

# **TAMIL NADU PUBLIC SERVICE COMMISSION**

## **SYLLABUS**

### **BIOTECHNOLOGY (PG standard)**

**CODE: 461**

#### **UNIT I:**

##### **CELL AND MOLECULAR BIOLOGY:**

Analysis of STR, Analysis of other configurations, Bioreactor scale-up, Modeling and simulation of Bioprocesses, Bioreactor considerations in Enzyme systems. Cells, Cell lines, Cell culture, Cell Organelles and its functions, types of Cell divisions, cell cycle and its regulation mechanism. Transport mechanism (Passive, Active, ATPase pumps and Na<sup>+</sup>/K<sup>+</sup> Pumps), receptors, signal Transduction, models of signal Amplification Secondary messengers, Structure of Nucleic Acids, Replication, Transcription, Translation and DNA repair mechanism in Prokaryotes and Eukaryotes. Promoters, Enhancers and Transcription factors. Genetic Codes and lac & trp operons.

##### **BIOCHEMISTRY AND MICROBIOLOGY:**

Structure, function and metabolism of carbohydrates, lipids, Nucleic Acids and proteins. Enzymes and its mechanism. Electron Transport Chain system, High energy compound and reducing equivalents. History of Microbiology, Classification of Microorganism, structural organization and multiplication of microorganism. Physical and chemical control of microorganisms, primary and secondary metabolites and their applications.

##### **GENETIC ENGINEERING:**

Genes, control gene expression, restriction enzymes, vectors (prokaryotic and eukaryotic) construction of DNA and genomic library.

##### **FOOD CHEMISTRY & NUTRITION:**

Carbohydrates, Protein & Lipids and its functional properties, Pigments, Food flavours, Enzyme activity, enzymatic and non-enzymatic browning. Nutrition: balanced diet, essential amino acids and essential fatty acids, water soluble and fat soluble vitamins, role of minerals in nutrition, co-factors, anti-nutrients, nutraceuticals, food acids, moisture relations in food, Chemical and biochemical changes during processing and storage. Food Additives, Role of JECFA in safety assessment of food additives, definition, chemical structure, role in food processing and product end characteristics, Nutritional disorders,

Diet therapy, probiotic and prebiotic foods, Therapeutic, organic foods, nutraceutical and functional foods.

### **FOOD MICROBIOLOGY, FOOD ANALYSIS, SAFETY & QUALITY MANAGEMENT:**

Characteristics and morphology of microorganisms, Microbial growth, Importance of microorganisms in food – primary sources in food – intrinsic and extrinsic parameters of food affecting microbial growth – Microbial spoilage of foods, Fermented and microbial foods – Food borne diseases and safety, Toxins from microbes, natural contaminants and health hazards associated with foods. Food analytical methods, statistical evaluation of analytical data, Principle and methods for subjective and objective quality evaluation of foods, Measurement techniques and instruments for food quality determination, destructive and non – destructive evaluation, International & National Food laws and standards.

### **DAIRY MICROBIOLOGY:**

New Microorganisms associated with milk & milk products. Hygienic milk production methods for milk preservation. Microflora of raw milk. Effect of processing treatments of the microflora of raw milk. Mastitis milk and its suitability for dairy processing. Starter culture technology. Microbiological Quality Control of the Dairy Plant: The HACCP concept. Sanitation of Dairy Plant equipment & environment. Importance of microbiological quality of water.

Microbiological testing of milk & milk products. (Diseases transmitted via milk & milk products). Microbiological standards recommended for milk & milk products. Introduction to Aseptic Techniques.

### **UNIT II:**

#### **FOOD PRODUCT PROCESSING & PRESERVATION TECHNOLOGY:**

High temperature processing, Use of non-thermal technologies for preservation Properties, Processing and Preservation of milk and milk products, fermented foods, Value addition and by products utilizations.

#### **FOOD ENGINEERING, PROCESS CONTROL & FOOD PACKAGING:**

Heat transfer, momentum transfer, mass transfer, Unit operations, membrane separation processes, mechanical separation process, thermal operations, thermodynamics, Refrigeration – principles and applications, cold chain

logistics, Engineering properties of food, food plant equipment design, Static and dynamic response, advanced control systems, Instrumentation.

### **PACKAGING SYSTEMS AND METHODS:**

Bag - in box; microwave packaging; retort pouch technology, active packaging; intelligent packaging, antimicrobial packaging; bio-degradable packages, non-migratory bioactive polymers (NMBP) in food packaging - types and applications; application of nanotechnology in laminates, edible packages; bacterial production of polymer, packaging-flavour interactions, factors affecting flavour absorption, effect of irradiation of polymeric packaging material on the formation of volatile compounds, protective packaging of foods; packaging of food products sensitive to oxygen, light, moisture. Case studies: packaging and lipid oxidation, modelling lipid oxidation and absorption shelf life evaluation of packaged food, package characterization and testing; time - temperature indicators (TTIs), defining and classifying TTIs, requirements for TTIs.

### **PACKAGING MATERIAL CHARACTERIZATION AND EQUIPMENT:**

Paper and paperboard - raw materials, manufacturing stages, pulping techniques, types of paper, specialty papers; glass - types of glass, properties, glass manufacturing, bottle forming process & designs, usp; cartons - designs, manufacturing, applications, corrugated fibre boards, fibre drums; plastic - classification, glass transition, melting, degradation temperature, properties of plastic - PE, PP, PS, PVC, EVA, PA, EVOH, PLA and others; metals in packaging and their properties; container cleaning - air blast, ionized air blast, water rinse, wash and rinse, aggressive wash and rinse, sterilization, bottle orienting systems. Filling equipment and method - solid, liquid, semi - solid food -types of fillers - filler for glass bottle, paper bottle, pouches, plastic cup thermoforming equipment; form-fill - seal equipment, sealing equipment, labelling, and capping, canning and cartoning equipment. industrial packaging: unitizing - shrink and stretch wrapping, palletizing, containerizing, rigid and semi-rigid containers; thermoformed packages - skin packaging and blister packaging; flexible containers; form - fill - seal system.

### **STRUCTURAL AND GRAPHIC DESIGN IN FOOD PACKAGING:**

Information required before designing a package for food product: product, targeted consumers marketing a product, branding requirements, style of packaging, budget - steps in designing of food packaging. Creating information architecture for printing, evaluation of packaging design, reuse of containers; child resistant package - design of security features, barcodes, RFID vision/inspection, metal detectors and x-ray inspectors, smart tracking

systems, case study. Graphic design: typography, color, illustration, marketing studies, package aesthetics, decoration aspects. Closure design: function, types, selection considerations, closure dimensioning, metal closures, closure seals, plastic closures, injection moulds and closure design, tamper evident closures, child resistant closures. Special closures and functions.

### **PACKAGING OF FRESH FOODS:**

Food packaging laws and regulation, food labelling, packaging requirements for different foods and processing methods - general classification and packaging types, varieties and trends; packaging of convenience foods; packaging of food products - fresh fruits and vegetables, packaging of fruit juices, packaging of jams and jellies, packaging of pickles and chutneys, packaging of fats and edible oils, packaging of break - fast cereals, packaging of tea, coffee & other beverage products; packaging of soft drinks; packaging of bakery products - bread, biscuits & cakes; packaging of snack foods; packaging of ready - cook products; packaging of spices, condiments, oleoresins.

### **PACKAGING OF PROCESSED FOODS:**

Packaging of meat and poultry products; packaging of fish and other sea - foods; packaging of dairy products; packaging requirements for thermal - processed, dehydrated, frozen, irradiated and other specially processed foods - packaging for defence food, space food, high energy food for high altitude, functional foods, recent trends and advancements in food packaging.

## **UNIT III:**

### **INSTRUMENTATION AND ANALYTICAL TECHNIQUES**

#### **HPLC ANALYSIS OF FOOD:**

HPLC analysis of food: HPLC (High performance liquid chromatography). Introduction, principle of separation, components of an HPLC system. Pump, injector, column (column hardware and column packing materials in brief) detector and different types of detectors, recorder, Application of HPLC, Minimum Response, Performance level- operation quotient and performance quotient.

#### **GCMS ANALYSIS OF FOOD:**

Gas Chromatography: Gas chromatography Introduction, sample preparation, principle of separations, components gas supply system, injection port, oven, column and stationary phases, types of columns, detectors different types of detectors, recorder, types of carrier gases used. Gas liquid chromatography:

principle; different types of detectors and its applications: discharge ionization detector (DID), electron capture detector (ECD), flame photometric detector (FPD), Hall electrolytic conductivity detector (EICD), helium ionization detector (HID), Nitrogen phosphorous detector (NPD), mass selective detector (MSD), photo ionization detector (PID), pulsed discharge ionization detector (PDD), thermal energy analyzer (TEA); various applications of GLC. Gas chromatography-mass spectrometry (GC- MS): principles and applications in foods, flavors and fragrances, residue analysis of veterinary hormonal substances and endocrine disruptors, identification of terpenes.

### **LCMS ANALYSIS OF FOOD:**

Liquid chromatography-mass spectrometry (LC-MS): principles and applications, plant phenols, proteins, proteomics, LC-MS for identification of post-translational modifications, oligosaccharides, lipids and phospholipids, nucleic acids. Inductively coupled plasma atomic emission spectroscopy (ICP/MS/OES/AES): principles and its applications. Scanning Electron Microscopy principles and applications, study of the structure of variety of food gels.

### **NON DESTRUCTIVE TECHNIQUES IN FOOD ANALYSIS:**

Non Destructive Techniques in Food Analysis: optical methods like visible, NIR, and FTIR spectroscopy; computer vision, delayed light emission and fluorescence; X-ray imaging for classifying food products based on internal defects; nuclear magnetic resonance techniques; ultrasonics; firmness measurement methods; linear visco-elastic methods; biosensors in food quality evaluation, new techniques for food quality data analysis and control.

### **MICROBIAL TECHNIQUES IN FOOD ANALYSIS:**

Microbial techniques in food analysis: Infectious and toxigenic agents of food borne diseases: detection, identification and control methods. Antibiotic resistant strains; methods of detection, conventional, modern, rapid methods, genetic approaches. Molecular based techniques in food analysis: Gel Electrophoresis of Plasmid DNA, Polymerase Chain Reaction (PCR) & Sequencing; Setting up a Gene-Specific Polymerase Chain Reaction, Gel Electrophoresis of Gene-Specific PCR Products, Determining DNA Concentration Using Fluorometer, Amplification of cDNA Using PCR, Sequencing of Gene-Specific Products. Real-time PCR assay for detection of microbial spoilage of foods.

## **UNIT IV:**

### **PROPERTIES OF STEAM:**

Introduction, Formation of Steam, Total Heat (or Enthalpy) of Water, Latent Heat of Steam, Dryness Fraction, Wetness Fraction, Total Heat (or Enthalpy) of Wet Steam, Total Heat of Superheated Steam, Advantages of Superheating Steam Use of Steam Tables, Specific Volume of Steam, Volume of Superheated Steam, External Work Done during Evaporation, Internal Energy of Steam, Entropy of Waters, Entropy of Evaporation's Entropy of Wet Steam sg, Entropy of Superheated Steam, Temperature Entropy Diagram for Water and Steam, Isothermal Lines on Temperature Entropy Diagram, Adiabatic Lines on the Temperature Entropy Diagram, Mollier Diagram or Total Heat Energy Chart for Steam, Methods of Heating and Expanding the Steam, Determination of Dryness Fraction of Steam. Type of Steam.

### **BOILERS:**

Definition, Classification of Boilers, Comparison of Fire Tube and water, Tube Boilers, Essentials of a Good Boiler, Factors Affecting Boiler Selection, Simple Vertical Boiler, Fraser Culman Boiler, Cochran Boiler, Lancashire Boiler, Cornish Boiler, Locomotive Boiler, Nestler Oil Fired Boiler, Babcock and Wilcox Boiler, Stirling Boiler, High Pressure Boilers, The Benson Boiler, The Loeffler Steam Generator, The Volex Steam Generator, La Mont Boiler, Boiler Mountings, Boiler Accessories, Steam Driers or Separators, Steam Trap, Pressure Reducing Valve.

### **MILK PROCESSING:**

Composition of milk, physical, chemical and biological properties of milk. Processing of market milk: Practices for reception, chilling, clarification, and storage of raw milk. Homogenization of milk: Definition, pre-treatment of milk for homogenization, theories of homogenization, synchronization of homogenization with HTST plant. Effect of homogenization on physico-chemical properties of milk. Bactofugation. Thermal Processing of Milk: Principles of thermal processing, kinetics of microbial destruction, thermal death curve, Arrhenius equation. Terminology's used in thermal processing, 'D-value', 'Z-value', 'Q<sub>10</sub>-value', 'Fo-value'. Process description and definitions: Thermization, Pasteurization, Sterilization, UHT processing. Thermization: significance and methods. Pasteurization methods: LTLT/HTST, vaporization, stassanization. Manufacture of special milks: Reconstituted/recombined milks, Flavoured milks, homogenized/ vitaminized milks. Lactose-hydrolysed milk.

## **UNIT V:**

### **QUALITY CONTROL IN DAIRY INDUSTRY:**

Importance of chemical quality control in dairy industry, setting up quality control laboratories and testing facilities, mobile testing laboratories. Sampling procedures; labelling of samples for analysis; choice of analytical tests for milk and milk products for chemical analysis; instrumental methods of analysis.

Calibration of dairy glasswares including butyrometers, pipettes, burettes, hydrometers, lactometers and freezing point thermometer. Preparation and standardization of reagents required in the analysis of milk and milk products. Legislation on production, transport, processing and marketing of milk and milk products: application of FSSAI, Agmark BIS, IDF, ISO, IPO and international sanitary regulations related to dairy products to the quality control of milk and milk products. Dairy effluents and their recycling. "Prediction of shelf-life behaviour and quality assurance in milk and milk products. Selection of tests for microbiology analysis of milk and milk products and their interpretations: Rapid methods of milk testing: Non culture methods.

Organizational aspects of microbiological quality of dairy products. Role of various agencies in the formulation of standards and controlling quality of dairy products. Various microbiological standards of BIS, FSSAI, ISO, CCDS for dairy products. Quality of dairy water supplies and purifications procedure and waste disposal. Treatment and disposal and wastewater and effluent. Dairy products borne infection and intoxications and public health significance. Microbial toxins in dairy products and their significance in public health.

Detection and control measures. Indicator organisms and their significance in dairy products: Faecal and non-faecal coliform including faecal streptococci. Total gram negative bacteria including *Salmonella* and *Shiegella* group. Predictions of shelf life behaviour and quality assurance in UHT processed/sterilized milk and milk products.

## **UNIT VI:**

### **FOOD PROCESS AUTOMATION:**

Food quality, automated evaluation of food quality, food quality quantization and process control, typical problems in food quality evaluation - beef quality evaluation; food odor measurement, continuous snack food frying quality. Data acquisition: Sampling elaboration with examples, concepts and systems for data acquisition such as: ultrasonic signal acquisition for beef grading, electronic nose data acquisition for food odor measurement, snack food frying data acquisition for quality process control, Image acquisition: elaboration with examples.

## **DATA ANALYSIS:**

Data pre-processing, Static data analysis, Dynamic data analysis, Image processing: Image segmentation, Image feature extraction etc.

## **MODELLING:**

Modelling strategies: Theoretical and empirical modelling, Static and dynamic modelling, Linear statistical modelling, ANN modelling etc.

## **PREDICTION:**

Prediction and classification, Sample classification for beef grading, examples such as, based on linear statistical and ANN models, Electronic nose data classification for food odour pattern recognition, Snack food classification for eating quality evaluation based on linear statistical and ANN models, One-step-ahead prediction.

## **CONTROL:**

Process control, internal model control, Predictive control, Neuro-fuzzy PDC for snack food frying process, Systems integration: Food quality quantization systems integration, Food quality process control systems integration, Food quality quantization and process control systems development.

## **UNIT VII:**

### **DAIRY TECHNOLOGY**

#### **PROCESSING AND STORAGE OF MILK:**

Introduction –Composition and Physico-chemical properties of milk and milk constituents – LP system, microbiology of milk and Quality assurance. Milk reception – Cooling methods- Transportation and Storage of milks. Quality determination and grading of milk. Cleaning and disinfection of transport, storage facilities and handling equipments. Milk processing - terminologies – Process flow diagram. Pasteurization – principles and objectives – methods-sterilization – UHT processed milk products, their properties and prospects, types of UHT plants. Equipments and working principles, hybrid technology for pasteurization of milk, microwave processing of milk.

#### **OPERATIONS AND MILK PRODUCTS:**

Cream separation – principles – gravity and centrifugal separation – equipments and working principles. Homogenization – theory - effect on milk -



working principle of homogenizers - Principles and equipment for bacto-fugation and Bactotherm processes, Microfluidization of milk: Principle, equipment, effects and applications, Cleaning and sanitization - CIP cleaning - bottle fillers and cappers- form fill seal machines— aseptic filling Recombined milk - fluid milk - standardized - toned - reconstituted milks. Special Milks - Soft curd milk - Flavoured milk - Vitaminized milk - sterilized milk - irradiated milk. Condensed milk PFA/BIS requirements of sweetened condensed milk - standardization. Evaporated milk- manufacturing technology - defects and remedies. Fermented Milk Products - Yoghurt- Acidophilus milk - technology and microbiology. Cheese - varieties - manufacturing methods.

### **ENZYME AND MICROBIAL INFLUENCE IN MILK PRODUCTS:**

Microbial rennet and recombinant chymosin, characteristics and application in cheese making; exogenous free and microencapsulated enzymes, immobilized enzymes-their application in accelerated ripening of cheese; enzymatically modified cheeses (EMC) their utilization in various food formulations. Technological requirements of modified micro-organisms for production of cheese and fermented milk products; technological innovations in the development of functional dairy foods with improved nutritional therapeutic and pro- biotic attributes; physiologically active bio-peptides/ nutraceuticals.

### **BY PRODUCTS AND ITS PROPERTIES:**

Protein hydrolysates - their physicochemical, therapeutic properties, production and application in food formulations; production of bio-yoghurt, probiotic cheese and fermented Milks; bifidus factors in infant food formulations their physicochemical, therapeutic properties, de-bittering and application in food formulations; Enzymatic hydrolysis of lactose for preparation of whey and UF-permeate beverages. Vegan foods. Microbial polysaccharides their properties and applications in foods, production of alcoholic beverages and industrial products from starch; whey and other by-products; bio-sweeteners types properties and their applications in dairy and food industry.

### **SHELF LIFE PARAMETERS AND PRESERVATION:**

Bio-preservatives- characteristics and their application in enhancing the shelf life of dairy and food products. Practical Effect of exogenous enzymes on hydrolysis of protein and fat in culture containing milk systems; to study the various factors affecting the coagulation of milk by microbial rennets. Manufacture and evaluation of pro-biotic cheese and fermented milks; determination of glycolysis, proteolysis and lipolysis in cheese and fermented milk; enzymatic process for manufacture of low lactose milk whey products;

preparation of casein hydrolysis; visit to a bio-processing unit. Current trends in cleaning and sanitization of dairy equipment: biological; detergents; Automation; Ultrasonic techniques in cleaning; bio- detergents, development of sanitizers- heat; chemical; radiation, mechanism of fouling and soil removal; Bio-films, assessing the effectiveness of cleaning and sanitization of dairy products.

## **UNIT VIII:**

### **FOOD LEGISLATION AND STANDARDS**

#### **INDIAN FOOD REGULATIONS:**

Need for food regulation, Food Safety and Food Standards Act 2006, Food Safety and Standards Authority of India (FSSAI) structure and functions, scientific committees and panels under FSSAI, Rule and Regulation making process. Food Safety and Standards Act, 2006 and the regulations made thereunder like Licensing and Registration, Packaging and Labelling Regulation, Food Products Standards and Food Additives Regulation, Nutraceutical Regulation, Claim Regulation, Contaminants and Toxins Regulation.

#### **PRODUCT SPECIFIC INDIAN REGULATIONS:**

Indian Food Regulation - Food product categorization, Use of food additives in different products, Processing aid regulation New product /additive approval Food Product Recall, BIS mandatory certified products, Packaged Commodity Rules, AGMARK, etc., including latest amendments.

#### **INTERNATIONAL FOOD REGULATIONS:**

Concepts and trends in food legislation, Information-Domination in the European Food Industry, Agriculture, Ethics and Law, WHO in Global Food Safety Governance, The Right to Food in International Law with Case Studies. Intellectual Property and Food Labelling: Trademarks and Geographical Indications, Agricultural Innovation: Patenting and Plant Variety Rights Protection, Cross- Contamination, Genetic Drift, and GMO Co-existence with Non-GM Crops, Legal Barriers to International Food Trade, food policies.

#### **PUBLIC HEALTH AND NUTRITION REGULATION:**

Roles on Nutrition Goals and Outcomes: Connecting of Food and Public Health Systems, Planetary Boundaries in Food and Agriculture Law, Food and Nutrition

in Cancer Prevention and Treatment, Pesticides and Cancer in Conventionally-Grown Versus Organic Food.

## **FOOD SECURITY AND SAFETY LEGISLATION:**

Internalizing Externalities: Techniques to Reduce Ecological Impacts of Food Production, Cooperatives and Producer Organizations Roles in Achieving Food Security, Governing the Global Food System towards the Sustenance with Artificial Photosynthesis. Food Safety and Policy, Trade, Labelling Law - European Food Law, United States and Canada, Australia and New Zealand, Africa, Asia, Association of Southeast Asian Nations (ASEAN).

## **UNIT IX:**

### **FOOD PRODUCT DESIGN AND DEVELOPMENT**

#### **FOOD NEEDS & CONSUMER PREFERENCE:**

Market survey and its importance in; designing a questionnaire to find consumer needs for a product or a concept; advantages of processed foods in urbanised Modern Society; why people buy processed foods. Developing a Product to Meet the Requirements.

#### **DESIGNING NEW FOOD PRODUCTS:**

New Food Product Development (NPD) process and activities, NPD success factors, new product design, food innovation case studies, market-oriented NPD methodologies, organization for successful NPD; Recipe Development; use of traditional recipe and modification; recent developments in food ingredients/additives flavourings, colorings, emulsifiers, stabilizer and sweeteners; involvement of consumers, chefs and recipe experts; selection of materials/ingredients for specific purposes; modifications for production on large scale, cost effectiveness, nutritional needs or uniqueness; use of novel food ingredients and novel processing technologies.

#### **STANDARDIZATION & LARGE-SCALE PRODUCTION:**

Process design, equipment needed and Design; establishing process parameters for optimum quality; Sensory Evaluation; Lab requirements; different techniques and tests; statistical analysis; application in product development and comparison of market samples; stages of the integration of market and sensory analysis.

## **QUALITY, SAFETY & REGULATORY ASPECTS:**

Product Stability; evaluation of shelf life; changes in sensory attributes and effects of environmental conditions; accelerated shelf life determination; developing packaging systems for maximum stability and cost effectiveness; interaction of package with food; Regulatory Aspects; whether standard product and conformation to standards; Approval for Proprietary Product.

## **ADVERTISEMENT, MARKETING & CASE STUDIES:**

Product performance testing; market positioning, Marketing: developing test market strategies; various tools and methodologies to evaluate consumer attitudes, preferences and market acceptance factors; Case Studies of some successes and failures- Factors that influence NPD success, innovation case studies to highlight best practice in terms of the integration of technological and marketing approaches to NPD; food choice models and new product trends.

## **UNIT X:**

### **FOOD SUPPLY CHAIN MANAGEMENT**

#### **SUPPLY CHAIN AND QUALITY MANAGEMENT:**

Introduction, actors in supply chain management, supply chain vs. value chain, factors affecting quality in supply chain management, challenges in supply chain and quality management, pricing and performance measurement in supply chains.

#### **FOOD SUPPLY CHAIN MANAGEMENT SYSTEMS AND INSTITUTIONS:**

Introduction to FSMS - ISO, GFSI, BRC, IFS, SQF, FSSC; HACCP, Codex, BIS and BIS standards, QCI, EIC, EPC and export regulation, AEPDA, FSSAI and FSSAI Act.

#### **MARKETING AND QUANTIFYING SUPPLY CHAIN:**

An overview, product differentiation and quality standards, major players in supply chain, marketing channels and legislations, case studies: national and international supply chain management of horticultural produce.

**ERP IN SUPPLY CHAIN:**

Introduction to Enterprise Resource Planning (ERP), inventory management, manufacturing, sales and purchase module, finance module, supply chain management, customer relationship management, HR management module.

**LOGISTICS & DISTRIBUTION MANAGEMENT:**

Physical distribution, distribution channels, channel conflict management, big data analysis, block technology, internet of things, artificial intelligence and sensor based traceability systems in supply chain.