

Syllabus for Ph.D Dairy Technology

Core Compulsory Courses

ADVANCES IN LIPID TECHNOLOGY

Objective

To comprehend the physicochemical and nutritional characteristics of fats and oils, and their processing and utilization for food purposes.

Theory

UNIT I

Current Trends in the fats & oil Industry in India and abroad: Sources and utilization of animal, vegetable and marine fats/oils - An overview.

UNIT II

Basic chemistry structure aspects of fats and oils in general, and milk-fat in particular, in relation to their processing, properties, utilization and significance in human diet.

UNIT III

The changing concepts in the role of edible fats and oils in human nutrition and health: PUFA, MUFA, CLA, Omega fatty acids, Trans fatty acids, Phytosterol, etc.

UNIT IV

Sources and classification of commercial edible fats and oils : Innovations in the production and processing of oils and fats from different sources, e.g. animal, plant, marine and microbial lipids for utilization in the dairy and food products; Non-conventional fats/oils for edible purpose – rice bran oil, microbial lipids.

UNIT V

Advances in refining including degumming, bleaching and deodorization oils and fats – Existing technologies and new developments - application of membrane techniques; Winterization.

UNIT VI

Physico-chemical properties of oils & fats; Polymorphism, crystallization kinetics; New antioxidants.

UNIT VII

Modification of fats and oils: Physical modification – Fractionation; Chemical modification – Hydrogenation and Interesterification; enzymatic/microbial modification of fats/oils; Cholesterol reducing treatments.

UNIT VIII

Applications of fats and oils: Margarine and low-fat table spreads; Bakery and confectionery fats; Coatings; Shortenings; Salad dressings; Technology of cooking oils, salad oils and oil based dressings; Frying process and systems; Changes in fats and oils during frying; Snack foods – Processing systems; Modified fats and oils for use in bakery and confectionery products, shortenings and spreads.

UNIT IX

Fat replacers, technological developments in low calories spreads and other fat-based products.

UNIT X

Advances in technologies for production of plasticisers, emulsifiers and protective coatings.

Suggested Readings

Cambie RC. 1989. *Fats for the Future*. International Union of Pure and Applied Chemistry. Ellis Horwood.

Gunstone FD & Padley FB. (Eds.).1997. *Lipid Technologies and Applications*. Marcel Dekker.

Hamilton RJ.1995. *Developments in Oils and Fats*. Blackie.

Hoffman G.1989. *Chemistry and Technology of Edible Oils and Fats and their High-Fat Products*. Academic Press.

Hui YH. (Ed.).1996. *Wiley Bailey's Industrial Oil and Fat Products*. Vols. I-IV. Interscience Publ., John Wiley & Sons.

Kamal BS & Kakuda Y.1994. *Technological Advances in Improved and 24 Alternative Sources of Lipids*. Blackie.

Karleskind A. (Ed.). 1996. *Oils and Fats Manual*. Vol. II. *Properties ,Production and Applications*. Lavoisier Tec-Doc Publ.

Khan R.1993. *Low-Calories Foods and Food Ingredients*. Blackie.

ADVANCES IN PROTEIN TECHNOLOGY

Objective

To comprehend the characteristics of food proteins and to familiarize students with their implications in processing, their interactions in food systems and their nutritional role.

Theory

UNIT I

Characteristics of proteins from plant, animal and microbial origins.

UNIT II

Denaturation of proteins: Effect of processing parameters on denaturation. Effect of denaturation on the physicochemical and biological properties of proteins in food systems.

UNIT III

Protein interactions with food constituents: protein-protein interactions. Protein-lipid interactions, protein-polysaccharide interactions, and protein-ion interactions. Significance of protein interactions: formation and stabilization of casein micelle, stability of concentrated milk products, and role of protein in food structure.

UNIT IV

Protein Nutrition: Recent concepts in protein nutrition in man: Enzyme development and protein digestion. Effect of processing on nutritive value of proteins. Mass and institutional feeding programs: Amino acid fortification of foods and concepts in protein supplementation and complementation.

UNIT V

Protein hydrolysates-- Production and processing; De-bittering of protein products; Bioactive peptides: their production and properties.

UNIT VI

Recent Technologies: Augmentation of world resources for protein foods: protein from plants, animals and microorganisms.

UNIT VII

Textured vegetable proteins and spun fibre technology: Extrusion cooking selection of ingredients and formulation, control of operational parameters, microstructure of extrusion cooked foods.

Suggested Readings

Encyclopaedia of Food Science, Food Technology and Nutrition. 1993. Vols. I-VII, Academic Press.

Fennema OR. 1985. *Food Chemistry*. Marcer Dekker.

Fox PF. 1983. *Development in Dairy Chemistry*. Vol. II. Applied Science Publ.

Fox PF. 1992. *Advanced Dairy Chemistry*. Vol I. *Proteins*. Elsevier.

Macrac R, Robinson RK & Sadler MJ. 1993. *IDF Special Issue* 9303.

Walstra P & Jenness R. 1984. *Dairy Chemistry and Physics*. John Wiley & Sons.

PRODUCT MONITORING AND PROCESS CONTROL

Objective

To develop the understanding of the concept of monitoring and optimization of food quality/characteristics and familiarize the students with the techniques involved.

Theory

UNIT I

The concept of Product-Process Monitoring in dairy and food industries: Definition of 'quality'; Optimization paradigm; Quality-prediction model based on quality kinetics and process state equations – Simulation modeling. Process/Product Optimization: Optimization procedures – Search methods, Response surface, Differentiation & Programming methods; Neural Networks; Optimization software.

UNIT II

Process Control: Objectives; Control loop – Loop elements and their functions; Modes of process control; Control techniques; control equipment.

UNIT III

Real-time Instrumentation : Sensors; their classification based on Proximity, working principle; examples of applications in process control; Requirements of on-line sensors; Biosensors – Construction, types, working principles, applications, merits and limitations; Time-temperature indicators – partial-history & full-history indicators; Commercial devices; Applications and limitations; E-Nose & E-Tongue – Simulation of natural organs; Components & their functions; Applications.

UNIT IV

Flavour analysis: Flavour bioassays – Gas Chromatography-Olfactometry techniques; Isolation, Separation and detection/Identification of flavour compounds – GC-MS, LC-MS, NMR, FTIR; analysis of chiral compounds.

UNIT V

Formation of flavour compounds in milk and milk products during heat processing (including UHT processing, caramelization and extrusion cooking), fermentation and ripening (cultured products and cheese flavour, with special reference to bitterness) and storage (Maillard browning); Aroma losses/retention during the drying process (in relation to milk powder, cheese powder and dry cultured products); Industrial processes for extraction of desirable and undesirable volatile components from fresh and/or stored products by supercritical fluid (SCF) technique.

UNIT VI

Monitoring of Food Structure: (a) Application of Thermal Analysis (DTA and DSC vis-a-vis dilatometry) and Pulse Nuclear Magnetic Resonance (PNMR) spectroscopy in determination of solid-fat content (SFC) of butter in relation to various processing and storage aspects; Glass transitions in dairy products; Starch gelatinization.

UNIT VII

Monitoring of Food Structure: (b) Elucidation of crystal characteristics of milk fat in ghee and other fat-rich products by means of X-ray Crystallography with reference to the impact of cooling and storage/handling conditions on the crystal nature and product texture; Process-induced changes in sub-microscopic particulate properties of milk products; structure-texture relationship.

UNIT VIII

Monitoring of Food Structure: (c) Influence of heat processing and freezing treatments on protein denaturation and other conformational as well as aggregation-disaggregation phenomena as monitored through Spectropolarimetry, Circular Dichroism and related techniques.

UNIT IX

Monitoring of Food Structure: (d) Particle-size analysis: Image analysis; Dynamic light scattering; Laser diffraction; Sieving, and other techniques.

UNIT X

Emerging Spectroscopic techniques in assessment of foods : Raman Spectroscopy and Electron Spin Spectroscopy – Working principles and applications - Monitoring of irradiated foods, detection of lipid autooxidation, etc.; Microwave & NIR absorption/reflection methods for Compositional analyses – Automated milk analysers; Proximate principles in cheese and milk powder.

UNIT XI

Ultrasound in product monitoring: Speed- and Attenuation-based measurements of liquid levels, density, mass flow, etc.

UNIT XII

Monitoring of Chemical Contaminants: Heavy metal quantification by Atomic Absorption Spectrophotometer; Quantification of Agrochemicals by HPLC;

Spectrofluorimetric determination of mycotoxins; Detection and quantification of Drug Residues.

UNIT XIII

Colour Characterization : Colour and appearance (gloss and translucence) monitoring through visual colorimeter, tri-stimulus colorimeters and reflectance spectrophotometer, CIE, Hunter-Lab, Munsel and other systems of three-dimensional expression of colour; Colour-based Sorting of foods; Computer Vision – Principles, applications and Benefits.

UNIT XIV

Objective Assessment of Subjective food-quality characteristics – Pitfalls and Promises.

Suggested Readings

- Acree TE & Teranishi R. 1993. *Flavour Science: Sensible Principles and Techniques*. Amer. Chem. Soc., Washington.
- Bartlett PN, Elliott JM & Gardner JW. 1997. *Electronic Noses and their Application in the Food Industry*. Food Technology: 51 (12) 44-48.
- Davenel A. 1996. On-line Control and Problems with Sensors. In: *Quality Control for Foods and Agricultural Products*. (J.L. Mutton, Ed.). VCH Publ., London.
- Kress-Rogers E & Brimelow CJB. (Eds.). 2001. *Instrumentation and Sensors for the Food Industry*. CRC Press, Woodhead Publ. Ltd.
- Mann CMD & Jones AA. 1994. *Shelf-life Evaluation of Foods*. Blackie.
- Peleg M & Bagley EB. 1983. *Physical Properties of Foods*. AVI Publ.
- Schartel BJ & Firstenberg ER. 1988. *Biosensors in the Food Industry: Present and Future*. *J. Food Protect.* 51(10): 811-820.

RESEARCH AND DEVELOPMENT MANAGEMENT IN DAIRY INDUSTRY

Objective

To provide in-depth knowledge to research scholar in selection and management of research project in the area of new product development and in patenting and transfer of technology processes.

Theory

UNIT I

Current Status of R&D Efforts in Dairy Processing in India and abroad.

UNIT II

Resource Management: Management of financial and human resources in dairy Industry: a) Structure and design of Research and Development organisation; b) Analysis of organization behaviour – Transactional analysis; and c) Personnel management – Typology analysis, individual and the organization, team building, human behaviour at work, motivation.

UNIT III

Management of R&D functions: a) Criterion for the selection of R&D projects; Technology Development Process and b) Techniques for monitoring R & D functions.

UNIT IV

Patenting Laws; Indian Patenting Act/International Protocols for technology transfer; Transfer of technology from Lab to Plant, HACCP, GMP/GHP practices in dairy processing. ISO14001, Total Quality Management (TQM), Six-Sigma concept.

UNIT V

Project proposal writing for research funding, Development of feasibility and technical report for dairy plant establishment, evaluation and report writing of projects.

Suggested Readings

Encyclopedia of Food Technology and Nutrition. 1993. Academic Press.

General Information on Patents. The Patent Office, Kolkatta.

IPR Bulletins (TIFAC) (www.tifac.org.in)

NAARM. 1990. *Agricultural Research Management*. National Academy of Agricultural Research Management, Hyderabad.

DEVELOPMENTS IN DAIRY PROCESSING

Use of bio-protective factors for preservation of raw milk: effect on physico-chemical, microbial and nutritional properties of milk and milk products

Present status of preservation of raw milk by chemical preservatives, thermal processing for preservation, methods of determining lethality of thermal processing, UHT processed milk products

Properties and prospects, types of UHT plants aseptic filling, heat stability and deposit formation aspects, effect on milk quality and techno economic considerations of UHT packaging.

Principals and equipment for bacto therm process and its application in dairy industry

High hydrostatic pressure processing.

Retort processing, dehydration and advances in drying of milk and milk products.

Freeze dehydration, physico-chemical changes during freeze drying in the industrial development

Water activity, sorption behaviour of foods, energy of binding water, control of water activity of different products in relation to their chemical, microbial and textural properties.

Hurdle technology and its application in the development of shelf stable and intermediate moisture foods.

Current trends in cleaning and sanitization of dairy equipments, biological and chemical, detergents, ultrasonic techniques in cleaning, biodegents and development of sanitizers.

Food contaminants, their incidence and implications and corrective measures

Heat classification of milk powders, functional properties of milk powders, porosity and other properties.

Definition, classification and technologies of fabricated and formulated foods and their nutritional aspects.

Imitation dairy products and dairy analogues.

Principle of extrusion processing, design and working of extruder, classification, application in dairy and food processing.

Food additives including stabilizers, emulsifiers, antioxidants, preservatives etc for formulated foods.

Active packaging, modified atmospheric storage, controlled atmospheric storage, shrink and stretch packaging

Biodegradable and Edible packaging.

DAIRY BY-PRODUCTS TECHNOLOGY AND PROCESSING

Need for byproducts utilization in the dairy industry. Composition and nutritive value of important dairy by-products.

Recent advances in processing and utilization of by-products.

Application of newer techniques in concentration and dehydration of different whey systems.

Membrane techniques, classification and characteristics of filtration processes, types of membranes commercially available, membrane hardware, design of membrane plants.

Modeling of membrane processes.

Membrane fouling and treatment, cleaning and sanitization of different types of membrane systems.

Application of membrane processes in the production of special foods.

Development of new processing and products for economic use of by products.

Principles of industrial preparation of lactose, value addition for casein and whey proteins and fortification of proteins in selected foods

Hydrolysis of whey proteins and its application in food industries.

Importance of Demineralization, different processes for demineralization and their principle and plant operation.

Functional properties of whey protein concentrates and whey protein isolates, casein, casein hydrolysates, coprecipitates and UF retentate and their modifications.

ADVANCES IN CHEMISTRY OF MILK PROCESSING

Objective

To highlight the impact of processing parameters on the milk constituents with special reference to chemical changes involved.

To impart the knowledge on the status and chemistry of contaminants in milk and milk products.

To impart the basic knowledge on the chemistry and significance of additives.

Theory

UNIT I

Heat induced changes and interactions between protein, lipids, carbohydrate and minerals during processing of milk. Effect of heat on the proteins of concentrated milk systems. Inactivation of milk indigenous enzymes during processing.

UNIT II

Milk fat replacers, chemistry of artificial sweeteners and fortified milk.

UNIT III

Physical changes in the fat globules in unhomogenized and homogenized milk; cold agglutination – its mechanisms and role.

UNIT IV

Specific and non – specific enzymatic coagulation of milk.

UNIT V

Status and formation of bioactive peptides in fermented milk products.

UNIT VI

Chemistry involved in high pressure processing of milk.

UNIT VII

Radio nuclides, drugs, pesticides, and polybiphenyls in milk.

Suggested Readings

Colette Shortt & John O' Brien. 2004. *Handbook of Functional Dairy Products*. CRC Press.

Fox PF & McSweeney PLH. 1998. *Dairy Chemistry and Biochemistry*. Blackie Academic Professional, Chapman & Hall.

IDF. 1989. Bulletin 238. Intern. Dairy Fed., Brussels.

IDF. 1997. Special issue 9701. Intern. Dairy Fed., Brussels.

IDF.1995. Special issue. *Heat Induced Changes in Milk*. Intern. Dairy Fed., Brussels.

Leo ML Nollet. 2004. *Intense Sweeteners. Handbook of Food Analysis*. 2nd Ed. Marcel Dekker.

Mathur MP, Roy DD & Dinakar P. *Textbook of Dairy Chemistry*. ICAR.

Nabors Lyn O'Brien. *Alternative Sweeteners*. 3rd Ed. Marcel Dekker.

ADVANCES IN ANALYTICAL TECHNIQUES IN DAIRY CHEMISTRY

Objective

To highlight the importance of modern analytical techniques used for analysis of milk and milk products.

Theory

UNIT I

Isoelectric focusing and 2-D polyacrylamide gel electrophoresis (PAGE), Capillary zone electrophoresis, Blotting technique.

UNIT II

Differential scanning calorimetry, Radio immuno assay (RIA), Enzyme linked immunosorbent assay (ELISA).

UNIT III

High performance liquid chromatography (HPLC), Circular dichroism (CD), Protein sequencing, X-ray crystallography.

UNIT IV

Atomic-, Mass-, Infrared-, Fluorescence- Spectroscopy.

Suggested Readings

- Blundell TL & Johnson LN.1976. *Protein Crystallography*. Academic Press.
- Calter P. 2004. *Methods in Molecular Biology*. Vol. 244 2nd Ed. *Protein Purification Protocols*. Humana Press.
- FL Creighton T.1998. *Protein Structure*. 2nd Ed. Portland Press.
- Nielsen SS. 1994. *Introduction to Chemical Analysis of Foods*. Part IV. Jones & Bertlett Publ.
- Oliver RWA.1989. *HPLC of Macromolecules - A Practical Approach*. IRL Press.
- Sawyer L. et al. 2002. *Milk Protein Structure-What can it tell the dairy industry?* *International Dairy Journal* 12: 299-301.
- Settle F.1997. *Handbook of Instrumental Techniques for Analytical Chemistry*. Hall International.
- Smith BJ. 1996. *Protein Sequencing Protocols, Methods in Molecular Biology*. Vol. 32. Humanta Press.
- Swadesh J.1997. *HPLC - Practical and Industrial Applications*. CRC Press.

Application of Biotechnology in Dairy Industry

Objectives

To impart knowledge in the application of Bio-technology in Dairy /Food Industry.

Unit I

Introduction, history and development of biotechnology status of biotechnology industry in India; Application of biotechnological products in dairy and food industry.

Unit II

Genetic improvement of lactic acid bacteria to enhance their technological and functional attributes e.g. acid, flavour, an EPS, phase resistance and probiotic functions.

Unit III

Metabolic engineering of lactic acid bacteria for production of vitamins, oligosachhaides and other metabolites.

Unit IV

Production of recombinant dairy/food enzymes/proteins e.g chymosin, lactoferrin lysozyme, lipases, proteases and immunoglobulins etc.

Unit V

Probiotics, prebiotics and functional foods, WHO guidelines for probiotics and functional foods, bioactive peptides, safety of probiotics Nutragenomics.

Unit VI

Bacteriocins: their types and application in food biopreservation..

Unit VII

Navel dairy ingredients e.g. resistant starch & starch products fat replaces soluble fibers, omega fatty acids and artificial sweetness.

Unit IX

Genetically modified foods and their safety concerns. Detection of GMOs. Regulatory standards for GMOs and GM foods.

Unit X

Application of molecular tools such as PCR, RT PCR, bio sensors and immunomagnetic methods for detection of food borne bacterial pathogens and spoilage organisms.

Suggested Readings

Bains W. 1993. Biotechnology from A to Z. Oxford Univ. Press, Oxford.

Crueger W & Crueger A. 1984. Biotechnology: A Textbook of Industrial Microbiology. Science Tech.

Joshi VK & Pandey A. (Ed.). 1999. Biotechnology. Food Fermentation. (2 Vol. set). Education Publ.

Knorr D. 1982. Food Biotechnology. Marcel Dekker

Dairy and food Microbiology

Objectives

To comprehend the current trends and concepts related to microbiology of dairy and other food products.

Unit I

Micro-organisms of importance in dairy and other food products. Factors affecting microbial growth and quality of foods.

Unit II

Preservation of foods by heat treatment, chemical irradiation and novel processing technologies. Modified atmosphere packaging, active packaging and nanopackaging for enhancing novel shelf life of foods.

Unit III

Microbial spoilage of dairy and other foods. Spoilage of pasteurized and UHT milks

Sweet & condensed milk, cream, butter, cheese and fermented milks, role of --- in spoilage of dairy foods stored at low temperature. Heat resistant proteases and lipases. Role of thermo----- spoilage factors.

Unit IV

Lactic acid bacteria in food fermentations; important metabolic pathways for lactose fermentation by starter bacteria, commercial production of starter cultures and their applications.

Unit V

Improving starter cultures for food fermentation by various methods, lactococcal plasmids and their importance, food grade vectors.

Unit VI

Microbiology of cheese starter and non starter lactic acid bacteria. Accelerated cheese ripening, role of secondary starter organism in Swiss, brie and mold ripened cheeses.

Unit VII

Microbiology of Dahi, Yoghurt, lassi and kefir. Flavour production in fermented milks. Use of fermented milks as vehicles for probiotic microorganisms.

Unit VIII

Current trends in food safety. Newly emerging food pathogens, Novel technologies for control of food pathogens.

Unit IX

Concepts in food toxicology. Food borne toxins, staphylococcal gastroenteritis, polulisms, and salmonellas.

Unit X

Current concepts in food quality and safety management. HACCP concept and its implementation. Food safety standards.

Suggested Readings

- Adams MR, Moss MO. 2002. *Food Microbiology*. 2nd Ed. Panima Publ.
- Batt CA, Patel PA & Robinson RK. 1999. *Encyclopedia of Food Microbiology*. (Set 1-3). Academic Press.
- DeVuyst & Vandamme. 2000. *Bacteriocins of Lactic Acid Bacteria*. Blackie.
- Jay JM, Lossener MJ & Golden DA. 2005. *Modern Food Microbiology*. Springer-Verlag.
- Marth EH & Steele JL. 2001. *Applied Dairy Microbiology*. Marcel Dekker.
- Ray B. 2003. *Fundamental Food Microbiology*. CRC Press.
- Robinson RK. 2002. *Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products*. 3rd Ed. John Wiley & Sons.
- Salminen S, Atte VW & Ouwehand A. 2004. *Lactic Acid Bacteria*. Marcel Dekker.
- Wood B & Warner PJ. 2003. *Genetics of Lactic Acid Bacteria*. Springer-Verlag.

DAIRY AND FOOD ENGINEERING-I

4+0

Objective

To disseminate the knowledge of properties of products and unit operations involved in dairy and food engineering

Theory

UNIT I

Engineering properties of dairy and food materials and their significance in equipment design; processing and handling of dairy and food products.

UNIT II

Concept of rheology: ideal elastic, plastic and viscous behavior, viscoelasticity, rheological models and constitutive equations, Maxwell model, Kelvin model and Burgers model, visco elastic characterization of materials, stress-strain behavior, creep, stress relaxation, non-Newtonian fluids and viscometry.

UNIT III

Rheology and texture of food materials: methods of texture evaluation, subjective and objective measurements, mechanical tests, firmness, hardness, dynamic hardness, objective methods of measuring texture, rheological properties of dairy products, strength of food materials.

UNIT IV

Mixing of materials: Factors in mixing, types, operation, mixing gas, liquid and solid, heat transfer in mixers, power requirement, transmission, scale-up of models.

UNIT V

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.

UNIT VI

Evaporation: Classification, design of multiple-effect evaporator, temperature distribution, boiling point elevation, operation, feeding methods, condensate and air removal, scale formation and removal, heat and mass balance, vapor recompression.

UNIT VII

Drying Spray dryer and its components, roller dryer and tray dryer, Constant and falling rate of drying, separation and recovery of dried product, design of recovery system, selection and design of auxiliary equipment.

Suggested Readings

Charm SE. 1971. *The Fundamental of Food Engineering*. AVI Publ.

Heldman DR & Singh R.P. 1984. *Food Process Engineering*. The AVI Publ.

Mohsenin NN. 1986. *Physical Properties of Plant and Animal Materials*. Gordon & Breach Science Publ.

Rao MA & Rizvi SSH. 1986 *Engineering Properties of Foods*. Marcel Dekker.

Watson EL & Harper IC. 1989. *Elements of Food Engineering*. AVI Publ.

DAIRY AND FOOD ENGINEERING-II

4+0

Objective

To develop competence in shelf life simulation of dairy products.

Theory

UNIT I

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, principles of IMF and their application.

UNIT II

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 productpackage- environment interaction, shelf life simulation for moisture, oxygen and light sensitive products.

UNIT III

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

UNIT IV

Microwave energy absorption, physical parameters in microwave heating processes, heat transfer phenomena, equipment and application in dairy food industry.

UNIT V

Thermo-bacteriology of dairy and food products, Survivor curve, thermal death curve, Arrhenous curve, techniques for determination of heat resistance of micro organisms, analysis of thermal resistance data, processing in containers, process time, lethality, design of batch and continuous sterilisation cycles in vat.

UNIT VI

Transducers: Electrical, mechanical, magnetic and optical transducers for measurement of process variables like temperature, pressure, flow, level, consistency, pH and humidity.

UNIT IV

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

Suggested Readings

Cheryan M. 1998. *Ultrafiltration and Microfiltration Handbook*. Technomic Publ.

Duckworth R. 1975. *Water Relations in Foods*. Academic Press.

Robertson GL. 1992. *Food Packaging (Principles and Practices)*. Marcel Dekker.

Rockland LB & George F Stewart. 1991. *Water Activity: Influence on Food Quality*. Academic Press.

Toledo RT. 1997. *Fundamentals of Food Process Engineering*. CBS Publ.