

10. FOOD ENGINEERING Syllabus for Conducting written Examination for direct Recruitment of Teaching posts in the Cadre of Assistant professors at UASM

➤ Food Processing Technology

EMERGING TECHNOLOGIES IN FOOD PACKAGING

Active packaging and intelligent packaging techniques, current use of novel packaging techniques. Oxygen, ethylene and other scavengers: Oxygen scavenging technology, selecting right types of oxygen scavengers; ethylene, carbon dioxide and other scavengers. Antimicrobial food packaging: Antimicrobial agents, constructing antimicrobial packaging systems, factors affecting the effectiveness of antimicrobial packaging. Advantages of NMBP; inherently bioactive synthetic polymers: types and application; polymers with immobilized bioactive compounds and their applications.

Time temperature labels and indicators (TTIs): Defining and classifying TTIs, Application of TTIs to monitor shelflife. Selfheating / rehydrating packages. Freshness indicator in packaging: Compounds indicating the quality of packaged food products, freshness indicators, pathogen indicators, other methods for spoilage detection.

Factors affecting flavour absorption, role of food matrix, role of differing packaging materials, flavour modification and sensory quality; packaging materials compatibility with foods. Developments in modified atmosphere packaging (MAP): Permeability properties of polymer packaging; measurement of permeability of water and gases. Selection criteria of packaging films. Recycling of packaging materials: Recyclability of packaging plastics, improving the recyclability of plastics packaging, testing safety and quality of recycled materials, uses of recycled plastics in packaging.

Problems of plastic packaging wastes, range of biopolymers, developing novel biodegradable materials. Edible Films and Coatings: Properties, types, sources, applications, advantages, disadvantages, theories of plasticization, challenges and opportunities. Safety and legislative aspects of packaging: Regulatory considerations; plastic, metal, paper and glass packaging.

INDUSTRIAL MANUFACTURING OF FOOD AND BEVERAGES

Industrial manufacturing of grain based products: formulation, processes, machinery and material balance of baked, puffed, flaked, roasted products. Extrusion technology: Importance and applications of extrusion in food processing; pre and post extrusion treatments; manufacturing process of extruded products; Breakfast cereals, RTE/RTC foods, instant premixes, functional foods. Industrial manufacturing of fruit and vegetable based products: formulation, process, machinery and material balance of minimally processed and retorted products.

IMF, high moisture stable foods; IQF; machines and equipment for batch and continuous processing of fruit and vegetable products. Coating or enrobing of chocolate (including pan-coating); maintenance, safety and hygiene of bakery plants. Fats and oil processing: Technology of refined oil, winterized oil, hydrogenated fat, texturized fat; by-products of fat/oil processing industries – oil seed protein isolates; antioxidant and its mechanism of application.

Non-alcoholic beverages: Carbonated beverages: carbonation equipment, ingredients, preparation of syrups, filling system, packaging, containers and closures. Non-carbonated beverages: Coffee bean preparation, processing, *brewing decaffeination*; instant coffee; Tea: types-black, green; Fruit juices and beverages. Aseptic packaging of beverages. Grain based and malted beverages. Alcoholic beverages: Wine and beer - ingredients, preparation, packaging, quality evaluation. Packaged drinking water: types, manufacturing processes, quality evaluation and raw and processed water; methods of water treatment. BIS quality standards of bottled water, mineral water, natural spring water, flavoured water, carbonated water.

FOOD MATERIAL AND PRODUCT PROPERTIES

Biomaterials and their properties in relation to processing and product development. Physico-chemical characteristics: Shape, sphericity, size, microstructure, volume, density, porosity, surface area, coefficient of friction, angle of repose, influence of constituents on processing. Flow behaviour of granular and powdered food materials; rheological models; creep phenomenon, stress-strain-time effects and relationships. Textural characteristics and textural profile analysis of food products.

Specific heat, thermal conductivity, phase transition; thermodynamics-basic principles and laws; kinetics of water absorption; heat capacity; thermal diffusivity, electrical resistance and conductance; dielectric constant; reflectivity. Food microstructure: Methods and systems for food microstructure determination; light microscopy, transmission electron microscopy, scanning electron microscopy; image analysis: image acquisition, image processing. Dextrinization, gelatinisation, crystallisation, gelation, foaming, coagulation, denaturation, syneresis, foaming, emulsification. Sensory attributes: Sensory properties and correlation with objective indices; microstructure and its relation to texture.

COCOA AND CHOCOLATE PROCESSING TECHNOLOGIES

Cocoa, chemistry of the cocoa bean, analysis of cocoa beans, processing of raw bean, changes taking place during fermentation of cocoa beans. Processing of cocoa beans: cleaning, roasting, alkalization, cracking and fanning; nib grinding for cocoa liquor; cocoa butter and cocoa powder; chemical changes during various stages of processing.

Types of chocolates, ingredients, chemistry of chocolate manufacture. Mixing, refining, conching, tempering, moulding, etc. to obtain chocolate slabs and chocolate bars. Dark, milk and white chocolate and their manufacturing processes. Quality evaluation, packaging and storage of chocolates. Compound coatings and candy bars; tempering technology, chocolate hollow figures, chocolate shells. Enrobing technology, manufacture of candy bars. Application of vegetable fats for enrobing. Production of chocolate mass.

SPICES, HERBS AND CONDIMENTS

Status and scope of spice processing industries in India; spices, herbs and seasonings: classification on the basis of origin and physical characteristics. Major spices: Post-harvest technology; processed products of following spices: ginger, chilli, turmeric, onion garlic, pepper and cardamom. Minor spices, herbs and leafy vegetables: all spice, sweet basil, caraway seed, cassia, cinnamon, clove, coriander, cumin, dill seed, nutmeg, mint, rosemary, saffron, sage. Chemical composition, processing methods, equipment used; recent advances in processing; spice quality evaluation, criteria for assessment of spice quality. Effect of processing on spice quality, contamination of spices with micro-organisms and

insects. Spice Essential Oils: methods of extraction, isolation, and encapsulation; Spice Oleoresins: method of extraction, isolation, separation equipment.

MEAT, POULTRY, FISH AND EGG PROCESSING

Meat and meat products in India. Meat production and trade practices. Prospects and problems in production of fresh meat in India. Research and Development activities on meat and poultry products. Breeds, pre-slaughter care, ante and post mortem, slaughter, handling of offal (edible and inedible). Cuts of beef, pork and mutton.

Meat plant sanitation, ante-mortem inspection, post-mortem inspection, condemnation, product inspection, laboratory inspection, labelling. Types of grades, factors used to establish quality grades, conformation, fleshing and finish. Properties of fresh meat: perception of tenderness, factors affecting tenderness, myofibrillar tenderness, marbling. Methods to improve tenderness (electrical stimulation, aging). Meat colour, pigments associated with colour, methods to improve meat colour. Water holding capacity of meat.

Poultry meat: Kinds of poultry, processing of poultry meat. Special poultry products: smoked turkey, packaged precooked chicken, freeze dried poultry meat. Egg and egg processing: Egg quality, egg preservation, egg powder production. Meat analogues and restructured meat products; Textured plant proteins; processes for preparation of meat analogues and restructured meat products. Chemical/nutritional composition of fish; fish in human diet. Selection of raw material for processing, streaking and filleting of fish; production of fish paste, fish oils, sauce, fish protein concentrates. Irradiation of fish and fish products; packaging of fish products; quality control and quality assurance. Allergens, toxins and infectious diseases from meat, poultry and fish products.

NUTRACEUTICALS AND SPECIALTY FOODS

Nature, type and scope of nutraceutical and functional foods. Nutraceutical and functional food applications and their health benefits. Nutraceutical compounds and their classification based on chemical and biochemical nature. Innovations in functional foods for health and wellness. Nutraceuticals/food components for specific diseases such as cancer, heart disease, diabetes, obesity, anti-aging and arthritis; Prebiotics and probiotics; Omega 3 and Omega 6 fatty acids, isoflavones, phenolic compounds, catechins, lycopene, glucosinolates. Delivery system and controlled release of nutraceuticals.

Design of specialty foods for different age groups. Selection of ingredients, health benefits and production of specialty foods. Nonthermal techniques, bioprocessing techniques, dehydration techniques; effect of processing on bioactive ingredients. Packaging requirements for specialty foods; storage and storage kinetics on quality; interactions of various environmental factors. Safety and regulatory issues for specialty foods, functional foods and nutraceuticals. Concept of personalized medicine. Use of nanotechnology in functional food industry. Biological functionality of cruciferous vegetables, tropical, subtropical and temperate fruits, herbs and spices.

FROZEN AND CONCENTRATED FOODS

Glass transitions in frozen foods and biomaterials; microbiology of frozen foods; physical properties of frozen foods; freezing loads and freezing time calculation innovations in freezing process, freezing

methods and equipment. Quality and safety of frozen foods: Quality and safety of frozen meat and meat product, poultry and poultry products, eggs and egg products, fish, shellfish and related products, frozen vegetables and fruits, frozen dairy products, frozen ready meals and confectionery. Packaging of frozen foods: Selection of packaging materials; shelf-life prediction of frozen foods. Transportation and storage of frozen foods, retail display equipment and management. Concentrated milk: Production and quality evaluation of evaporated milk and sweetened condensed milk. Concentrated juice products: Production and quality of fruits and vegetable juice concentrate, puree and paste, tomato juice concentrates, mango pulp.

ASEPTIC PROCESSING AND PACKAGING

Introduction to aseptic processing; aseptic processing of semi-solid, fluid and particulate foods. Pre-sterilization and sterilization operations; cleaning and CIP. Advantages and disadvantages. Quality Assurance: Effect of aseptic processing on nutrients, microorganisms; in-process and post-process assurance; HACCP; regulatory aspects of processing and packaging; shelf life modules. Equipment for aseptic processing and packaging for retail and institutional packages. Packaging of aseptically processed foods: packaging material characteristics, aseptic filling, sterilization of packaging materials, package design; types of aseptic packaging systems: fill and seal; form, fill and seal; erect, fill and seal; thermoform, fill and seal; blow mold, fill and seal.

TRADITIONAL FOODS

Introduction to traditional foods of India; composition and nutritive values. Present status of traditional food products; globalization of traditional food products. Overview of heat-desiccated, coagulated, fried and fermented traditional food products. Process technology for traditional Indian breads, fried foods, fermented foods and traditional sweets. Packaging systems for traditional food products.

Application of membrane technology; microwave heating, steaming, extrusion for industrial production of traditional food products (shrikhand, dhokla, wadi, murukku). Utilization and scope of legumes and grains in India for novel food product development such as ready to eat products and flour mixes. Process technology for convenience traditional food products (ready to eat and serve - curried vegetables, pulses and legumes), chutneys, paste.

Processing and preservation of sweets and desserts: kulfi, kheer, khoa, rabri, gulabjamun, peda, rasgolla and barfi. Processing and preservation of traditional fermented foods: idli, dosa, vada, dhokla, dahi (curd), shrikhand. Processing and preservation of snacks: gujiya, samosa, potato chips, banana-chips, bhujia, fried dhals. Processing and preservation methods of baked products: roti, naan, parantha, kulcha, puri, bhatura. Processing and preservation of beverages: murabba, sharbat, coconut water, flavoured milk and alcoholic beverages.

TECHNOLOGIES OF CONVENIENCE FOODS

Equipment for frying, baking, toasting, roasting, flaking, popping, blending, coating, chipping. Grain based foods: Roasted, toasted, puffed, popped and flaked products; Coated grains- salted, spiced and sweetened; Flour based snacks; batter and dough-based products; savoury, wafers and papads. Fruit and vegetable-based snacks: Coated nuts – salted, spiced and sweetened products- chikkis, fried groundnut.

Technology of ready- to- eat baked food products; drying, toasting, roasting and flaking, coating, chipping. Technology for RTE puffed snacks. Extruded snack foods: Formulation and processing technology, flavouring and packaging. Puddings and curries; vegetables and meat based food products. Technology of instant cooked rice; carrot and other cereal based food products. Technology of cereal and pulse based ready-to-eat instant premix.

FOOD POWDER AND PREMIXES

Size, shape, particle size distribution, density; crystalline and amorphous microstructure of powders; cohesive forces in powders; adhesive forces and surface energies; stickiness of powders; surface structure of powders. Fluidity of powders; compressibility of powders; mixing property of powders; segregation of powder particles; flow and packing properties. Handling of food powders; basic flow patterns in storage vessels; storage vessel design; mass-flow operation; Powder conveying: belt, screw, chain, pneumatic. Principles; equipment; criteria for selecting comminution process; aggregation and agglomeration; instantization. Encapsulation: principles, methods of encapsulation, viz. spray drying, coacervation, extrusion, co-crystallization.

Spray, drum and freeze-drying process and equipment for manufacture. Undesirable properties: attrition, segregation, caking, dust explosion hazards, laboratory testing to assess explosion characteristics of dust clouds, safety from dust cloud explosion hazards. Packaging requirements, design of package, effect of environmental factors on quality of food powders, shelf life test and prediction. Principles of powder rehydration- wettability, sinkability, dispersibility, solubility; improvement of rehydration properties. Surface composition of food powders: Microscopy and spectroscopy techniques for analysing the surface of food powder; factors affecting food powder surface composition; impact of powder surface composition on powder functionality.

FOOD INGREDIENTS AND ADDITIVES

Intentional and unintentional food additives, functions, classification; toxicology and safety valuation of food additives; beneficial effects of food additives. Food additives generally recognized as safe (GRAS); tolerance levels and toxic levels in foods - LD 50 values of food additives. Preservatives: general mechanism of action; basis of selection; classes; chemical preservatives: characteristics, antimicrobial spectrum, mechanism of action, toxicology, regulations, application in food. Antioxidants: characteristics, types/classes/groups, mechanism of action/ working of antioxidants, functions, sources, application in food, limits and toxic effects of synthetic antioxidants, synergistic effects of antioxidants, role of free radicals in human body, natural antioxidants. **Unit 3:** Flavouring agents: functions, selection, forms, sources, process of flavour creation; natural and synthetic flavouring; extraction methods; production process; applications in food. **Unit 4:** Emulsifiers and Stabilizers: characteristics/ functional properties; functions; basis of selection; types; mechanism of emulsion formation; mechanisms of emulsion stabilization and destabilization; applications in food.

Hydrocolloids: definition, function and functional properties: sources; application in food. Sweeteners: characteristics; classification/types; applications in food; limits and toxicology of non-nutritive sweeteners. Colouring agents: properties; functions; classification; sources of natural and synthetic colours: extraction; applications in food, levels of use, misbranded colours, colour stabilization. Other additives: humectants, clarifying agents, stabilizers and thickeners, bleaching and maturing agents, humectants, sequestrants /chelating agents, anti-caking agents, buffering agents, acidulants.

FLAVOUR CHEMISTRY AND TECHNOLOGY

Classification of food flavour, chemical compounds responsible for flavours, difficulties of flavour chemistry research. Chemical compounds, classes and their flavour response. Flavour intensifiers and their effects. Flavour Extraction: Methods of flavour extraction, isolation, separation and equipment for flavour extraction. Flavour development during biogenesis: Flavour compounds from carbohydrates and proteins; lipid oxidation; flavour formulation: creating and formulating flavour; synthetic flavours, blended flavouring, flavour creation for new products, delivery of flavours from food matrices.

Sensory evaluation, discrimination analysis, descriptive analysis, instrumental analysis (Absorption Spectroscopy (W/VIS), chromatography, mass spectrometry). Food flavours in different food products: principal components in baked products, cheese, milk, meat, fish, wine, coffee, tea, chocolate, fruit and vegetable products and fermented foods. Flavouring compounds generated during food processing: Volatile and non-volatile flavouring compounds. Principles and techniques of flavour encapsulation, types of encapsulation, factors affecting stabilization of encapsulated flavour and their applications in food industry, Packaging and flavour compounds interaction.

BIOPROCESSING AND SEPARATION TECHNOLOGY

Gas-Liquid, Gas-Solid, Liquid-Liquid, Liquid-Solid separation; concept of phase equilibrium, stage equilibrium, stage efficiency, equilibrium concentration; Single stage contact equilibrium, counter-current multiple contact stages, concept of equilibrium line and operating line, determination of optimum number of contact stages by analytical and graphical method. Rate of extraction, Rate of gas absorption, Individual and over all mass transfer coefficient; calculation of tower height for gas absorption for both dilute and concentrated solution. Construction and working mechanism of different extraction equipment like single stage extraction, multiple stage static bed system.

Solid Separation Process: Introduction, concept of size, shape, cut-size, sieving, magnetic separation, Eddy-current separation, wet separation, ballistic separation, colour separation, liquid-solid and liquid-liquid separation by hydro cyclones, surface velocity classifier, elutriators, impingement separator, electrostatic precipitation. Distillation: Introduction, boiling point diagram, differential or simple distillation, flash or equilibrium distillation, continuous rectification with and without reflux, reflux ratio, optimum reflux ratio, batch distillation, application of distillation in food processing.

Introduction to micro-filtration, ultrafiltration, reverse osmosis, electro dialyses, dialyses, physical characteristics of membrane separation, factors affecting reverse osmosis process, concentration polarization. Design of reverse osmosis and ultra-filtration systems, operation layout of the modules, electrodialysis, vaporization, fabrication of membranes, application of membrane technology in food industry.

ENZYMES IN FOOD PROCESSING

General characteristics of enzymes, classes and nomenclature of enzymes; Enzymatic reactions; factors affecting enzyme activity; Enzyme kinetics; Enzyme inhibition. Enzyme Production: Selection and sources of commercial enzymes; Advantages of microbial enzymes; rDNA in enzyme engineering; Problems of scale up; Enzyme extraction and purification. Immobilization: Techniques, advantages and disadvantages, use of immobilized biocatalysts in food processing. Enzymes for protein and lipid modification.

Application of enzymes in baking: Fungal amylase for bread making; maltogenic – amylases for anti-staling xylans and pentosans as dough conditioners; oxidases as replacers of chemical oxidants; synergistic effect of enzymes. Enzymes in fruit processing: Applications of enzyme in fruit juice clarification, removal of haziness and bitterness, uses of enzymes in wine production. Enzymes in meat, fish and milk processing: Meat tenderization and flavour development, fish processing (de-skinning, collagen extraction etc.), egg processing, cheese processing. Enzymes in flavour production: Role of enzymes (enzyme-aided extraction of plant materials for production of flavours, production of flavour enhancers such as nucleotides, MSG; flavours from hydrolysed vegetable/animal protein) Enzymes in the processing of fats and oils: specificity, stability and application of lipases and related enzymes; Role of enzymes in hydrolysis of triglycerides, inter-esterification and randomization. Enzyme allergy.

FOOD PROCESS AUTOMATION AND MODELLING

Linear programming-concepts, graphical and algebraic solution; Simplex method; Duality theory; Post-optimality analysis; Sensitivity analysis; Transportation and assignment models; Computer applications to LP, queuing theory. Project scheduling and management by PERT-CPM; Integer programming; Non-linear programming; Simulation; Goal programming; Decision theory; Markov chains; Sequencing problem.

The principles of modelling, kinetic modelling, the modelling of heat and mass transfer; introduction diffusion equation, the Navier-stokes equations, heat and mass transfer in porous media Luikov's equation. Modelling thermal processes: cooling and freezing, modelling product heat load during cooling and freezing. Modelling foods with complex shapes, numerical solution of the heat conduction equation with phase change. Modelling thermal processes: heating, introduction, processing of packed and solid foods, continuous heating and cooling processes, Modelling food quality and microbiological safety. Case Studies in modelling.

Design considerations of agricultural and food processing equipment. Design of food processing equipment, Dryers, design of dryers. Determination of heat and air requirement for drying grains. Types of heat exchanger. Design of heat exchangers and evaporators. Design of material handling equipment like belt conveyor, screw conveyor, bucket elevator and pneumatic conveyors. Measurement systems for post harvest fruit and vegetable quality control. Genetic algorithm optimization: traditional optimization techniques and their limitations, non-traditional method, fitness function in biological evolution, computational procedure for optimization of independent parameters using genetic algorithm. Artificial neural network modelling: Developing predictive model between independent and dependent parameters by using artificial neural network – neural network architecture, weights and bias values of neurons, least square method for NN parameters optimization, matrix representation and computation of the values of NN parameters. Raw food material sorting, grading, size reduction, mixing and agitation, thermal processing, dehydration, packaging, CIP, quality control. Bottle washing machine automation; bottling plant drive system. Demineralization plant control system; labelling machine control system; charger level automation; reverse osmosis plant automation; thermal plant automation; Dehydration and freezing plant automation.

ZERO WASTE PROCESSING

Food processing waste and by-product, ISO 14000 for environmental management system, biochemical and nutritional aspects of food processing byproducts. Waste minimization: chain management issues

and good housekeeping procedures; minimise energy use in food processing; minimise water use in food processing.

Microbiological risk management, effects of postharvest changes in quality on the stability of plant co-products, separation technologies for food wastewater treatment and product recovery. Co-product recovery techniques: Enzymatic extraction and fermentation for the recovery of food processing products, supercritical fluid extraction for extraction of high-value food processing co-products, membrane and filtration technologies, recovery of nutraceuticals, micronutrients, functional ingredients, natural dyes. Waste management and co-product recovery: Meat, cereal, dairy, fish, fruit and vegetable processing; waste management of food packaging. Food processing waste water treatment and gas production from solid food processing.

➤ **Processing and Food Engineering**

TRANSPORT PHENOMENA IN FOOD PROCESSING

Introduction to heat and mass transfer and their analogy. Steady and unsteady state heat transfer. Analytical and numerical solutions of unsteady state heat conduction equations. Use of Gurnie-Lurie and Heisler Charts in solving heat conduction problems :Applications in food processing including freezing and thawing of foods.

Convective heat transfer in food processing systems involving laminar and turbulent flow. Heat transfer in boiling liquids. Heat transfer between fluids and solid foods. Functional design of heat exchangers: shell and tube, plate and scraped surface heat exchangers. Radiation heat transfer: governing laws, shape factors, applications in food processing.

Momentum transfer. Mass flow and balance. Steady and unsteady flow. Theory and equation of continuity. Bernoulli's theorem and application. Flow through immersed bodies, Measurement of flow, pressure and other parameters. Flow driving mechanism.

Molecular diffusion in gases, liquids and solids. Molecular diffusion in biological solutions and suspensions. Molecular diffusion in solids. Unsteady state mass transfer and mass transfer coefficients. Molecular diffusion with convection and chemical reaction. Diffusion of gases in porous solids and capillaries. Mass transfer applications in food processing.

UNIT OPERATIONS IN FOOD PROCESS ENGINEERING

Review of basic engineering mathematics. Units and dimensions. Mass and energy balance. Principles of fluid flow. Heat transfer: Conduction, convection and radiation. Heat exchangers and their designs. Drying and dehydration: Psychrometry, theories of drying, EMC, equipment for drying of solid, paste and liquid foods. Evaporation: Components, heat and mass balance in single and multiple effect vaporators, equipment and applications, steam economy. Thermal processing: Blanching, pasteurization and sterilization, death rate kinetics, process time calculations, sterilization equipment. Refrigeration and freezing: Principles, freezing curve, freezing time calculation, freezing equipment, cold chain.

Mechanical separation: Principle and equipment involved in sieving, filtration, sedimentation and centrifugation, cyclone separation. Material handling: Conveyors and elevators, components and design considerations for belt, chain, bucket and screw conveyors. Size reduction: Principles of size reduction, size reduction laws. Size reduction equipment: Jaw crusher, gyratory crusher, roller mill, hammer mill.

FIELD CROPS PROCESS ENGINEERING

Production and utilization of cereals and pulses, grain structure of major cereals, pulses and oilseeds and their milling fractions. Grain quality standards and physico-chemical methods for evaluation of quality of flours. Pre-milling treatments and their effects on milling quality. Parboiling and drying, conventional, modern and integrated rice milling operations. Wheat roller flour milling. Processes for milling of corn, oats, barley, gram, pulses, paddy and flour milling equipment. Layout of milling plants.

Dal mills handling and storage of by-products and their utilization. Storage of milled products. Expeller and solvent extraction processing. Assessment of processed product quality. Packaging of processed products. Design characteristics of milling equipment, selection, installation and their performance. Quality standards for various processed products. Value added products of cereals, pulses and oilseeds.

HORTICULTURAL CROPS PROCESS ENGINEERING

Importance of post harvest technology of fruits and vegetables, structure, cellular components, composition and nutritive value of fruits and vegetables, fruit ripening, spoilage of fruits and vegetables.

Harvesting and washing, pre-cooling, blanching, preservation of fruits and vegetables, commercial canning of fruits and vegetables, minimal processing of fruits and vegetables. Cold storage of fruits and vegetables, controlled atmosphere and modified atmosphere packaging of fruits and vegetables, quality deterioration and storage. Dehydration of fruits and vegetables, methods, osmotic dehydration, foammat drying, freeze drying, microwave heating, applications, radiation preservation of fruits and vegetables, irradiation sources. Intermediate moisture foods, Ohmic heating principle, high pressure processing of fruits and vegetables, applications, sensory evaluation of fruit and vegetable products, packaging technology for fruits and vegetables, general principles of quality standards and control, FPO, quality attributes.

STORAGE ENGINEERING AND HANDLING OF AGRICULTURAL PRODUCE

Storage of grains, biochemical changes during storage, production, distribution and storage capacity to estimate models, storage capacity models, ecology, storage factors affecting losses, storage requirements and bulk storage, godowns, bins and silos, rat proof godowns and rodent control, method of stacking, preventive method, bio-engineering properties of stored products, function, structural and thermal design of structures, aeration system.

Grain markets, cold storage, controlled and modified atmosphere storage, effects of nitrogen, oxygen and carbon dioxide on storage of durable and perishable commodities, irradiation, storage of dehydrated products, food spoilage and preservation, BIS standards. Physical factors influencing flow characteristics, mechanics of bulk solids, flow through hoppers, openings and ducts; design of belt, chain, screw, roller, pneumatic conveyors and bucket elevators, principles of fluidization, recent advances in handling of food materials.

FOOD PACKAGE ENGINEERING

Introduction to packaging: Package, functions and design. Principle in the development of protective packaging. Deteriorative changes in food stuff and packaging methods of prevention. Food containers: Rigid containers, glass, wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and papersacks, corrosion of containers (tinplate). Flexible packaging materials and their properties. Aluminum as packaging material. Evaluation of packaging material and package performance. Packaging equipment: Food packages, bags, types of pouches, wrappers, carton and other traditional package. Retortable pouches: Shelf life of packaged foodstuff. Methods to extend shelf-life. Packaging of perishables and processed foods. Special problems in packaging of food stuff.

Package standards and regulation: Shrink packaging, aseptic packaging, CA and MAP. Biodegradable packaging: Recent advances in packaging, active packaging, smart packaging, antioxidant and antimicrobial packaging, edible films and biodegradable packaging, micro encapsulation and nano encapsulation.

INSTRUMENTATION AND SENSORS IN FOOD PROCESSING

Basic instrumentation systems and transducer principles. Displacement transducers, Potential meters, LDVT, Piezoelectric and capacitive transducers, Digital transducers, velocity transducers. Acceleration and absolute motion measurement, Force transducer, strain gauge, Hydraulic load cell, Cantilever type and probing ring. Method of separation of force: Torque, power and energy measuring technique.

Temperature measurement using bi-metals, thermistors, thermocouples, humidity measurement, manometers. Flow transducer, positive displacement, venturimeter, Rotameter, Drag force, hot wire anemometer. Theory and classifications of chemical sensors, biosensors, fibre optic sensors, gas sensors etc. Biosensor: Concepts, types of biosensors, methods of immobilizing biosensors, application. Imaging methods: X-ray imaging, Computed tomography, MRI, Ultrasound, Hyperspectral imaging. Spectroscopy and chemometrics: UV and visual spectroscopy, NIR spectroscopy, FTIR spectroscopy.

APPLICATION OF ENGINEERING PROPERTIES IN FOOD PROCESSING

Physical characteristics of different food grains, fruits and vegetables: Shape and size, description of shape and size, volume and density, porosity, surface area. Rheology: ASTM standard, terms, physical states of materials, classical ideal material, rheological models and equations, viscoelasticity, creep-stress relaxation, non-Newtonian fluid and viscometry, rheological properties, force, deformation, stress, strain, elastic, plastic behaviour.

Contact stresses between bodies, Hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity, temperature, water film and surface roughness. Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials, aero dynamics of agricultural products, drag coefficients, terminal velocity.

Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, methods of determination, steady state and transient heat flow. Electrical properties: Dielectric loss factor, loss tangent, A.C. conductivity and dielectric constant, method of determination, energy absorption from high frequency

electric field. Application of engineering properties in design and operation of agricultural equipment and structures.

FOOD QUALITY AND SAFETY

Food safety: Need for quality control and safety, strategy and criteria, microbiological criteria for safety and quality, scope of food toxicology, toxic potential and food toxicants, biological and chemical contaminants. Food additives and derived substances, factors affecting toxicity, designing safety in products and processes, intrinsic factors, establishing a safe raw material supply, safe and achievable shelf life. Process equipment and machinery auditing, consideration of risk, environmental consideration, mechanical quality control. Personnel hygienic standards, preventative pest control, cleaning and disinfecting system, biological factors underlying food safety. Process equipment and machinery auditing, consideration of risk, environmental consideration, mechanical quality control.

Personnel hygienic standards, preventative pest control, cleaning and disinfecting system, biological factors underlying food safety. Preservation and stability, contaminants of processed foods, adulteration, prevention and control, FSSAI, ISO, Codex, GMP, BIS and HACCP. Practices, principles, standards, specifications, application establishment and implementation, HACCP and quality management system. Food Safety Management Systems (FSMS), Traceability.

FOOD PROCESSING TECHNOLOGIES

Mixing and homogenization; Principles of solid and liquid mixing, types of mixers for solids, liquid and pastes homogenization. Emulsification: Principles and equipments. Novel dehydration technologies; Osmotic dehydration, foam mat drying, puff drying, freeze drying, microwave drying, dehumidified air drying, extrusion: Theory, equipment, applications. Non-thermal processing; Principles and equipment involved in ohmic heating, pulsed electric field preservation, hydrostatic pressure technique (vacuum processing, high pressure processing of foods), ultrasonic technology, irradiation, quality changes and effects on microorganisms, nanotechnology in food processing.

Distillation, leaching and extraction: Principles and equipment for distillation, Crystallization, phase equilibria, multistage calculations, leaching principles and equipment, solvent extraction, super-critical fluid extraction, near critical fluid extraction: Equipment and experimental techniques used in NCF extraction and industrial application, advanced methods for extraction of food components and aroma recovery. Food plant hygiene; Cleaning, sterilizing, waste disposal methods, Food processing plant utilities, steam requirements in food processing, HACCP in food processing industries.

FOOD PROCESSING EQUIPMENT AND PLANT DESIGN

Design considerations of processing agricultural and food products. Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation, membrane separation. Human actors in design, selection of materials of construction and standard component, design standards and testing standards. Plant design concepts and general design considerations: Plant location, location factors and their interaction with plant location, location in theory models, and computer aided selection of the location.

Feasibility analysis and preparation of feasibility report; Plant size, factors affecting plant size and their interactions, estimation of break-even and economic plant size. Product and process design, process

selection, process flow charts, computer aided development of flow charts. Hygienic design aspects and worker's safety, functional design of plant building and selection of building materials, estimation of capital investment, analysis of plant costs and profitability's, management techniques in plant design including applications of network analysis, preparation of project report and its appraisal.

SEED PROCESS ENGINEERING

Processing of different seeds and their engineering properties, principles and importance of seed processing. Performance characteristics of different unit operations such as pre-cleaning, grading, conveying, elevating, drying, treating, blending, packaging and storage, seed processing machines like calper, debreader, huller, velvet separator, spiral separator, cleaner-cum-grader, specific gravity separator, indent cylinder, disc separator, and colour sorter, seed treater, weighing and bagging machines, their operation and maintenance, installation and determination of their capacity, seed quality maintenance during processing, plant design and layout, economy and safety consideration in plant design. Seed drying principles and methods, theory of seed drying, introduction to different types of heat exchangers, significance of moisture equilibrium, method of maintaining safe seed moisture, thumbrule and its relevance.

Importance of scientific seed storage, types of storage structures to reduce temperature and humidity, management and operation/cleanliness of seed stores, packaging-principles, practices, materials and hermetic packaging, seed treatment methods and machines used, method of stacking and their impact, design features of medium and long term seeds to storage building.

AGRI-PROJECT PLANNING AND MANAGEMENT

Project development, market survey and time motion analysis. Selection of equipment, technology option, techno-economic feasibility and processing in production catchment. Product and process design, PERT, CPM, transport model, simple x, linear and dynamic programming, operation log book. Material balance and efficiency analysis, performance testing, performance indices, energy requirement and consumption. Marketing of agricultural products, market positioning BIS/FSSAI/ISO standards/guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed.

FARM STRUCTURES AND ENVIRONMENTAL CONTROL

Farmstead planning, survey and data collection for information bank. Analysis of data, Layouts Cost estimation and appraisal. Project development; Time, motion and input analysis, flow charts and drawings and case studies. Farm structures (farmstead, livestock, poultry, storage godowns, farm machinery storage, biogas, greenhouse, nethouse etc), their design, constructional details and design of low cost structures. Heating, ventilating and exhaust systems, air distribution and air cleaning, combustion of fuels and equipment.

Drying and dehumidification system, air-water contact operations and evaporation, process and product air conditioning, energy efficient environmental control practices. Rural electrification, house holds electric wiring, rural water supply and sanitation. Instruments and measurements: Codes and standards.

DAIRY PRODUCT PROCESSING

Procurement, transportation and processing of market milk, cleaning and sanitization of dairy equipment. Special milks such as flavoured, sterilized, recombined and reconstituted one and double toned. Condensed milk: Methods of manufacture and related equipment, evaluation of condensed and evaporated milk. Dried milk: Definition, methods of manufacture of skim and whole milk powder, instantiation, physiochemical properties, evaluation, defects in dried milk powder. Cream: Cream separation, neutralization, sterilization, pasteurization and cooling of cream, defects in cream, Butter: methods of manufacture, defects in butter.

Ice cream: Methods of manufacture and related equipment, defects in ice cream, technology of softy manufacture. Cheese: Methods of manufacture, cheddar, Gouda, cottage and processed cheese, defects in cheese. Indigenous milk products: Method of manufacture of *yoghurt, dahi, khoa, burfi, kalakand, ulabjamun, rosogolla, srikhand, chhana, paneer, ghee, lassi* etc. Probiotic milk product.

PROCESSING OF MEAT POULTRY AND FISH

Meat : Genetic engineering of farm animals for better meat quality, automation for the modern slaughter house, hot-boning of meat, new spectroscopic techniques for online monitoring of meat quality, real-time PCR for the detection of pathogens in meat, new developments in decontaminating raw meat, automated meat processing, developments in chilling and freezing of meat, high pressure processing of meat, approaches for the development of functional meat products, new techniques for analyzing raw meat, modified atmosphere packaging, perspectives for the active packaging of meat products

Poultry: Breeding and quality of poultry, stunning and slaughter of poultry, processing and packaging of poultry, new techniques of preservation of poultry, production of turkeys, geese, ducks and game birds, microbial hazards in poultry production and processing, latest trends in measuring quality of poultry and poultry products, treatment and disposal of poultry processing waste.

Fresh fish handling and chill storage, modified atmospheric packaging of seafoods, fish odours and flavours, assessment of freshness of fish and sea foods, traditional dried and salted fish products, proteolysed fish products, minced fish technology, retort pouch processing technology, irradiation and microwave in fish handling and processing, advanced freezing technology for fish storage, high pressure processing of seafoods, value addition of fresh water and aquacultured fish products, application of enzymes in fish processing and quality control, toxins, pollutants and contaminants in fish and seafoods.

Milk: Physical, chemical and nutritional properties of milk components, improvements in the pasteurization and sterilization of milk. Flavour generation in dairy products, controlling texture of fermented dairy products, functional dairy products, on-line measurement of product quality in dairy processing, high pressure processing of milk products, novel separation technologies to produce dairy ingredients, new technologies to increase shelf-life of dairy products, genetic engineering of milk proteins, production and utilization of functional milk proteins, methods of improving nutritional quality of milk, significance of milk fat in dairy products, chromatographic, spectrometric, ultrasound and other techniques for analysis of milk lipids.

DESIGN OF AQUACULTURAL STRUCTURES

Inland fish farming and associated considerations. Fish physiology and micro-climatic considerations. Site selection for aquaculture structures. Design of dykes, sluice, channels etc. Aeration and feeding systems: Design of fish rearing structures, hatcheries, containers for livefish, fingerlings, fishseeds. Aquaculture in recirculatory systems, oxygen and aeration, sterilization and disinfection. recirculation of water: Reuse systems, water exchange, design of re-use systems, Inlet and outlet structures and water treatment plants.

THERMAL ENVIRONMENTAL ENGINEERING FOR AGRICULTURAL PROCESSING

Requirements of temperature and moisture in food preservation, processing, storage, animal and plant production systems, human comfort etc. Thermodynamic properties of moist air, psychrometric chart, psychrometric processes and applications. Mass transfer and evaporation of water from free surfaces, theory of psychrometer, direct contact transfer processes between moist air and water-air washer, cooling tower, heating and cooling of moist air by extended surface coils, dehumidification using moisture absorbing materials. Solar irradiations on structures, calculation of heating and cooling loads in buildings/storage structures.

Design of air conditioning systems, air distribution and duct design, air flow pattern and control, equipment, components and controls. Instruments for measurement and control of temperature and moisture. Thermal insulation materials for environmental control systems, applications of Environmental controlling green house, dairy industry, potatoes to range *etc.*