PART - A (20 Marks)

ANSWER ALL QUESTIONS (each question 2 marks)

1) Differentiate between functional foods and superfoods with examples.

Functional foods are foods that provide additional health benefits beyond basic nutrition due to added bioactive components.
Example: Probiotic yogurt, fortified milk.

Superfoods are naturally nutrient-dense foods rich in antioxidants, vitamins, or minerals that promote health.
Example: Blueberries, chia seeds.

2) A packaged food sample shows early spoilage. Demonstrate how microbial analysis can be applied to assess its quality.

Microbial analysis involves performing **total plate count (TPC)** and detecting specific spoilage organisms using selective media.
If microbial load exceeds permissible limits, the product is considered unsafe, indicating contamination or improper storage.

3) Classify food resources based on their origin.

Food resources are classified into:

1. **Plant origin** – cereals, pulses, fruits, vegetables.
2. **Animal origin** – milk, meat, eggs, fish.
3. **Microbial origin** – yeast, algae, mushrooms.

4) Outline the basic principles of HACCP.

HACCP is based on seven principles:

1. Hazard analysis
2. Identify Critical Control Points (CCPs)
3. Establish critical limits
4. Monitoring procedures

5. Corrective actions
6. Verification procedures
7. Documentation and record keeping

5) Define macronutrients and micronutrients and explain their importance.

Macronutrients are nutrients required in large amounts (carbohydrates, proteins, fats) and provide energy and body building functions.

Micronutrients are required in small amounts (vitamins and minerals) and regulate body processes and prevent deficiency diseases.

6) Explain the role of nutrients in human physiology.

Nutrients provide **energy**, support **growth and tissue repair**, and regulate **metabolic processes**.
They maintain immune function, enzyme activity, and hormonal balance.

7) Discuss the health effects of Selenium deficiency and give examples of Selenium-rich foods.

Selenium deficiency can cause **weakened immunity**, **thyroid dysfunction**, and **Keshan disease (cardiomyopathy)**.

Selenium-rich foods include **Brazil nuts, seafood, eggs, and whole grains**.

8) Explain the production of food additives using biotechnology concepts.

Food additives are produced using **microbial fermentation and genetic engineering**.
Example: Citric acid from *Aspergillus niger*, and enzymes like amylase produced using recombinant microorganisms.

9) List commonly used nanomaterials in foods.

Common nanomaterials include:

- Nano-silver
- Nano-titanium dioxide

- Nano-encapsulated vitamins
- Nano-silica

These improve stability, shelf life, and bioavailability.

10) Enumerate three applications of nanotechnology in food and food packaging.

1. **Improved food packaging** with antimicrobial nano-coatings.
2. **Nano-encapsulation** for nutrient delivery.
3. **Detection of pathogens** using nanosensors.

PART – B (40 Marks)

11 (a) (i)

As a food science consultant, illustrate how current food production systems are involved in bringing products from farm to consumer. (8 Marks)

Introduction

Modern food production operates through an integrated farm-to-fork supply chain system, combining agriculture, food processing technology, quality assurance, logistics, and regulatory compliance. The goal is to ensure food safety, nutritional quality, traceability, sustainability, and consumer protection.

The system includes multiple interconnected stages from primary production to final consumption.

1. Primary Production (Agricultural Stage)

This includes crop cultivation and animal husbandry.

Key Components:

- Use of certified seeds and breeds
- Precision farming (GPS, soil testing, smart irrigation)
- Integrated pest management (IPM)

- Good Agricultural Practices (GAP)
- Sustainable farming techniques

Example:

Wheat grown using drip irrigation and soil nutrient mapping improves yield and quality.

Risk Points:

- Pesticide residue
- Soil contamination
- Water contamination

2. Harvesting and Post-Harvest Handling

After harvesting, food undergoes:

- Cleaning
- Sorting
- Grading
- Pre-cooling
- Storage under controlled temperature

Cold Chain System

Perishable items like milk, fruits, and meat require refrigeration (0–4°C) to prevent microbial growth.

Example:

Milk collected in stainless steel containers, chilled immediately to prevent spoilage.

3. Food Processing and Value Addition

Processing converts raw materials into consumable products.

Types of Processing:

- Mechanical (milling, grinding)
- Thermal (pasteurization, sterilization)
- Fermentation

- Drying and dehydration
- Extrusion

Quality Control:

- HACCP implementation
- Microbial testing
- Standardization

Example:

Wheat → Flour → Bread
Milk → Pasteurized milk → Flavored milk / Yogurt

4. Packaging Systems

Packaging ensures safety, shelf life, and marketing appeal.

Advanced Packaging:

- Modified Atmosphere Packaging (MAP)
- Vacuum packaging
- Antimicrobial coatings
- Smart packaging (time-temperature indicators)

Packaging prevents:

- Oxidation
- Moisture loss
- Microbial contamination

5. Distribution and Logistics

- Refrigerated transportation
- Warehousing
- Inventory management
- Retail supply chains

E-commerce platforms have introduced digital traceability systems.

6. Retail and Consumer Stage

- Proper labeling (nutrition facts, expiry date)
- Storage instructions
- Consumer awareness

Sustainability & Modern Developments

- Reduction of food waste
- Blockchain traceability
- Organic production systems
- Carbon footprint monitoring

Conclusion

Modern food production is a highly coordinated, technology-driven system ensuring food moves safely and efficiently from farm to consumer while maintaining quality, safety, and regulatory compliance.

11 (a) (ii)

Health benefits and safety concerns of fat substitutes (8 Marks)

Introduction

Fat substitutes are ingredients used to replace fats in food products to reduce calorie content and lower health risks associated with high-fat diets.

Types of Fat Substitutes

1. Carbohydrate-Based

- Maltodextrins
- Modified starch
- Cellulose derivatives

2. Protein-Based

- Microparticulated whey protein
- Soy protein derivatives

3. Fat-Based

- Olestra
- Structured lipids

Health Benefits

1. Calorie Reduction

Fat provides 9 kcal/g. Substitutes reduce energy density.

2. Obesity Management

Low-fat diets assist weight control.

3. Cardiovascular Health

Reduced intake of saturated fats lowers LDL cholesterol.

4. Diabetes Management

Lower fat intake improves insulin sensitivity.

Safety Concerns

1. Gastrointestinal Effects

Olestra may cause abdominal cramps and diarrhea.

2. Reduced Absorption of Fat-Soluble Vitamins

May decrease vitamins A, D, E, K absorption.

3. Long-Term Health Impact

Insufficient long-term data in some cases.

4. Consumer Misperception

“Low-fat” label may lead to overeating.

Regulatory Control

Fat substitutes must be approved by:

- Food Safety and Standards Authority of India
- United States Food and Drug Administration

Toxicity and safety trials are mandatory.

Conclusion

Fat substitutes provide metabolic and cardiovascular benefits but require strict regulatory monitoring to ensure consumer safety.

QUESTION 11 (b)

11 (b) (i)

Food Laws and Regulations for Safe Food Production (8 Marks)

Introduction

Food industries must comply with national and international laws to protect public health and prevent food adulteration.

1. National Regulatory Authority

Food Safety and Standards Authority of India

Functions:

- Licensing
- Food standards formulation
- Inspection and enforcement
- Labeling regulations
- Recall procedures

2. International Standards

Codex Alimentarius Commission

- Sets global food safety standards
- Promotes harmonization of regulations

- Protects consumer health

3. Food Safety and Standards Act (2006)

Covers:

- Additive limits
- Contaminant standards
- Hygiene requirements
- Packaging regulations

4. Good Manufacturing Practices (GMP)

- Personnel hygiene
- Sanitation procedures
- Equipment maintenance

5. HACCP Compliance

Hazard identification
Critical control monitoring
Corrective action system

Consumer Protection Measures

- Nutritional labeling
- Allergen declaration
- Expiry date indication
- Adulteration prevention

Conclusion

Compliance ensures legal protection, consumer safety, and global trade acceptance.

11 (b) (ii)

Interpretation of Microbial Indicators in Food Samples (8 Marks)

Introduction

Microbial indicators are microorganisms used to assess food hygiene, safety, and potential contamination.

1. Total Plate Count (TPC)

Measures total viable microorganisms.

High count → Poor processing hygiene.

2. Coliform Count

Indicates fecal contamination and sanitation failure.

Presence suggests unsafe handling conditions.

3. Yeast and Mold Count

Indicates spoilage potential in bakery and dairy products

4. Pathogen Detection

Testing for:

- Salmonella
- E. coli
- Listeria

Presence → Immediate product rejection.

Interpretation Guidelines

- Compare with regulatory standards
- Evaluate processing environment
- Assess storage conditions
- Decide corrective action

Quality Decision Making

If:

- TPC within limit → Acceptable
- High coliform → Investigate sanitation

- Pathogen detected → Product recall

Conclusion

Microbial indicators are critical tools for ensuring food safety, regulatory compliance, and consumer protection.

QUESTION 12 (a)

12 (a) (i)

Apply knowledge of carbohydrates, proteins, and lipids to select and differentiate suitable dietary sources and food items for hospital meal plans. (10 Marks)

Introduction

Hospital nutrition is a specialized branch of clinical dietetics that focuses on designing therapeutic diets tailored to the physiological condition, disease status, and recovery needs of patients. Macronutrients—carbohydrates, proteins, and lipids—must be carefully selected based on digestibility, metabolic tolerance, disease condition, and nutrient density.

Meal planning in hospitals differs from general meal planning because it must align with:

- Medical diagnosis
- Nutritional requirements (RDA and clinical modification)
- Patient tolerance
- Mode of feeding (oral, enteral, parenteral)

1. Carbohydrates in Hospital Meal Planning

Physiological Role

Carbohydrates are the primary source of energy, providing 4 kcal/g and maintaining blood glucose levels.

Selection Criteria

- Easily digestible
- Low glycemic index (for diabetic patients)
- High fiber (for constipation)
- Low residue (for gastrointestinal disorders)

Suitable Dietary Sources

Condition	Recommended Sources	Rationale
Post-surgery	Rice gruel, semolina porridge	Easy digestion
Diabetes	Whole wheat chapati, oats, millets	Low GI control
Renal patients	Refined rice (limited)	Controlled potassium
GI disorders	Soft cooked rice, mashed potatoes	Reduced fiber load

Differentiation

Simple carbohydrates (glucose solutions) are used in IV feeding for critically ill patients, while complex carbohydrates are preferred in stable patients.

2. Proteins in Hospital Meal Planning

Physiological Role

Proteins provide amino acids for:

- Tissue repair
- Immune function
- Enzyme and hormone synthesis

Selection Criteria

- High biological value (HBV) proteins
- Easily digestible
- Disease-specific protein modification

Suitable Sources

Condition	Recommended Sources	Justification
Post-operative	Egg white, milk, paneer	High biological value
Burns	High-protein supplements	Prevent muscle wasting
Renal disease	Limited protein intake	Reduce kidney load
Liver disease	Moderate plant proteins	Lower ammonia buildup

Clinical Consideration

Protein intake may increase to 1.2–2 g/kg body weight in trauma patients.

3. Lipids in Hospital Meal Planning

Physiological Role

Lipids:

- Provide 9 kcal/g
- Aid absorption of fat-soluble vitamins
- Maintain cell membrane integrity

Selection Criteria

- Prefer unsaturated fats
- Avoid trans fats
- Control saturated fats for cardiac patients

Suitable Sources

Condition	Recommended Sources	Rationale
Cardiac patients	Olive oil, nuts (controlled)	Improve HDL
Malnourished	Moderate healthy fats	Energy density

Condition	Recommended Sources	Rationale
Pancreatitis	Low-fat diet	Reduce enzyme load

Special Therapeutic Diet Modifications

1. Diabetic diet → Controlled carbohydrate distribution
2. Renal diet → Restricted protein and potassium
3. Cardiac diet → Low sodium, low saturated fat
4. High-protein diet → Post-surgical recovery

Conclusion

Effective hospital meal planning requires individualized macronutrient selection based on disease condition, metabolic demand, and digestive tolerance to promote recovery and prevent complications.

12 (a) (ii)

Link macronutrient physiological functions to energy production, tissue repair, and metabolic regulation in patients. (6 Marks)

Introduction

Macronutrients play interconnected roles in maintaining energy balance, supporting healing processes, and regulating metabolism in clinical settings.

1. Carbohydrates and Energy Production

Carbohydrates are broken into glucose, which enters glycolysis and the Krebs cycle to produce ATP.

In hospitalized patients:

- Prevents muscle protein breakdown
- Maintains blood glucose
- Supports brain function

Glucose is especially critical in ICU patients.

2. Proteins and Tissue Repair

Amino acids:

- Repair surgical wounds
- Produce antibodies
- Support immune response

Protein deficiency leads to delayed wound healing and increased infection risk.

3. Lipids and Metabolic Regulation

Lipids:

- Provide concentrated energy
- Regulate inflammatory responses
- Maintain hormonal balance

Omega-3 fatty acids reduce inflammation in chronic illness.

Integrated Metabolic Role

- Carbohydrates spare proteins
- Proteins maintain nitrogen balance
- Lipids regulate energy storage

All three maintain metabolic homeostasis during stress and illness.

Conclusion

Macronutrients function synergistically to support energy metabolism, recovery, immune response, and physiological stability in hospitalized patients.

✅ **QUESTION 12 (b)**

12 (b) (i)

Apply biotechnological principles for production of food additives, bioflavours, and biocolours and justify their use over synthetic alternatives. (10 Marks)

Introduction

Biotechnology uses living organisms, enzymes, and genetic engineering techniques to produce food additives in a sustainable and controlled manner. It ensures higher purity, safety, and consumer acceptance compared to synthetic chemical methods.

1. Microbial Fermentation

Microorganisms convert substrates into valuable compounds.

Examples:

- Citric acid from *Aspergillus niger*
- Lactic acid from Lactobacillus
- Monosodium glutamate via Corynebacterium

Advantages:

- High yield
- Controlled production
- Eco-friendly

2. Genetic Engineering

Recombinant DNA technology enhances enzyme production.

Examples:

- Recombinant amylase
- Recombinant protease
- Bio-vanillin production

Benefits:

- Increased efficiencyyyyyy
- Reduced contamination
- Specific product formation

3. Production of Bioflavours

Microbial conversion of precursors to:

- Vanillin
- Esters

- Alcohol-based flavors

Natural labeling increases market value.

4. Production of Biocolours

Examples:

- Beta-carotene from algae
- Lycopene from fungi
- Anthocyanins from plant cultures

Natural colors reduce health risks associated with synthetic dyes.

Justification Over Synthetic Alternatives

Biotechnology	**Synthetic**
Eco-friendly	Chemical waste
Safer	Possible toxicity
Consumer acceptance	Artificial perception
Sustainable	Petrochemical dependency

Regulatory Oversight

Approved by:

- Food Safety and Standards Authority of India
- European Food Safety Authority

Conclusion

Biotechnological production ensures sustainable, safe, and consumer-friendly alternatives to synthetic additives.

12 (b) (ii)

Classify and select microbial polysaccharides for food applications and explain their role in improving texture, stability, and shelf life. (6 Marks)

Introduction

Microbial polysaccharides are biopolymers produced by microorganisms and widely used as food stabilizers, thickeners, and texture enhancers.

Classification

1. Xanthan Gum

Produced by Xanthomonas campestris
Used as thickener in sauces.

2. Dextran

Produced by Leuconostoc
Used in bakery for moisture retention.

3. Pullulan

Produced by Aureobasidium pullulans
Used in edible films and coatings.

Functional Properties

- Increase viscosity
- Improve emulsion stability
- Prevent phase separation
- Enhance mouthfeel
- Extend shelf life

Application Examples

- Ice cream → Improved creaminess
- Salad dressings → Stabilized emulsion
- Bakery → Moisture retention

Conclusion

Microbial polysaccharides improve structural integrity, sensory quality, and product stability, making them essential in modern food product development.

QUESTION 13 (a)

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13 (a)

Illustrate how nanomaterials are used to enhance food safety, extend shelf life, and improve quality of food products, with suitable examples. (8 Marks)

Introduction

Nanotechnology involves the application of materials at the nanoscale (1–100 nm), where unique physical, chemical, and biological properties emerge. In the food industry, nanomaterials are increasingly used to enhance food safety, extend shelf life, improve nutrient delivery, and maintain quality.

Due to their high surface area-to-volume ratio, nanomaterials exhibit enhanced antimicrobial, barrier, and encapsulation properties, making them valuable in modern food systems.

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1. Nanomaterials in Food Safety Enhancement

A. Antimicrobial Nanomaterials

Certain nanomaterials possess strong antimicrobial properties due to their ability to disrupt microbial cell membranes.

Examples:

- Silver nanoparticles (AgNPs)
- Zinc oxide nanoparticles
- Titanium dioxide nanoparticles

Mechanism of Action:

- Penetrate bacterial cell walls
- Generate reactive oxygen species
- Damage DNA and proteins

Application:

- Incorporated into food packaging films
- Used in surface coatings

- Applied in food contact materials

Result:

- Reduction of pathogenic bacteria like Salmonella and E. coli
- Prevention of cross-contamination

B. Nanosensors for Pathogen Detection

Nano-based biosensors detect:

- Toxins
- Pathogens
- Spoilage organisms

Example:
Gold nanoparticle-based biosensors change color when detecting microbial contamination.

Benefit:

- Rapid detection
- Real-time monitoring
- Reduced foodborne outbreaks

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2. Nanotechnology for Shelf Life Extension

A. Improved Barrier Properties in Packaging

Nanoclays and nanocomposites improve packaging strength and barrier properties.

Functions:

- Reduce oxygen permeability
- Prevent moisture transfer
- Minimize oxidation

Example:
Nanoclay-incorporated plastic films used in meat packaging to prevent rancidity.

B. Controlled Release Systems

Nano-encapsulation allows:

- Gradual release of preservatives
- Controlled antioxidant delivery

Example:
Encapsulation of essential oils in nano-carriers for antimicrobial effect.

C. Prevention of Lipid Oxidation

Nano-encapsulated antioxidants (Vitamin E, polyphenols) protect fats from oxidation.

Outcome:

- Delayed rancidity
- Extended freshness
- Maintained sensory quality

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3. Improvement of Food Quality

A. Enhanced Nutrient Bioavailability

Nano-encapsulation improves absorption of:

- Fat-soluble vitamins (A, D, E, K)
- Omega-3 fatty acids
- Curcumin

Benefit:

- Increased bioavailability
- Reduced dosage requirement

B. Texture and Sensory Improvement

Nanoemulsions:

- Improve mouthfeel
- Enhance stability in beverages
- Prevent separation

Example:
Nanoemulsified flavors in functional drinks.

C. Fortification Without Taste Alteration

Nano-delivery systems mask undesirable taste of nutrients like iron and zinc.

Advantages of Nanotechnology in Food

- Increased efficiency
- Reduced preservative requirement
- Improved food safety
- Smart packaging capabilities

Safety Concerns

Despite benefits, potential risks include:

- Nanoparticle migration into food
- Toxicity accumulation
- Environmental impact

Therefore, strict safety evaluation is required.

Conclusion

Nanomaterials significantly enhance food safety, shelf life, and quality by providing antimicrobial protection, improved packaging performance, and enhanced nutrient delivery. However, responsible application and regulatory oversight are essential to ensure consumer safety.

✅ **QUESTION 13 (b)**

13 (b)

As a regulatory compliance officer, interpret and explain the policies, regulations, and guidelines governing the usage of nanomaterials in foods, highlighting safety assessment, labeling, and approval requirements. (8 Marks)

Introduction

The use of nanotechnology in food systems raises safety, ethical, and regulatory concerns due to the novel properties of nanoscale materials. Regulatory authorities require comprehensive risk assessment before approval of nano-enabled food products.

1. Safety Assessment Requirements

Before approval, nanomaterials must undergo:

A. Toxicological Evaluation

- Acute toxicity studies
- Chronic exposure studies
- Genotoxicity testing

B. Migration Studies

Testing whether nanoparticles migrate from packaging into food.

C. Risk Assessment

Includes:

- Exposure assessment
- Hazard identification
- Dose-response analysis

2. Regulatory Authorities Governing Nanomaterials

In India:

Food Safety and Standards Authority of India

Responsible for:

- Approval of food additives

- Setting permissible limits
- Monitoring safety

In Europe:

European Food Safety Authority

Requires:

- Scientific opinion
- Detailed risk assessment
- Mandatory safety documentation

In the United States:

United States Food and Drug Administration

- Evaluates nanomaterials under food additive regulations
- Requires pre-market approval

3. Labeling Requirements

Regulations may require:

- Declaration of nano-ingredients
- Transparency in ingredient listing
- Consumer awareness

In some jurisdictions, nano-forms must be specifically labeled.

4. Ethical and Environmental Considerations

- Environmental toxicity
- Waste disposal impact
- Long-term ecological risks

Regulatory bodies demand sustainability assessments.

5. Approval Process

1. Submission of safety dossier
2. Laboratory and clinical testing
3. Risk-benefit analysis
4. Expert committee evaluation

5. Market approval

Challenges in Regulation

- Lack of standardized testing methods
- Limited long-term data
- Public perception concerns

Conclusion

Regulation of nanomaterials in food requires comprehensive safety assessment, transparent labeling, and strict approval procedures to balance technological advancement with consumer protection and environmental safety.