

02. DAIRY SCIENCE Syllabus for Conducting written Examination for direct Recruitment of Teaching posts in the Cadre of Assistant professors at UASM

➤ Dairy Technology

Advances in Dairy Processing

Use of bio-protective factors for preservation of raw milk: effects on physico-chemical, micro-bial and nutritional properties of milk and milk products; Present status of preservation of raw milk.

Methods of determining lethality of thermal processing; UHT processed milk products, their properties and prospects, types of UHT plants, aseptic fillers, heat stability and deposit formation aspects, effect on milk quality; techno-economic considerations; Nutritional aspects of UHT treated milk vis-à-vis retort sterilized/ HTST treated milk.

Principles and equipment for bacto-fugation and bacto-therm processes; Partial homogenization and its application in dairy industry, Low pressure homogenization; Microfluidization of milk: Principle, equipment, effects and applications.

Concentration processes and their impact on quality of finished products; Dehydration: advances in drying of milk and milk products; Freeze dehydration: physico-chemical changes and industrial developments; Glass Transition Temperature and its relevance to dried milks.

Water activity; Sorption behaviour of foods, energy of binding water, control of water activity of different milk products in relation to their chemical, microbiological and textural Properties; Hurdle technology and its application in development of shelf-stable and intermediate-moisture foods; Use of carbonation in extending the shelf life of dairy products.

Current trends in cleaning and sanitization of dairy equipment; Automation, Ultrasonic techniques in cleaning; Bio-films; Bio-detergents, innovations in sanitizers - chemical, radiation; Mechanism of fouling and soil removal; Assessing the effectiveness of cleaning and sanitization of dairy equipment, Water conservation methods.

Advances in Food Processing

Status of food processing industry in India and abroad; Prospects and constraints in development of Indian food industry.

Development in Post-harvest management of Fruits and Vegetables (Controlled and Modified Atmospheric Storage, Designing aspects of CAS/MAS, Components of CAS/MAS), hypobaric storage, harvesting indices for fruits and vegetables.

Newer methods of drying of foods (Super-heated steam drying, Freeze drying, infrared drying and microwave drying; Osmodrying process), Concepts of UHT and retort sterilization of food products, packaging materials for thermally processed foods.

Basic principles involved in fermentation, Technological aspects of pickled vegetables like sauerkraut, cucumbers, Technology of wine, beer and distilled alcoholic beverages, defects in alcoholic beverages.

Advances in milling of rice (solvent extractive milling) and Turbo milling of wheat. Emerging concepts in cereal processing including gluten free products, Low calories bakery products, Technologies for breakfast cereals, Utilization and importance of dairy ingredients in bakery products.

Definition, classification and technologies of fabricated and formulated foods and their nutritional aspects. Imitation dairy products and dairy analogues; meat analogues. Principle of extrusion processing, design and working of extruder, classification, application in food and dairy processing. Food additives, including stabilizers, emulsifiers, antioxidants, preservatives, etc. for formulated foods. Fortification of staples.

Non-thermal processing technologies for food: Principles, Effect on food constituents and Salient application in food sector/industry.

Enzymes in food processing; newer concepts in food processing including organic foods; Processing of organic raw material; Genetically modified foods; Space foods, Nutrigenomics, metabolomics and other Omics concepts in food processing.

Rheology of Dairy and Food Products

Introduction to rheology of foods: Definition of texture, rheology and psychophysics – their structural basis; Physical considerations in study of foods; Salient definitions of stress tensor and different kinds of stresses.

Rheological classification of Fluid Foods: Shear-rate dependence and time dependence of the flow-curve; Non-Newtonian fluids; Mechanisms and relevant models for non-Newtonian flow; Effect of temperature on rheology; Compositional factors affecting flow behaviour; Viscosity of food dispersions: dilute and semidilute systems, concentration effects.

Viscometers; Types (Co-axial cylinders, Spindle or Impeller type, Cone-plate, Capillary, Falling sphere, Vibratory, Extrusion, and Orifice), comparative assessment, merits and limitations; Rheometer: principles and operational features.

Rheological characterization of semi-solid and solid foods; Mechanical models for viscoelastic foods (Maxwell, Kelvin, Burgers and generalized models) and their application; Dynamic measurement of viscoelasticity.

Large Deformations and failure in foods: Definitions of fracture, rupture and other related phenomena; Texture Profile Analysis; Instrumental measurements: Empirical and fundamental methods; Rheometers and Texture Analyzers; Measurement of extensional viscosity; Acoustic measurements on crunchy foods.

Rheological and textural properties of selected dairy products; Measurement modes and techniques; Effect of processing and additives (stabilizers and emulsifiers) on food

product rheology; Relationship between instrumental and sensory data; Microstructure of dairy products; Tribology and its applications.

Biotechnology for Dairy Applications

Introduction to process biotechnology; Principles of recombinant DNA technique; Development and impact of biotechnology on dairy and food industry.

Microbial rennet and recombinant chymosin - characteristics and applications in cheese making; exogenous free and microencapsulated enzymes. Immobilized enzymes - their application in continuous coagulation of milk in cheese making; Enzyme modified cheeses (EMC) - their utilization in various food formulations.

Technological requirements of modified micro-organisms for applications in cheese, Probiotic and fermented milk products; physiologically active bio-peptides/nutraceuticals.

Protein hydrolysates - production, physico-chemical, therapeutic properties and application in food formulations; Enzymatic hydrolysis of lactose for preparation of whey and UF-permeate beverages; Continuous lactose hydrolysis of whey.

Microbial polysaccharides - their properties and applications in foods; Production of alcoholic beverages; Bio-sweeteners - Types, properties and their applications in dairy and food industry.

Bio-preservatives - characteristics and their applications in enhancing the shelf life of dairy and food products.

Advances in Traditional Indian Dairy Products

Global prospects and export potential of traditional Indian dairy products.

Differences in quality of traditional dairy products from cow, buffalo, goat, camel, and sheep milks; Process innovations in commercial production of heat-desiccated, coagulated and fermented traditional dairy products; Mechanized production of traditional milk based sweets; Automation for manufacture of ghee, *paneer*, *dahi*, *lassi* and traditional sweetmeats.

Composite traditional milk products; Application of membrane technology and microwave processing for industrial production of traditional Indian dairy products.

Technologies for region specific traditional Indian dairy products and their value addition, their application as a vehicle for delivering functional ingredients; Manufacture of dietetic traditional dairy products.

Techno-economic aspects for establishing commercial units for traditional products.

Convenience traditional dairy products; Food safety issues; Shelf life extension of food using newer techniques; Novel packaging and preservatives.

Non-Conventional Processes for Dairy and Food Industry

Irradiation: sources and properties of ionizing radiation; Mechanism of interaction with microorganisms and food components; Chemical effects; Industrial irradiation systems, benefits and limitations; UV pasteurization of milk; Safety aspects in radiation processing; National and international regulations in relation to radiation processing; Cold plasma processing.

High frequency heating (Microwave and Radio frequency processing): Principles, merits and demerits; Design and working of processing units; Applications in dairy and food processing; Microwavable packaging; Safety aspects.

Infra-red (IR) heating and Ohmic heating: Principle, equipment and applications.

Ultrasonic treatment of food: Mechanism of ultrasound induced cell damage, generation of ultrasound, design of power ultrasonic system, types of ultrasonic reactors, application of power ultrasound in food processing, effects on food constituents, ultrasound in amalgamation with other food processing operations – thermo-sonication, manosonication, thermo-manosonication, advantages and future prospects.

High hydrostatic pressure (HHP) processing: Principle of microbial inactivation, barotolerance of microorganisms, effect on food constituents; equipment; dairy and food applications; Merits and demerits of HHP.

Pulsed electric field processing; Description/ mechanism and factors affecting microbial inactivation; effects on food components; Present status and future scope for food applications.

Super-critical Fluid Extraction; Principle, instrumentation and applications.

Membrane Processing for Dairy Applications

Membrane techniques; Classification and characteristics of filtration processes; types of commercially available membranes; membrane hardware, design of membrane plants, modelling of ultrafiltration (UF) processes, mass transfer model, resistance model; Membrane fouling-problems and mitigation strategies; Cleaning and sanitization of different types of membranes.

Factors affecting permeate flux during ultrafiltration and reverse osmosis of milk and sweet/sour whey, energy requirements for membrane processing of milk and whey.

Applications of ultrafiltration (UF), reverse osmosis, nanofiltration and microfiltration in the dairy industry: food and pharmaceutical grade lactose, low lactose milk powder, dairy whiteners, WPC, WPI, MPC, MPI, Native micellar casein powder, etc. Preparation, properties and uses of Milk Protein Concentrate (MPC) and Milk Protein Isolate (MPI); Manufacture of some cheeses and fermented milk products and impact of membrane processing on quality of such products. Use of membrane processing techniques for separating prophylactic biological from milk.

Demineralization: principles, processes, equipment and applications.

Functional properties of whey proteins (WPC and WPI), micellar casein and UF milk retentate and their modifications.

Advances in Dairy and Food Packaging

Trends in packaging industry; designing framework for packaging; Testing of packaging materials.

Adhesives; Graphics; Coding (Barcode and Quick Response code), and labelling used in food packaging.

Protective packaging of foods; Effect of light, oxygen and moisture on packaged food.

Packaging of dairy products, convenience foods, fresh produce and fruits and vegetable products, Packaging of fats and oils, spices, meat, poultry, fish and other sea foods.

Modified atmosphere packaging, Shrink and stretch packaging; Self-heating and self-cooling cans.

Retort pouch technology, microwavable, biodegradable, and edible packages; Principles and applications of Active Packaging, Smart and Intelligent Packaging, Antimicrobial packaging.

Industrial packaging: unitizing, palletizing, containerizing, distribution systems for packaged foods.

Safety aspects of packaging materials; sources of toxic materials and migration of toxins into food materials, packaging and flavour interaction.

Technology of Food Emulsions, Foams and Gels

Food dispersions, their characteristics and factors affecting food dispersions.

Food emulsions; Emulsifiers and their functions in foods; HLB concept for food emulsifiers; Emulsion formation and stability; Surfactants.

Dairy based foams and their applications, structure of foams; Egg foams and uses; Foam formation and stability.

Theory of gel formation; Carbohydrate and protein based gels. Gelled milk products. Advances in food gels (organogel, hydrogel and nanogel).

Structure of dairy based emulsions, foams and gels; blend of stabilizers and emulsifiers; Effect of stabilizers and/or emulsifiers on functional properties of dairy foods; Aerosols and propelling agents in foamed dairy products.

Techniques for evaluating the structure of food emulsions, foams and gels

Functional Foods and Nutraceuticals

Classes of functional foods and their status.

Functional ingredients; Classification; Dietary and therapeutic significance.

Food fortification; Significance and techniques of fortifying foods with functional ingredients.

Infant nutrition; Dietary formulations, special needs, additives; Geriatric Foods: Design considerations, ingredients, special needs; Sports foods: Significance, strategies and design considerations.

Reduced calorie foods: Significance, strategies, additives (fat replacers, bulking agents, non-nutritive sweeteners).

Low sodium and low lactose foods: Nutritional and health significance.

Herbs; Classification; Therapeutic potential, applications; Phytochemicals; Classes; Physiological role; Applications; Bioactive ingredients from animal and marine sources.

Probiotic, prebiotic and synbiotic foods: Concept and applications.

Production and Applications of Dairy Ingredients

An overview of dairy ingredients for food processing; Composition, nutritive value and health attributes of dairy ingredients; Important quality indices; National and international regulatory standards.

Principles of conventional and novel approaches for separation, concentration and fractionation of milk components(Ig, lf, b-Lg): centrifugal separation, concentration, drying, membrane processing, enzyme-assisted separation, supercritical fluid extraction, electric field assisted membrane technique, etc.

Chemical, physical and functional characteristics of concentrated and dried dairy ingredients (SMP, WMP, lactose, whey powder, WPC, WPI, MPC, casein and caseinates, cream powder, butter powder, cheese powder, yogurt powder, buttermilk powder, etc.).Miscellaneous dairy ingredients, viz. dairy permeates, hydrolysates, coprecipitates and lactoferrin.

Interactions of dairy ingredients with other food components and its effect on product quality.

Applications of dairy ingredients in food industry: bakery and confectionery; Infant, adult and sports nutrition; Processed meat products; spreads; functional Foods; edible films and coatings.

Advances in Cheese Technology

Rennet coagulation: Measurement of milk clotting activity and gelation properties, Catalytic mechanism and milk-clotting properties of rennet and rennet substitutes. Advances in renneting of milk; recombinant rennet.

Acid coagulated milk gels: formation, rheology, structural properties, etc.

Advances in cheese starters; genetics of Lactic Acid Bacteria (LAB); Exo Polysaccharide (EPS) starters; Genetic engineering of LAB.

Biochemistry of cheese ripening: Metabolism of residual lactose and lactate, protein hydrolysis, lipid hydrolysis, amino acid catabolism; Development of cheese flavour, and body and texture; Cheese microstructure. Accelerated cheese ripening.

Mold-ripened cheeses; Starter cultures, technology, ripening process (Blue, Roquefort, Camembert, etc.)

Low fat and low-sodium cheeses: challenges, strategies and advances; Membrane technology in cheese; Cheese as an ingredient in food systems.

Technology of non-bovine cheese: popular varieties, challenges, strategies; Technology of cheeses prepared by coagulation other than rennet and acid (Ricotta, Brown whey cheese, etc.); Advances in cheese packaging; Automation in cheese making; Cheese analogues.

➤ **Dairy Engineering**

Dairy and Food Engineering-I

Viscoelastic characterisation of materials, stress-strain behaviour, creep, stressrelaxation, solving problems on creep and stress relaxation of foods, non-Newtonian M fluids; Viscometry-capillary and rotational viscometers, derivation on principle of operation of capillary and rotational viscometers, fitting of flow models; Rheometers: types and applications, temperature sweep, amplitude sweep and frequency sweep; identification of LV region.

Freezing: IQF, Cryogenic freezing- process and equipment details, freezing curves, freezing time calculations, design of freezing equipment, freeze drying, freeze concentration.

Design of single and multi-effect evaporators, design of TVR and MVR, design and selection of evaporator pumps, calculation of wetting rate, concept of condenser free design of evaporator, design of condenser (barometric and surface), flash vessel, preheater design for bacterial destruction, DSI, vacuum pump, concept of fanless cooling tower, aroma recovery unit.

Design of spray drier and its components, design of three stage drier, selection of fans, roots blower, selection of nozzle, HPP cum homogeniser used for automation, CIP, cleanable bag filter, concept of cyclone free spray drier operation, use of computer software in design of evaporators and spray riers.

Novel processing methods and equipment: high pressure processing, ohmic heating, ultraviolet light, pulsed electric field, pulsed light field, micro and nanoencapsulation, microwave heating, cold plasma, ultrasound processing and low dose e-beams.

Ultra-high temperature processing (UHT): concept, process, system; Design: plate and tubular type, their merits and demerits and selection; heat balances and concept of differential temperature; steam cleaning systems. Analysis of sterilization performance and validation, determination of residence time distribution. Pouch forming, can and carton filling systems for UHT. Cleaning and sterilization of UHT processing plants

Analytical Heat and Mass Transfer

One-dimensional steady state heat conduction through fins (Extended surfaces): actual and approximate solution. Efficiency, effectiveness and design of profile area offins.

Two-dimensional steady state heat conduction: analytical and numerical solution.

Unsteady state heat conduction: Concept of Biot number, Lumped parameter analysis, transient heat flow in semi-infinite solids, use of Heisler charts.

Forced convection heat transfer in flow over a flat surface: hydrodynamic and thermal boundary layer, continuity equation, momentum equation and energy equation, heat transfer coefficient/ Nusselt number in laminar and turbulent region of boundary layer. Stanton number; Colburn analogy; empirical co-relations.

Forced convection heat transfer in flow through tubes: Nusselt number in the entrance region and fully developed laminar and turbulent region.

Condensation and boiling heat transfer: Film wise condensation on vertical surface; Nusselt equation, regimes of boiling, boiling heat transfer.

Performance analysis of parallel flow and counter flow heat exchangers. LMTD and effectiveness NTU approach. Application of computational software for process heat transfer applications.

Mass transfer - Fick's law of diffusion, diffusion of gases and liquids through solids, equimolar diffusion, isothermal evaporation of water into air, mass transfer coefficients. Governing equation for mass transfer; boundary conditions. Various non-dimensional numbers and their analogy to heat transfer. Examples of simultaneous heat and mass transfer

Transport Phenomena

Introduction to vector analysis, dot product and cross product and its physical significance, Stress tensor, total and partial derivatives, total acceleration, Eulerian and Lagrangian frames of reference, Reynolds transport theorem, Different three dimensional co-ordinate systems (Cartesian and Polar).

Introduction to transport phenomena - transport processes and similarities in momentum, energy and mass transfer; Application of transport phenomena in CFD, practical examples in food engineering. Classification of flows and flow visualization; vorticity and potential and stream function, Potential flow, Cauchy Reimann equations.

Steady-state equations - Momentum transport equations for Newtonian and non-Newtonian fluids, continuity equation in different co-ordinates; Derivation for Cartesian, cylindrical and spherical coordinate system.

Equations of motion - Navier-Stokes equations and their application in viscous fluid flow between parallel plates and through pipes.

Turbulent transport mechanism - Mathematical analysis; Eddy viscosity and eddy diffusivity; Velocity, temperature and concentration distribution; time smoothing equations. Inter-phase transport in isothermal system -friction factors for various geometries.

Dimensional analysis- Buckingham Pi-theorem and matrix method, application to transport phenomena, analysis among mass, heat and momentum transfer, Reynolds' and Chilton –Colburn analogy.

Non-dimensional numbers in transport phenomena- definition, mathematical relation and physical significance; Boundary layer concept - Theoretical and exact solutions for heat, mass and momentum transfer. Governing equations, Blasius solution and Von-Karman integral equation.

Advances in Refrigeration Engineering

Vapour compression refrigeration system: major components and their different types; Theoretical vapour compression cycle, theoretical COP; Effect of operating parameters on COP; actual vapour compression cycle; Multi-pressure commercial refrigeration systems.

Vapour absorption refrigeration system; Ammonia-water system, lithium bromide - water system, vapour absorption refrigeration cycle and its representation on enthalpy-concentration diagram; Absorption system calculations.

Heat Pumps: different heat pump circuits; analysis of heat pump cycle; Use of heat pumps in dairy plant for energy conservation.

Non-conventional refrigeration systems; Steam jet refrigeration, thermoelectric refrigeration, vortex tube, cooling by adiabatic demagnetization.

Design elements of refrigeration equipment: compressor, condenser, evaporator, cooling tower, spray pond, etc. Balancing of different components. Design of brazed PHE for condensers

Design of cold storage and air-conditioning systems: types of cooling loads and their calculation, design of cold storage for food products, construction of cold storage, equipment selection, insulating materials, vapour barriers, ice bank tank. Concept of Ice silos, centralised distribution of ammonia through pump, PUF panel design.

Control and maintenance of a commercial refrigeration plant: Pressure regulating valves, Thermostatic valves, LP/ HP cut-outs, high to low side bypass valve, condenser water regulating valve, capacity control devices, pump down control, defrosting

methods, liquid charging, advanced intelligent control systems; General preventive maintenance of refrigeration plant.

Design of Food and Dairy Processing Equipment

Design of vessels: codes and regulations, Design for pressure and temperature, loading; allowable stress, minimum thickness after forming, design for internal and external pressure, cylindrical and spherical shells, formed heads, reinforcement openings; fabrication requirements, inspection, tests and non-destructive examination, pressure tests, design and stress evaluation, design problem.

Design of storage vessels/ tanks, horizontal and vertical tanks, design of insulated and un-insulated tanks, nozzles and mountings, Design problems.

Design of high-pressure vessels: constructional features, material for high pressure, multi shell construction, solid walled vessel.

Supports for vessel: bracket support or Lug support, web (gusset plates), skirt support, skirt design, skirt bearing plate, saddle support, Design problems.

Heat exchangers: shell and tube heat exchangers, construction codes, general design considerations, U- tube heat exchangers, double pipe exchanger, scraped surface exchanger, spiral tube exchangers, joints; welded tube joints, baffles and tube bundles, tube sheet, double tube sheet construction; plate type heat exchanger; air cooled heat exchangers; Computer software for design of heat exchanger, Design problems.

Design of reactor vessel: material of construction, agitation, classification, heating systems, design consideration, tank coils, design of agitation system components, baffles, power requirement for agitation, Hygienic engineering design.

Fundamentals of CAD/ CAM for design of dairy and food processing equipment.

Engineering Properties of Dairy and Food Products

Geometrical Properties; Shape, size, volume, density, porosity, surface areas, friction, rolling resistance, angle of repose, specific surface area, mean diameter, sphericity, particle size analysis, Hausner's ratio, Carr's index.

Aerodynamic, Hydrodynamic and Frictional Properties; Drag coefficient, terminal velocity, Relation between drag coefficient and Reynolds number, terminal velocity from time distance relation. Pressure drop through packed beds.

Thermal properties; Specific heat, thermal conductivity, thermal diffusivity, methods of determination, steady state and transient heat flow, enthalpy, surface heat transfer coefficient freezing point. Measurement of thermal properties and prediction techniques.

Electrical conductivity, capacitance, inductance, Dielectric properties, viz. dielectric and microwave, dielectric constant, Dielectric loss factor, loss tangent, energy absorption, heating; Optical properties, colorimetry, transmittance and reflectance.

Non-destructive quality evaluation techniques; Measurement techniques and instruments for food quality determination, destructive and non-destructive quality evaluation, UV-VIS NIR spectroscopy, X-ray, CT, NMR, machine vision system. FTIR, DSC, machine vision system, particle size determination by laser diffraction, e-nose, biosensors, etc.

Application of engineering properties in equipment design, processing and handling of dairy and food products.

Mechanization in Manufacturing of Indigenous Dairy Products

Present status of mechanization in manufacture of indigenous dairy products.

Preliminary design calculations and material selection, design considerations like force alignment and vibration. Analysis of stresses and strains in rectangular and modes and effects analysis. Manufacturing system types and principles, manufacturing models-physical and mathematical models, realistic model building and design of prototypes.

Design of liquid-filled SSHE for preheating applications; Design of equipment for batch and continuous mechanized manufacture of khoa, khoa-based sweets, chhana and chhana-based sweets; Conical process vat, single SSHE, triple SSHE, etc. Equipment for manufacture of batch and continuous manufacture of fermented dairy products, paneer, butter and ghee. Sizing and optimization. Cooling systems for viscous products. Machining standards for stainless steel.

Instrumentation and automation in manufacturing of indigenous dairy products. Automatic filling machines. Changes in engineering properties of milk during manufacture of indigenous dairy products.

Design, layout and preparation of project report for establishing unit for the manufacture of indigenous dairy products. Scaling up of prototypes to commercial capacity.

Dairy and Food Engineering-II

Water activity and states: a thermodynamic quantity, water sorption isotherms, hysteresis, theories of sorption hysteresis, water activity measurement methods, water binding, control of water activity and moisture; Relationship between water activity and glass transition. Diffusion and sorption kinetics of water in foods

Different types of packaging materials, their key properties and applications, Plastic packaging, different types of polymers used in food packaging and their barrier properties. Recent innovations in packaging, identification and testing of packaging materials

Permeability and shelf-life: theoretical considerations, permeability to gases and vapours, measurement methods, permeability of multilayer materials, permeability in relation to packaging requirements of food products. Development of shelf-life models based on moisture gain, lipid oxidation and light.

Calculation of shelf life and requirements for packaging, deteriorative reactions accelerated testing, relationship between transport properties of the package and shelf life of packaged products, simulation of product package- environment interaction, shelf life simulation for moisture, oxygen and light sensitive products.

Theory of ultra-filtration, reverse osmosis and electrodialysis, selection and types of membrane and properties, concentration polarization, mathematical description of flow through membrane, application and use in dairy industry. Design calculation and selection of various membrane systems.

Microwave energy absorption, physical parameters in microwave heating processes, heat transfer phenomena, equipment and application in dairy food industry. Types of waveguides, electromagnetic resonators and microwave tubes.

Bio-Thermal Process Engineering

Introduction to biochemical engineering: biochemical kinetics, kinetics of substrate utilization, enzyme reaction, growth of microorganisms, fermenters, pasteurization and sterilization and thermal destruction.

Design and analysis of fermentation vessels: residence time distribution, reactors in food processing, reactor types, analysis of reactor systems.

Mixing in reactors: mixing equipment, power consumption, gas-liquid mixing, liquid-liquid dispersion, solids suspension and solid-liquid mass transfer. Scale-up of mixers and alternative mixing devices.

UHT systems and recent advances: factors affecting spoilage of food, Aseptic packaging systems and conditions.

Thermo-bacteriology: Survivor curve, thermal death curve, Arrhenius curve, techniques for determination of heat resistance of microorganisms, analysis of thermal resistance data, processing in containers, process time, lethality, design of batch and continuous sterilisation cycles in vat.

Industrial Instrumentation and Process Control

Introduction; Instrumentation systems and its classification, measuring instruments, characteristics of instruments, intelligent versus dumb instruments, Microprocessor based instrumentation, Function of measurement systems, its elements and applications. Industrial instrumentation, Structure of industrial instrumentation in real time applications

Control Systems; Feedback principles. Mechanical, hydraulic and pneumatic system components. Characteristics of liquid system, gas system, thermal system. Mathematical model of liquid process, gas process, flow process, thermal process, mixing process, Chemical reaction, D.C. and A.C. Servomotors, D.C. and A.C. Tachogenerators, Potentiometers and optical encoders, Synchro and stepper motors, Modelling and objectives of modelling for batch and continuous processes, Selfregulation. Pneumatic valves

Process Control and Controllers; Principles of automatic process control, Process characteristics, control system parameters, Process control loop, Elements of process control, process variables, Process facility considerations, controller modes, lag time, error signals, and correction signals, Actuators and Control valves; on-off, P, PI, P-ID, cascade, feed forward, and ratio controllers, Fuzzy controllers. Data loggers and data acquisition, Introduction to computer based control systems, PLC, DCS, SCADA, HMI, etc.

Modern Transducers and Display Devices; Silicon micro transducers, optical transducer principles, types, characteristics of fibres and fibre optic transducers, Introduction to smart transducers and their applications, displays and their classification - Storage CRTs, Flat CRTs, LEDs, LCD display, Gas discharge plasma displays, Incandescent display, Electrophoretic image displays (EPID), Liquid vapour display (LVD).

Industrial Automation and Robotics

Introduction; Automation in Production System, principles and strategies of automation, basic elements of an automated system, advanced automation functions, levels of automation. Flow lines and transfer mechanisms, fundamentals of transfer lines.

Material handling and Identification Technologies: Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods.

Automated manufacturing systems; Components, classification and overview of manufacturing systems, Manufacturing cells, GT and Cellular manufacturing, FMS, FMS and its planning and implementation. Quality control systems: Traditional and modern quality control methods, SPC tools, inspection principles and practices, inspection technologies.

Control technologies in automation; Industrial control systems. Manufacturing industries, continuous versus discrete control, computer process and its forms.

Computer based industrial control; Introduction and automatic process control building blocks of automation systems; LAN, Analog and Digital I/O modules, SCADA systems and RTU. Distributed control system: Functional requirements, configurations and some popular distributed control systems. Industrial control applications in dairy and food processing industry. Microcontroller units (MCU); Arduino, Raspberry Pi sensors compatible with MCUs: temperature- RH, ultrasound and infrared sensors.

Basic principles of robotics, configurations, control. Application of machine vision systems, Image processing and analysis. Typical pick and place, loading and unloading, packaging and palletizing applications.

Unit Operations

Grading, cleaning, washing, sorting, shelling, dehusking, decortication, milling, polishing, pearling, drying (evaporative, osmotic and freeze drying), Mixing, clarification, coagulation, mechanical separation, sedimentation.

Handling of food products; Mechanics of bulk solids, selection of bulk handling equipment, operation and construction of conveyors and elevators, viz. belt conveyors, screw/auger conveyors, bucket elevators and drag/chain conveyors. Estimation of energy requirement, damage to products during mechanical handling. Operation and maintenance of conveying equipment.

Mechanical cleaning and sizing of food products – size reduction, size characteristics, particle geometry, energy for size reduction of granular materials and dry powders, size- reduction equipment, performance characteristics of size reducers. Different milling methods, cryogenic grinding.

Crystallization; Material and energy balance in crystallizers, Principles of crystal growth, super saturation and nuclei formation, operation of batch and continuous crystallizers.

Distillation; Flash-off distillation, binary mixtures, differential distillation, steam distillation.

Flow through porous media, adsorption, pressing, expelling, extraction, palletizing, and extrusion.

Environmental Engineering

Waste water sources, characteristics, standards for disposal of dairy waste water.

Physical, chemical and biological characteristics of waste water, measurement of organic content in waste water

Physical unit operations in waste water treatment: screening, racks, mixing, flocculation, sedimentation, floatation, elutriation, vacuum filtration and incineration.

Chemical unit operations in waste water treatment: reaction kinetics, chemical precipitation, aeration and gas transfer process, rate of gas transfer, adsorption and disinfection.

Biological unit operations- aerobic and anaerobic cycles, kinetics of biological growth, application of kinetics to treatment systems, aerobic waste treatment, anaerobic waste treatment

Air conditioning systems: clean – room air conditioning; important pollutants of air; properties of particulate matter and air pollution control methods. Dairy plant fire hazards.

Energy Management and Auditing in Dairy and Food Plants

Energy audit; its need and types. Bench marking of energy costs. Matching energy use to requirement. Optimizing the input energy requirements. Fuel and energy substitution. Energy Balance and computation of efficiency of energy.

High efficiency boilers, improved combustion techniques, energy conservation in steam distribution systems, upkeep and maintenance of steam auxiliaries and fittings.

Electrical load management; Demand management, Energy saving controllers, Power factor and its improvement. Transformer; Energy saving in transformers.

Electric motor; Selection and application, energy efficient motors. Variable speed drives and Variable Frequency drives. Industrial lighting

Energy conservation in Refrigeration and Cold storages, cooling towers, pumps and pumping systems, fans, blowers, air compressors, Maintenance and upkeep of vacuum and compressed air pipelines.

Processing equipment; Improving efficiency and energy conservation opportunities in kettles, PHEs, Evaporators and Driers. Hot air generator, thermic fluid heater, steam radiator, waste heat recovery and thermal energy storage in food processing facilities, condensate recovery and reuse.

➤ **Dairy Chemistry**

Physico-Chemical Aspects of Milk Constituents

Basics of chemical reaction kinetics, Order and molecularity of a reaction. Kinetics of denaturation of whey proteins and Maillard browning. Kinetics of enzymatic reactions; the role of enzymes as biological catalysts; factors affecting the rate of enzyme reaction: concentration of substrate, concentration of enzyme, concentration of reaction products, pH, temperature, time, activators and inhibitors. Thermal inactivation of enzymes present in milk. Concept of activation energy

Electrolytic dissociation: activity, ionic strength and dissociation constants of acids and bases; effect of ionic strength on dissociation constants. Buffer, buffer capacity and buffer index of milk and milk products. Redox reactions and photo-oxidation of milk.

Adsorption at solid – vapour interphase; Monolayer and multilayer adsorption; capillary condensation; adsorption isotherms; Hysteresis. Sorption of water on milk Dairy Science and Technology: Dairy Chemistry

Colloidal and surface phenomena in milk; adsorption at solid-liquid and liquid-liquid interphases; Gibb's equations. Interfacial tension, surface tension, surface active agents, general aspects of foaming, churning and whipping of cream; emulsion and emulsion stability; coalescence and dispersion; an introduction to the concept of Nano emulsion and Nano micelles.

Micelles: definition, critical micelle concentration, formation and stability; Colloidal stability of casein micelles in milk, zeta potential, size distribution of casein micelles and fat globules. Gels and their formation, structure and stability; acid and rennet gels.

Milk Carbohydrates, Minerals and Water Soluble Vitamins

Lactose: occurrence, isomers, molecular structure, levels in milk of different species.

Physical properties of lactose: crystalline habits, hydrates, lactose glass, specific rotation, equilibrium of different isomers in solution, solubility, density, sweetness.

Chemical properties of lactose: hydrolysis; Pyrolysis; Oxidation; Reduction; Degradation with strong bases; Derivatives; Dehydration and Fragmentation; Browning reaction; Oligosaccharides in milk-health significance.

Minerals: major and minor minerals; Factors affecting variation in salt composition of milk; Distribution and importance of trace elements in milk.

Physical equilibrium amongst milk salts; Effect of various treatments on salt equilibrium; Partitioning of salts and factors affecting them.

Salt balance and its importance in the processing of milk; Protein-mineral interactions.

Water soluble vitamins: molecular structure, levels in milk and milk products; factors affecting their levels; Biological significance; Ascorbic acid structure; Relation with redox potential (Eh) of milk and milk products.

Milk lipids: General classification, neutral and polar lipids (phospholipids) in milk, gross composition of milk lipids in different species, physico-chemical properties of milk lipids; role of major milk lipids in milk and milk products and biological significance of milk lipids; Composition of milk fat globule membrane.

Fatty acid profile of milk lipids; factors affecting the profile of fatty acids; Different properties of fatty acids

Unsaponifiable matter and its importance; Composition of unsaponifiable matter; Chemistry, levels and physiological functions of sterols; Fat soluble vitamins and carotenoids in milk.

Chemical properties of milk lipids: hydrolysis by alkali, water and enzymes; hydrogenation, halogenation, transesterification, inter-esterification and fractionation.

Autoxidation: Definition, theories, induction period, secondary products of autoxidation, factors affecting, prevention and measurement; various methods for evaluating primary and secondary oxidation products; Antioxidants: Definition, types, reaction mechanism and estimation. Thermal oxidation of fat

Chemistry of Food Constituents

Water: Forms of water in foods; water- solute interactions, and food stability in relation to water activity; solute mobility; property of ice crystals; role of ice in the stability of food at sub-freezing temperatures.

Carbohydrates: Starch; Types, swelling behaviour, gelatinization and their role in bread making; modification of starches for industrial applications, physico-chemical changes taking place during malting. Oligosaccharides: Structural units of commercially

available oligosaccharide, their properties and preparation methods, Hydrocolloids, their properties and utilization in different food preparations; mutual interactions among hydrocolloids and interactions with proteins.

Proteins: Classification, distribution and physico-chemical properties of food proteins from various sources; structure-function relationship and their modifications; denaturation of food proteins. Application of enzymes in food Industry; Immobilized enzymes, Browning reactions in foods: enzymatic browning and non-enzymatic browning (caramelization and maillard reaction).

Food Lipids: Physico-chemical properties of food lipids and their modifications; Composition of various types of edible oils/fats with special reference to their quality; auto-oxidation of food lipids.

Phytochemicals: Chemistry of polyphenols, phenolic acid, flavonoids, phytosterols, phytostanol.

Food Additives: Sweeteners, anticaking agents, antioxidants, humectants, preservatives, neutralizers, stabilizers, emulsifiers, texture modifiers, flavours and colours etc.

Chemistry of Milk Proteins

Milk proteins of different species and their variability. Distribution and fractionation of different nitrogen fractions of milk proteins; nomenclature of milk proteins; genetic polymorphism and biological significance of milk proteins.

Major milk proteins: caseins (acid and micellar), methods of isolation; Fractionation of casein and heterogeneity; Physico-chemical properties; amino acid composition; Casein micelle models; Primary structure of different caseins; Modification of casein: Physical, chemical (glycosylation, phosphorylation) and enzymatic.

Alpha-lactalbumin and beta-lactoglobulin, bovine serum albumin: distribution and methods of isolation and their physico-chemical properties.

Minor milk proteins: Proteose-peptone, immunoglobulins, lactoferrin, and fat globule membrane proteins.

Denaturation of milk proteins, various factors affecting denaturation; Casein-whey protein interactions.

Indigenous milk enzymes: Properties and their significance with particular reference to lipases, proteases, phosphatases, catalase, peroxidase, xanthine oxidase, lysozyme, lactoperoxidase and galactosyltransferase

Chemistry of Processed Dairy Foods

Process induced changes in milk constituents during preparation and storage of concentrated and dried milks.

Role of biologically active components in human milk; Standards, composition and properties of infant milk and infant food formulations

Heat induced changes in milk leading to coagulation; Heat stability of concentrated milk as affected by different process variables, Milk constituents and additives; Age gelation: Mechanism and control.

Biochemical changes during ripening of different varieties of cheese; Lactic acid fermentation in cheese and other fermented dairy products; chemical defects in cheese.

Storage stability of cream, butter and ghee. Physico-chemical properties of ghee; Ghee flavour, texture (grains) and colour in ghee.

Role of different ingredients during processing and storage of ice cream/ frozen desserts; Concept of antifreeze protein/ice structuring protein in ice cream.

Chemical Quality Assurance and Management Tools

Concept of quality assurance and quality control in relation to dairy industry; Quality management systems - good manufacturing practices (GMP); HACCP certification; ISO 9001, ISO 22000, FSSC, total quality management (TQM); Lean and Six sigma, Five –S, Kaizen, Kanban and other quality tools; Good laboratory practices (GLP), laboratory accreditation

Role of international organisations such as ISO, IDF, CAC, AOAC, WTO and national organisations like BIS, FSSAI, AgMark and APEDA in dairy industry, Quality Council of India (QCI), Export Inspection Council (EIC); Guidelines for setting up quality control laboratory and chemical safety aspects; sampling of milk and milk product; Food labeling guidelines.

Detergents, sanitizers and disinfectants; Calibration of milk testing glassware; Preparation of standard reagents; Detection of adulterants in milk and milk products; Quality of packaging material for dairy products; Instrumentation in analysis of milk and milk products.

Agro-chemicals/veterinary drug residues; occurrence of pesticide residues, antibiotic residues, heavy metals etc. in dairy products and their testing methods, Laboratory auditing, Food traceability systems, Food recall and withdrawal.

Research Techniques

Electrophoresis: principles and types, isoelectric focussing

Chromatographic techniques: Principles and types (Paper and Column Chromatography, TLC, GLC, HPLC, gel-permeation, ion-exchange, affinity).

Separation of bio-molecules using membranes; Centrifugation: principle, types and applications.

Spectrophotometry: UV, visible, IR and flame photometry; Potentiometry: principles, ion-selective electrodes; buffers. Measurement of size and zeta potential of colloidal solution or emulsion using dynamic light scattering/ particle size analyser

Immuno based analytical techniques such as ELISA and Lateral flow assay.

➤ **DAIRY MICROBIOLOGY**

MICROBIAL PHYSIOLOGY

Bacterial growth: Growth phases and kinetics; synchronous, continuous, and associative growth; factors affecting bacterial growth; growth measurement; sporulation.

Effect of environment on the growth of bacteria: Temperature, air, osmotic pressure, pH, hydrostatic pressure, surface tension, metals, electromagnetic and other waves Sonics, various chemicals, their application in dairy industry; mechanism of action of antimicrobials.

Bacterial nutrition; Nutrient media; Nutritional groups of bacteria; Role of growth factors; Active and passive transport.

Energy metabolism: Electron transport chain, fermentation, respiration and photosynthesis.

MICROBIOLOGY OF PROCESSED DAIRY FOODS

Introduction to microbes in foods, history and development of food Microbiology, microorganisms important in foods, microbial ecology of processed foods and food ecosystem, factors influencing microbial growth in foods; Intrinsic factors and extrinsic factors.

High temperature food preservation, factors affecting heat resistance in microorganisms, thermal destruction of microorganisms, low temperature food preservation, food preservation by irradiation, food preservation by drying and fermentation, modern processing techniques-ohmic heating, high pressure processing, infra-red heating, cold plasma, pulsed electric field, ultra sound etc., bio preservation of foods - concepts: metabolites of lactic acid bacteria; Bacteriocins, Antifungal substances etc., protective cultures and other antimicrobials (herbs, spices and other natural antimicrobial compounds), Nanoscience in food preservation; microencapsulation.

Microbial stress response in the food environment; Stress adaptation, sublethal stress and injury, antibiotic resistance in food bacteria, predictive modelling for food spoilage, industrial strategies for ensuring safe foods, HACCP; GMP, GHP

Antimicrobial packaging; concepts and development, modified atmosphere packaging (MAP), intermediate moisture foods (IMF), and hurdle technology in processed foods.

New prospects and problems in processed dairy foods. Genetically modified foods

MICROBIAL MORPHOLOGY AND TAXONOMY

Evolution of life on earth, history and diversity of microorganisms

Principles of classification and taxonomy of Eubacteria (Bacteria and Archaea); Major characteristics used in taxonomy; Cultural, Morphological, Biochemical; Physiological, Genetic and Molecular; Numerical Taxonomy (Taxometrics) and Chemotaxonomy.

Assessing Microbial Phylogeny: Chronometers; Phylogenetic trees, r-RNA, DNA and proteins as indicators of phylogeny.

Cell ultra-structure (prokaryotes and eukaryotes); Cell wall- structure, chemical composition, synthesis and inhibition; cell membrane, cytoplasmic inclusions, cytoskeleton, cell appendages- capsule, flagella, pili; sporulation - structure of endospore, composition and function of spore constituents, induction and germination.

Fungi: Distribution, importance and recent classification, study of yeasts and moulds in dairy foods

History, development and scope of virology; classification and nomenclature, characteristics of viruses (acellular organization and viral genome), viral reproduction, brief account of viroids and prions

MICROBIOLOGY OF FLUID MILK AND DAIRY PRODUCTS

Common microbes in milk and their significance, Microflora of mastitis milk and its importance in dairy industry, Sources of microbial contamination of raw milk and their relative importance in influencing quality of milk during production, collection, transportation and storage; Clean milk production and natural antimicrobial systems in raw milk, Microbial changes in raw milk during long storage, Microbiological grading of raw milk.

Microbiological aspects of processing techniques like bactofugation, thermization, pasteurization, sterilization, boiling, UHT, non-thermal processes (pulsed electric field) and membrane filtration of milk; Role of psychrotrophic, mesophilic, thermophilic and thermotolerant bacteria in spoilage of processed milks, their sources and prevention; Heat induced damage in bacteria and role of resuscitation in recovery of injured microbial cells. Microbiological standards (BIS/ FSSAI) of heat-treated fluid milks

Microbiological quality of dairy products; fat rich (cream and butter), frozen (ice cream), concentrated (evaporated and condensed milk), dried milks (roller and spray dried), infant dairy foods and legal standards; Sources of contamination and factors affecting microbial quality of these products during processing, storage and distribution; Microbiological defects associated with these products and their control.

Microbiological quality of traditional dairy products in India; heat desiccated (khoa, burfi, peda, kheer, etc.), acid coagulated (paneer, chhana, rasogolla, etc.), fermented (dahi, lassi, srikhand, etc.) and frozen (kulfi); Sources of microbial contaminants and their role in spoilage; Importance of personnel and environmental hygiene on quality of traditional milk products; Microbiological standards for indigenous dairy foods.

Food poisoning- Food intoxications, Food infections and Toxi-infections, pathogens associated with fluid milks, dairy products and their public health significance; Sources of pathogens and their prevention; Importance of biofilms, their role in transmission of pathogens in dairy products and preventive strategies.

MICROBIAL GENETICS

Macromolecules: DNA, RNA and their structure, types, organization, function and properties of macromolecules, DNA replication.

Regulation and Gene Expression: Gene Expression and its regulation in Prokaryotes- Transcription, Genetic Code, Translation, Negative and Positive regulation in gene expression, Operon Models - Lac, Trp.

Mutations: Mutations - Spontaneous and Induced, Type of mutations, Mutagenic agents – physical and chemical, Damage and repair system operating in Prokaryotes.

Plasmids and gene transfer systems: Plasmids and their properties, transposable elements, bacterial recombination, transformation, transduction and conjugation.

Recombinant DNA technology, Fundamental aspects of genetic engineering/ recombinant DNA technology, restriction enzymes, plasmid vectors (cloning as well as expression vectors), PCR and real time PCR.

ENVIRONMENTAL MICROBIOLOGY

Environmental microbiology; Aero-microbiology; Airborne pathogens, toxins, aerosols, nature and control of bio-aerosols, aquatic environments and microbial habitats; Soil as a microbial environment; Microbes in extreme environments.

Bio-geochemical cycles; Carbon cycles (fixation, energy flow and respiration), nitrogen cycle (fixation, ammonia assimilation, nitrification and nitrate reduction) sulphur cycle (assimilatory sulphate reduction, sulphur mineralization, oxidation and reduction), iron cycle; microbial influenced metal corrosion, acid mine drainage, metal recovery and desulfurization.

Environmentally transmitted microbial pathogens (Salmonella, E. coli, Campylobacter, Yersinia etc.) and viruses (enteric and respiratory); indicator microorganisms (concept, total and faecal coliforms, faecal streptococci, bacteriophage etc.); Biofouling and biofilms; microorganisms as indicators of environment pollution; microbial toxicants and bio-organic pollutants.

Waste water treatment: physical - screening, racks, mixing, flocculation, sedimentation, floatation, elutriation, vacuum filtration and incineration; biological unit operations- aerobic and anaerobic cycles; kinetics of biological growth, application of kinetics to treatment systems, aerobic waste treatment, anaerobic waste treatment; waste water utilization for value addition, disposal and reuse of Waste water after treatment, solid wastes management; environment laws.

BIOTECHNOLOGY IN DAIRY INDUSTRY

History and development of biotechnology; Status of biotechnology industries in India to meet the demands of dairy and food Industries.

Genetic improvement of lactic starters to enhance their technological functions for industrial applications, e.g. acid, flavour, EPS, probiotic functions; Metabolic engineering of lactic acid bacteria; Production of recombinant dairy/ food enzymes/

proteins, e.g. chymosin, lactoferrin, lysozyme, lipases, proteases, immunoglobulins etc. Detection of GMOs and GM foods and their safety from public health point of view.

Dairy based functional foods/ health foods and nutraceuticals. Value addition in dairy products through fortification/supplementation with bioactive components and probiotic cultures, Nutrigenomics.

Application of molecular tools, biosensors, etc. for detection of foodborne pathogens and spoilage microorganisms.

Molecular tools for studying biodiversity; Regulatory standards, value added products for GMOs and GM foods.

DAIRY STARTER CULTURES

Taxonomy and characteristics of starter cultures: Taxonomy and natural habitat of starter cultures, Desirable properties of starter cultures with respect to various fermented milk products, Characteristics of starter organisms, bacteria (*Lactococcus*, *Leuconostoc*, *Streptococcus*, *Pediococcus*, *Lactobacillus*, *Bifidobacterium*, *Enterococcus*, *Propionibacterium*, *revibacterium*), yeasts and moulds.

Carbohydrate, citrate and protein metabolism; Lactose, galactose and glucose metabolism-transport of sugars across the cell boundaries, homolactic and heterolactic fermentations, other pathways of sugar metabolism, formation of flavouring agents from citrate fermentation, proteolytic systems and protein metabolism in lactic acid bacteria: Genetics of starter bacteria: Plasmids and plasmid instability; Industrially significant genes; Genetic modification of lactic acid bacteria, transposons and insertion sequences. Genetics of flavor formation in starter bacteria; Major enzymes and pathways involved.

Classification of starters: Single, mixed and multiple strain, mesophilic and thermophilic starter cultures; propagation and preservation of starter cultures; factors affecting propagation of starter, functional starters producing exopolysaccharides, vitamins and antimicrobial compounds, commercial starter preparations: concentrated and super concentrated starters; Production systems for bulk cultures: Lewis, Jones and Tetra-pack systems; growth media: nutritional requirements of lactic acid bacteria, growth media formulations; PIM/PRM, pH control during culturing- external and internal pH control systems; preservation of bulk starter cultures- frozen and freeze dried, spray dried cultures; direct vat starter cultures.

Growth inhibition of lactic acid bacteria by antibiotics, bacteriocins, bacteriophages, cleaning and sanitizing agents and naturally occurring antimicrobial systems in raw milk; sources, types and characteristics of phages associated with starters, morphology and taxonomy, phage host interaction, prevention and control of phages during starter handling and fermented milk products manufacturing, mechanisms of phage resistance in lactic acid bacteria, inhibitory substances produced by lactic acid bacteria.

MICROBIAL SAFETY AND QUALITY

Principles of quality and safety functions in dairy processing unit: Introduction to ISO standards— ISO: 9000:2000; ISO: 9004:2000; ISO: 9001:2000: Brief concept and principles of QMS and standard requirements for certification HACCP, Hazard Analysis

and Risk-Based Preventive Controls (HARPC), SAFE, GMP, SSOP, FSMS, personnel hygiene and food handling in dairy industry. Principles of safety in a food microbiological laboratory-Bio-safety concept, Biosafety level-1-4 containment design and layout; Standard microbiological practices for safe handling in food laboratory, safety equipment, facility design.

General principles for establishment of microbiological criteria Definition, purpose and components of microbiological criteria; mandatory and advisory criteria Sampling methods - two and three class sampling plan as per International council for microbiological standards for foods (ICMSF) Establishment of microbiological standards, guidelines and specifications for different dairy foods as recommended by ICMSF, CODEX, FSSAI

Conventional and rapid methods for detection of hygiene indicators; definition, selection criteria of indicator organisms as an index of food quality Conventional detection methods for indicator organisms – Standard plate count (SPC), coliforms, E. coli, yeast and mould Counts (YMC), spore counts; enterobacteriaceae count; Faecal streptococci count; Dye reduction tests Rapid techniques like D-count, petrifilm, ATP bioluminance including commercial kits for monitoring hygiene indicators

Conventional and rapid methods for detection of safety indicators; definition, selection criteria of indicator Organisms as an index of food safety; Conventional detection methods for detection of pathogenic organisms as per ISO protocol specified by FSSAI – Staphylococcus aureus; Bacillus cereus; Pathogenic E.coli; Salmonella; Shigella; Listeria monocytogenes; Enterobacter sakazakii; Sulphite reducing clostridia (SRC), Campylobacter jejuni; Rapid techniques like VIDAS, SPR, RT-PCR including commercial kits, for monitoring safety indicators.

Bio-sensors and micro-techniques for rapid monitoring of contaminants; definition, history, basic characteristics of bio-sensors; classification based on biorecognition molecule - Microbial, spore, Aptamer, DNA, immune and enzyme etc. Biosensors based on Transducers - electrochemical, optical, mechanical and calorimetric etc. Bio-sensors for rapid detection of hygiene indicators, pathogenic bacteria, antibiotics, pesticides, heavy metal, aflatoxin M1 in milk.

MICROBIOLOGY OF CHEESE AND FERMENTED DAIRY FOODS

Evolution and classification of cheeses and fermented Dairy foods; Introduction, classification and types of cheeses and fermented dairy foods. Market share and recent market trends

Microbiology of cheese, Cheese starter cultures involved in the manufacture, their types, roles, Current classification and metabolic pathways. Rennet, rennet substitutes; Microbial and recombinant rennet used in cheese preparation. Bacteriophages of cheese starters. Microbes associated with spoilage, defects, causative organisms and preventive measures. Health aspects of cheese.

Microbiology of cheese ripening Microbiological changes, Factors Influencing Growth of Microorganisms, Flavour development, Role of starter flora and supplementary flora in cheese ripening. Accelerated cheese ripening through biotechnological approaches, Cheese with high linoleic acid content, Enzyme-modified cheese, GMO Microbiological and biochemical aspects of major cheese varieties - Cheddar, Swiss- Type Cheeses -

Emmental, Very hard cheese - Parmesan, Dutch cheese varieties - Edam, Gouda, Pasta Filata/Pizza Cheese - Mozzarella, Unripened cheese - Cottage, Internal mould ripened cheese - Roquefort, Surface mould ripened cheese - Camembert, Bacterial surface ripened cheese - Limburger; Microbiology of processed cheese.

Microbiology of Fermented dairy foods; Dahi, lassi, yoghurt, Kefir, Koumiss, functional fermented dairy based beverages, fermented whey drinks, and dairy based fermented cereal foods, fortified fermented dairy foods - Microbes associated with spoilage and preventive measures. Safety and standards of fermented foods.

Functional cheeses, Cheese as matrix for probiotic delivery. Health aspects of cheese and fermented foods: nutritional value, and therapeutic benefits.

PROBIOTICS AND PREBIOTICS

Probiotics, Prebiotics and Synbiotics: Concepts, definitions and history. Gut microbiota and its role in human health and disease

Identification of probiotic strains isolated from different niches by polyphasic approach using phenotypic, biochemical and genotypic tools/techniques. Characterization and selection of candidate probiotic strains on the basis of FAO/ WHO or ICMR/DBT guidelines.

Mechanism of action of probiotics: Colonization in the gut; Adhesion to intestinal mucosal surface – role of surface proteins; Antimicrobial/antagonistic activity of probiotics, Pathogen exclusion; Immuno-modulatory action; Impact on gut homeostasis; Host microbe interaction and their cross talk; Role of biomarkers for probiotic functionality.

Mechanism of action of prebiotics and synbiotics: Selective stimulation of beneficial bacteria in the gut microbiota; Effect on gastric emptying and intestinal transit rate; Production of short chain fatty acids (SCFA); Effect of SCFA on host metabolism and immunomodulation; Anti-adhesive prebiotics. Synbiotics and their action through improved viability of probiotic microorganisms and provision of specific health benefits

Dairy based foods as carrier of probiotics: Dairy based products as delivery vehicles – Stability towards manufacturing conditions, enhancing stability through encapsulation or drying strategies for lyophilized formulations etc., co-culture compatibility with starters, minimum effective dose, and large-scale production of probiotic biomass through fermentation for application in foods and as drugs/ supplements.

Designer probiotics: Genetically modified probiotics as oral vaccines, enhanced adhesion properties and health promoting functions.

Safety, human trials and regulatory guidelines: In vitro and in vivo safety assessment of probiotics; designing human trials; regulatory guidelines - US, Canada, Europe and India.

RESEARCH TECHNIQUES

Microscopy: Principles, design and application of bright field, dark field, phase contrast, fluorescence, atomic force, confocal laser and electron microscopes.

Cell fractionation: Physical and chemical methods of microbial cell lysis: Ultrasonication, glass bead lysis, micro-fluidization, enzymatic and solvent induced techniques.

Molecular separation: Ultrafiltration, crystallography, isoelectric focusing, chromatography, SDS-PAGE, micro and ultracentrifugation.

Assay methods: Spectrophotometric methods, ELISA, protein and enzyme assays, microbiological assay, and microbial receptor assay.

Studying nutritional and therapeutic attributes of microorganisms and fermented dairy foods - Use of cell culture and small animal models.

MICROBIAL FERMENTATION TECHNOLOGY

Fermentation for enhancing shelf life of foods, types of fermentation - submerged/solid state and semi-solid.

Microbial growth, metabolism, death, membrane transport, fermentation kinetics and fermentation modelling, batch, fed batch, continuous culture systems.

Bioreactor design, measurement and control in fermentation. Different types of fermenters, scaling up of fermentation, sterilization, agitation; pH, Eh, temperature measurement and control, downstream processing and product recovery, immobilization in fermentation

Biosensors in fermentation applications Biosensors, basic principles; application in detection of sugars, alcohol, amino acids

Industrial production of microbial cell biomass, organic acids, enzymes, antibiotics, micro-nutrients, amino acids, vitamins, ethanol, SCP and alcoholic beverages.