walsh, H.M. and Keny S.P. Chapter Meat Packaging in Meat Processing- improving quality edited by Joseph Ken-y, John Keny and David Ledward. Woodhead Publishing Ltd. England.

Fadini, A.; Rocha, F.; Alvim, I.; Sadahira, M.; Queiroz, M.; Alves, R.; Silva, L. Mechanical properties and water vapour permeability of hydrolysed collagen–cocoa butter edible films plasticised with sucrose. Food Hydrocoll. 2013, 30, 625–631.

Valencia, G.A.; Luciano, C.G.; Lourenço, R.V.; Bittante, A.M.Q.B.; Sobral, P.J.D.A. Morphological and physical properties of nano-biocomposite films based on collagen loaded with laponite. Food Packag. Shelf Life 2019, 19, 24–30. [CrossRef]

Wang, Z.; Hu, S.; Wang, H. Scale-up preparation and characterization of collagen/Sodium alginate blend films. J. Food Qual. 2017, 2017, 4954259.

Said, M.I.; Erwanto, Y.; Abustam, E. Properties of edible film produced using combination of collagen extracts of bligon goatskin with glycerol. Am. J. Anim. Vet. Sci. 2016, 11, 151–159.

Sommer, I.; Kunz, P.M. Improving the water resistance of biodegradable collagen films. J. Appl. Polym. Sci. 2012, 125, E27–E41.

Wang, W.; Liu, Y.; Liu, A.; Zhao, Y.; Chen, X. Effect of in situ apatite on performance of collagen fiber film for food packaging applications. J. Appl. Polym. Sci. 2016, 133.

Zhuang, Y.; Ruan, S.; Yao, H.; Sun, Y. Physical properties of composite films from tilapia skin collagen with pachyrhizus starch and rambutan peel phenolics. Mar. Drugs 2019, 17, 662.

Murali, R.; Anumary, A.; AshokKumar, M.; Thanikaivelan, P.; Chandrasekaran, B. Hybrid biodegradable films from collagenous wastes and natural polymers for biomedical applications. Waste Biomass Valor. 2011, 2, 323–335.

90. Filipini, G.D.S.; Romani, V.P.; Martins, V.G. Blending collagen, methylcellulose, and whey protein in films as a greener alternative for food packagingPhysicochemical and biodegradable properties. Packag. Technol. Sci. 2020, 34, 91–103.

Anumary, A.; Thanikaivelan, P.; AshokKumar, M.; Kumar, R.; Sehgal, P.K.; Chandrasekaran, B. Synthesis and characterization of hybrid biodegradable films from bovine hide collagen and cellulose derivatives for biomedical applications. Soft Mater. 2013, 11, 181–194.

Wang, W.; Zhang, X.; Li, C.; Du, G.; Zhang, H.; Ni, Y. Using carboxylated cellulose nanofibers to enhance mechanical and barrier properties of collagen fiber film by electrostatic interaction. J. Sci. Food Agric. 2017, 98, 3089–3097.