

21. DAIRY CHEMISTRY

Unit 1

Milk constituents, their normal contents and physical and chemical nature. Specific compositional differences among milk from various species; Variations in milk composition due to breed, feed, season, stage of lactation and mastitis; Colostrum and abnormal milks, physical properties of milk; Acid base equilibria, oxidation-reduction potential, density, viscosity, interfacial tension, freezing point, electrical conductivity, thermal conductivity, refractive index, milk buffer capacity, physical equilibria among milk salts; Effect of various treatments on salt equilibria; Salt balance and its importance in processing of milk; Water activity, and its effect on shelf life; Colloids, properties and colloidal stability of milk; Emulsions, foams and gels formation, their stability and importance in dairy processing.

Lactose – structure, isomers, physical, chemical and biochemical properties. Browning mechanisms. Estimation and biosynthesis. Lactose intolerance. Significance of carbohydrates in milk and milk products. Distribution of trace elements in milk and their technological and nutritional importance; Water soluble vitamins – molecular structure and their levels in milk and milk products, biological significance, and factors affecting their levels.

Unit 2

Levels, distribution, isolation and genetic polymorphism of different milk proteins; Casein micelles – structure, size distribution, stability and physico-chemical properties; Casein models. Amino acid composition and physico-chemical properties of different fractions of caseins; Whey process, denaturation of milk proteins as influenced by temperature, pH and additives; Biosynthesis, structure, function and physico-chemical properties of α -lactalbumin and β -lactoglobulin, immunoglobulins, lysozyme, lactoferrins, lipoproteins and fat-globule membrane proteins and their importance; Milk protein allergenicity; Role in immune response; Chemistry of milk enzymes and their significance with reference to milk processing and milk products. Kinetics of chemical reactions and enzyme kinetics; Casein hydrolysate, co-precipitates, and whey protein concentrates; bioactive peptides.

Unit 3

Milk lipids – classification, composition, structure and general physical and chemical properties. Auto-oxidation – definition, theories, factors affecting, prevention and measurement. Antioxidants – mechanism of reaction and estimation. Lipolysis. Fatty acids – profile, properties and affecting factors. Unsaponifiable matter. Cholesterol – structure, forms, importance and level in milk. Chemistry of phospholipids and their role in milk and milk products. Fat – soluble vitamins – chemistry, physiological functions, levels in milk, cream, butter and ghee. Biosynthesis of milk fat. CLA biosynthesis and its nutritional and health benefits.

Unit 4

Milk adulteration and detection methods; Estimation methods for antibiotics, pesticides, heavy metals, lactose, lactate, protein, total solid, fat, salt, vitamin C, calcium, phosphorous, iron, citric acid in milk and milk products. Estimation of vitamin A, total phospholipids and free fatty acids in ghee. Estimation of starch in food. Measurement of BOD and COD in dairy waste.

Unit 5

Cream – Size distribution of fat globules, creaming phenomenon, composition and properties of cream and dry cream. Chemistry of neutralization and ripening. Butter. Mechanism of churning during butter preparation. Desi and creamery butter composition, properties, microstructure, grading, standards and defects. Ghee –

Compositional differences in ghee prepared by different methods and variations in ghee and butter oil, Analytical constants and factors affecting them. Differences in cow and buffalo ghee. Hydrolytic and oxidative deterioration of ghee, their causes and prevention. Adulteration of ghee and methods of detection. Ghee grading, Antioxidants: natural and synthetic. Physico-chemical characteristics of buttermilk and ghee residue.

Unit 6

Heat stability of milk as affected by various milk constituents and additives. Role of protein-protein interaction and age gelation of UHT milk. Physical and chemical changes during preparation of concentrated milk and subsequent storage. Compositional differences between condensed and evaporated milk. Dried milk; Structure and physico-chemical properties. Physical properties of instant powder, Infant food. Spoilage of milk powder and its control. Khoa : composition and changes during manufacture. Composition and changes during preparation of chhana and paneer.

Unit 7

Cheese : Composition and varietal differences. Chemistry of rennin action. Influence of acidity, renneting and heat on the process of cheese manufacture. Changes during manufacture and ripening. Role and mechanism of action of stabilizers and emulsifiers, rheological properties and defects of cheese. Milk clotting enzymes from different sources – microbial, animal and plant. Theories and metabolic pathways of fermentation. Dahi, yoghurt and Acidophilus Milk : Composition and specific differences, chemical changes during fermentation, flavour development. Composition of Lassi and buttermilk. Nutritional and therapeutic significance of fermented milk products.

Unit 8

Ice-cream : Composition and physical structure, changes during ageing, freezing, hardening and defects. Role and mechanism of stabilizers and emulsifiers. Kulfi: composition and differences with ice-cream.

Unit 9

Definition of quality, quality control and assurance. Standards, statutory and voluntary organization. PFA act, sampling, labelling, PFA and AGMARK, BIS, ISO9000 standards for milk products. Total quality management, sensory evaluation of milk and milk products. Calibration of glasswares (lactometer, butyrometer, milk pipette, thermometer) used in Quality control laboratory, legal requirements of packaging material and product information, nutrition labelling.

Unit 10

Spectroscopy – UV – Vis spectrophotometry, IR. Separation techniques : TLC, GLC, HPLC, Ion exchange, size exclusion, affinity chromatography, analytical sedimentation, sedimentation equilibrium, isopycnic ultracentrifugation. Ultrafiltration. Precipitation by salting out agents. Electrophoresis – PAGE, SDS-PAGE, Radio-tracers technique. Flame photometry and potentiometry (principle, various electrodes, electrometric measurements of pH, buffers).

22. DAIRY MICROBIOLOGY

Unit 1

Microflora associated with milk and milk products and their importance. Morphological, natural, physiological, spoilage and pathogenic characteristics of commonly occurring microbes in milk and milk products; Newer approaches for classification of microorganisms; types of microbes in normal and mastitic milk and importance of somatic cell counts; Food poisoning, food infections, toxi-infections and other milk borne diseases; Emerging food borne pathogens associated with milk and milk products; Epidemiological studies using DNA fingerprinting techniques like RAPD, RFLP, DGGE, TGGE, Rep-PCR, etc. Sources of microbial contamination of raw milk and their relative importance in influencing quality of milk during production, collection, transportation and storage. Microbial and chemical changes in raw milk during chilling and refrigeration.

Unit 2

Bacteriological aspects of processing techniques like bactofugation, thermisation, pasteurization, sterilization, boiling. UHT, pulsed field treatment and membrane filtration of milk. Types of spoilages in heat-treated milks. Enumeration of heat resistant microbes. Germination and sporulation of bacterial spores; Prevention of post-processing contamination in heated milk. Identification of sources of contamination in heat treated milks. D, F and Z values for various microbes. Heat induced damage and repair in bacterial cells. Role of resuscitation in recovery of heat injured microbial cells; Bacteriological grading of raw and heat-treated milk. Microbiological spoilage aspects of thermally processed milks; Role of psychrotrophic, thermoduric, thermophilic bacteria and their metabolites in milk spoilage, biofilms.

Unit 3

Naturally occurring preservative systems in milk like LP system, Immunoglobulins, Lysozyme, Lactoferrin, etc. Preservation of milk and milk products by physical (irradiation) and chemical agents; Food grade Biopreservatives (GRAS), Bacteriocins of lactic acid bacteria; Nisin and other antimicrobials produced by Lactic Acid Bacteria (LAB). Application of bacteriocins as food grade biopreservatives in enhancing shelf life of foods; Enhancing antimicrobial potentials of LAB by recombinant DNA technology and Genetic engineering; Residues of antibiotics, detergents, sanitizers, pesticides and aflatoxins in milk, mode of action on microbes and biological consequences – as well as their detection by newer approaches like Charm test, HPLC, ELISA and biosensor based techniques.

Unit 4

Microbiological quality of fat rich products (cream and butter); Frozen dairy products (ice-cream); Concentrated dairy products (evaporated and sweetened condensed milk) and Dried milks (roller and spray dried milks and infant foods); Factors influencing the microbiological quality of above products during their production, processing, handling, storage and distribution; Microbial defects associated with these products and their control; Microbiological safety in relation to potential pathogens and their public health significance; National and International microbiological standards for dairy products (BIS, ICMSF, Codex Alimentarius Standards).

Unit 5

Lactic Acid Bacteria (LAB) as starters : Types of starter cultures and their classification; Identification of LAB based on conventional and molecular techniques such as 16S rRNA sequencing. Ribotyping, PCR and DNA fingerprinting; Microbiology of starter cultures; Single and multiple strain cultures, and custom cultures; Associative growth of starter cultures; Concepts of starter growth and metabolism of

lactose and citrate; Production of taste and aroma compounds by starters in fermented milks and milk products; Changes caused by starters in milk during growth; Modern trends in propagation, production and preservation of starter cultures; Production of starter concentrates; DVS starters: Judging of starter quality and activity; Starter defects; Starter failure; Intrinsic and extrinsic factors associated with starter failure; Bacteriophages of dairy starters and their impact on dairy industry; Prevention and control of starter failures.

Genetics and molecular biology of acid, flavour and therapeutic properties of LAB. Role of plasmids in their metabolism; Genetic manipulation of LAB for ameliorated performance; Food grade cloning and expression vectors; LAB as hosts for expression for heterologous proteins and development of food grade oral vaccines; LAB genome projects.

Unit 6

Dairy products as functional / health foods : LAB as probiotics in development of health foods; Selection criteria, colonization and functional properties; Antibacterial and therapeutic properties of probiotic cultures; Survival and stability of probiotics in health foods, gut and their tracking; Concept of probiotics and synbiotics; Genetic markers of probiotic functions and their application for mass screening; Genomics of probiotic Lactobacilli and Bifidobacteria; Cloning and sequencing of probiotic genes; Sequence analysis; Blast, Clustal W and Clustal X. Pair-wise and multiple alignment; Homology and Phylogenetic tree / dendrograms; LAB as nutraceutical ingredients – a source of vitamin synthesis and exopolysaccharide production; Bioactive peptides and their role as nutraceuticals in dairy foods.

Unit 7

Role of starters in the preparation of yoghurt, koumiss, kefir, cultured buttermilk, and whey based beverages and other fermented products; Therapeutic properties of fermented foods; Microbial defects in these products, safety and their prevention and control; Microbiology of hard, semi-hard and soft varieties of cheese; Role of starter culture and non-starter lactic acid bacteria (NSLAB) during preparation and ripening of cheese; Accelerated ripening of cheese; Production and use of microbial rennet substitutes; Recombinant chymosin and its application; Defects in cheese, Microbiological safety and their prevention and control.

Unit 8

Microbiological quality of indigenous dairy products, viz., khoa and chhana based sweets: Burfi, peda, rasogulla, gulabjamun, kheer, kulfi, shrikhand, paneer, dahi, lassi, ghee, etc. Sources of microbial contamination, their role in spoilage of these products and their microbiological safety, Prevention and control: Role of personnel and environmental hygiene at the level of production and processing; Need for microbiological standards for assessing the quality and safety of indigenous products; Concept of TQM and HACCP implementation in improvement of quality and safety of indigenous products; Current role of modified packaging for extending the shelf stability of indigenous dairy products, Antimicrobial packaging, controlled and modified atmosphere (CAP / MAP) based technologies.

Unit 9

Preparation of byproducts from dairy effluents by microbial fermentation; Cleaning and sanitization of equipments, machineries and other contact surfaces used in production and processing of milk and milk products; Types of detergents and their mechanisms of soil removal from the surfaces; Efficacy of sanitizers including gaseous disinfectants and evaluation of sanitizing disinfectant properties; Factors affecting activity of detergents and sanitizers; Built detergents, commercial detergents and

combined detergent-sanitizers; Biological consequences of dairy waste disposal; Disposal of dairy effluents after microbial treatment; BOD and COD analysis in dairy effluents; Microbiological quality of air and water used in Dairy Plants.

Unit 10

Microbiological aspects of quality control and quality assurance in production of milk and milk products; Good Manufacturing Practices (GMP) and the relevance and Sanitary Standard Operating Procedures (SSOP); Importance of Total Quality Management (TQM) in dairy industry; Application of HACCP programme in dairy industry; Safety concerns of bio-film formation on equipment surfaces and their control measures; Risk assessment approaches and role of productive microbiology in dairy foods; Conventional and current methods like impedance, ATP luminescence, pyruvate, etc. in detection of food pathogens; Application of immunological, PCR, Real time PCR, DNA probes, Microarrays (Biochips) and Biosensors, etc. for detection of food pathogens; Biosafety of Genetically Modified Organisms (GMOs) / foods.

23. DAIRY TECHNOLOGY

Unit 1 : Market Milk

Status of dairy industry in India. Recent policy changes related to dairy sector (MMPO & WTO). Principles and practices for production of high quality milk. Methods of milk procurement, payment, quality assessment, detection of adulterants, handling and transportation of milk. Methods of raw milk preservation. Physical properties and chemical composition of milk of cow, buffalo and other species of milch animals; their importance in milk processing. Centrifugal separation, clarification and bactofugation and factors affecting their efficiency. Homogenization process and its implications in dairy processing; efficiency of homogenization and factors affecting it. Thermal processing of milk. Principles and methods of pasteurization and sterilization. UHT processing and aseptic packaging. Special milks. Principles of production, processing and marketing of toned, double toned, reconstituted, recombined, flavoured and filled milks.

Unit 2 : Fat Rich Dairy Products

Basic principles and recent concepts in production and processing of different types of cream, butter, margarine, fat spreads, butter oil and *ghee*. Fractionation of fat and its application. Health aspects of milk fat. Cholesterol reduced and cholesterol-free dairy products.

Unit 3 : Frozen Milk Products

Trends in the frozen milk products industry in India. Definition, classification and composition of ice-cream and other frozen desserts. Role of milk constituents and other ingredients, processing steps, packaging and storage methods on quality of ice-cream. Technological aspects of manufacture of plain, fruit, soft-serve, low fat and dietic ice-creams and novelties. Indigenous frozen desserts, kulfi, malai-ka-baraf etc.; their production techniques and quality. Distribution of frozen desserts. Newer ingredients for use in the ice-cream industry.

Unit 4 : Cheese and Fermented Milk Products

Status and scope of cheese industry. Fermented milk products – their nutritional and therapeutic value. Definition and classification of cheese and fermented milks. Milk in relation to cheese making. Manufacture of Cheddar, Gouda, Mozzarella and Swiss cheeses. Role of starter cultures in cheese quality. Types of rennet for cheese manufacture. Physical and chemical changes during cheese ripening. Manufacture of processed cheese, cheese spread and cheese foods. Mechanization of cheese-making process. Modern concepts in accelerated cheese ripening. Storage and defects. Production and storage of *dahi*, yoghurt, *shrikhand*, *lassi* and *misti dohi*. Probiotic dairy products.

Unit 5 : Concentrated and Dried Milk Products

Milk in relation to processing and manufacture of concentrated and dry milks. Principles and methods of manufacture, storage and defects in sweetened condensed milk. Evaporated milk. UHT sterilized concentrated milk. Whole milk powder. Skim milk powder, high-fat powders, and ice-cream powder. Instantization of milk powder. Newer technologies and formulations for infant foods and weaning foods, malted milk and malted milk foods.

Unit 6 : Indigenous Milk Products

Status and role of traditional dairy products in Indian dairy industry and economy. Characteristics of various traditional products, their prospects and constraints. Methods of production; physico-chemical changes during manufacture; quality attributes, shelf-life, preservation and packaging. Process innovations relating to *khoa*, *chhana*, *paneer*, *rabri*, *kheer*, *khoa* and *chhana*-based sweets.

Unit 7 : Utilization of Milk Byproducts

Status, availability and utilization of dairy byproducts. Associated economic and pollution problems. Manufacture of casein, sodium and calcium-caseinates, edible casein, hydrolysates, coprecipitates, whey protein concentrates, whey beverages, whey syrups and lactose. Use of buttermilk. Development / formulation of new products based on dairy byproducts.

Unit 8 : Packaging of Milk and Milk Products

Present status and scope. Role of packaging and package design considerations. Evaluation of packaging materials and package performance. Packaging materials and systems for liquid, concentrated, dried, frozen and fat-rich dairy products. Special packaging methods such as vacuum, shrink and aseptic packaging. Modified atmosphere packaging. Package standards, regulations and quality control.

Unit 9 : Cleaning and Sanitation

Properties of important dairy detergents and sanitizers. Choice of detergents and sanitizers guiding principles and limiting factors. Basic principles in formulating the cleaning and sanitizing procedures for dairy equipments. Automation in cleaning and sanitization processes including CIP. Quality of water in detergency.

Unit 10 : Advances in Dairy Technology

Radiation preservation of milk and milk products. Theory and application of microwave heating, ohmic heating and high pressure processing. Immobilization of enzymes and their use in dairy and food industry. Theory of ultrafiltration, reverse osmosis, nanofiltration and microfiltration techniques. Selection and types of membranes. Application of membrane technology in dairy and food industry. Fouling, cleaning and sanitization of membranes. Emulsions, foams and gels. Electrodialysis and ion exchange in dairy applications. Processing of cereals and legumes for incorporation in milk and milk products. Use of milk solids in bakery and confectionery products. Application of biotechnology in dairy industry.

Unit 11 : Legal and Quality Aspects for Milk and Milk Products

Safety aspects of milk with reference to mycotoxins, antibiotics, pesticides, weedicides and heavy metals. PFA, BIS and Agmark standards for milk and milk products. Quality systems such as HACCP, ISO certification, etc.

24. LIVESTOCK PRODUCTS TECHNOLOGY

Unit 1: Basic and General Aspects of Livestock Products

Composition and physico-chemical properties of cow and buffalo milk. Milk proteins, lipids, carbohydrates, minerals, vitamins and other minor constituents of milk. Nutritive value of milk. Reception of milk - platform tests, filtration and clarification, chilling, separation, standardization, pasteurization and homogenization. Cleaning and sanitation of dairy equipments.

Present status and future prospects of meat and poultry industry. Structure, composition, physical biochemical and nutritive aspects, and functional properties of different kinds of meat, fish, poultry and eggs. Sensory evaluation and organoleptic properties of livestock products. Postmortem aspects of muscle as meat. Ageing of meat and chemical changes. Meat in human health. Bacteria, yeasts, molds, parasites important in food microbiology. General principles of spoilage. Chemical and deteriorative changes caused by micro-organisms. Contamination and spoilage of meat, fish, poultry and eggs. Food poisoning and food-borne infections. Assessment of microbial condition and wholesomeness of different livestock products. National and International microbial standards.

Unit 2: Abattoir and Poultry Processing Plants

Origin and source of animal foods. Lay out, construction, design, organization, operation and maintenance of abattoirs and poultry processing plants. Pre-slaughter care and slaughtering techniques for different animals and birds. Antemortem and postmortem inspection. Judging and grading of animals and birds on foot and on rail. Condemnation and disposal of unfit material. Disposal of slaughterhouse effluents. Sanitation, plant operation and maintenance. Sanitary standards for meat packing plants. Meat cutting and deboning. Adulteration and misrepresentation of meat. State, municipal and other regulations pertaining to meat trade. Meat food products order. Processing and utilization of various animal and poultry by-products, slaughterhouse and poultry plant offals. Methods of utilization of blood, fat, hides and skin, horns, hooves, wool, hair, feather, glands and other by-products. Importance and utilization of by-products in industry, Application of computer science in abattoir operation. Robot technology and its application in meat and poultry industry.

Unit 3: Processing and preservation

Principles of processing of dairy products. Special milk: sterilized milk, flavoured milk, homogenized milk, soft curd milk, Vitaminized/irradiated milk, fermented milk, standardized milk, reconstituted/rehydrated milk, recombined milk, toned, double toned milk, skimmed milk, Humanized milk. Processing of dairy products: - butter, butter oil, icecream, cheese, cream, condensed milk, dried milk, dried milk products etc. Indigenous dairy products: ghee, khoa, dahi, makkhan, chhana, paneer, Khurchan, Lassi, Organic milk.

Principles of preservation of livestock products. Equipment and technology of processing and preservation. Industrial food preservation, chilling, freezing, freeze drying, dehydration, canning irradiation, pasteurization, curing, smoking, use of chemical additives and antibiotics. Cooking methods including micro-wave cooking. Tenderisation and use of enzymes for processed foods. Production of value added products, process methods, process optimization and quality control. Development and preservation self stable (canned and dehydrated) intermediate moisture, textured, cured, fermented fabricated meat and poultry products. Sanitation, regulation and

inspection of processed meat foods. Effect of processing on nutritional, chemical, microbiological and organoleptic qualities of livestock products. Economics of precosting and product development. Application of biotechnology in processing and preservation of meat, poultry and fish products. Bioactive products and biogenic amines.

Unit 4: Wool, Mohair and Fur

Basic aspects of wool science. Shearing, physical and chemical characteristics, processing, grading, standardization, storage and marketing of wool, mohair and fur (National and International).

Unit 5: Packaging

Principles of packaging. Types of packaging materials. Characterisation, methods and systems of packaging. Gas packing, Vacuum packing, modified atmosphere packing, shrink and stretch packing, industrial packaging. Aseptic and retort pouches. Standardisation and quality control of packaging material. Product attributes and packaging requirements for different livestock products. Latest trends in packaging of meat, poultry, eggs, wool and fish products.

Unit 6: Quality Control

Grades and grading of livestock products. Stress factors effecting meat quality – PSE, DFD, Hot boning, Cold shortening and electrical stimulation. Regulatory and inspection methods – Municipal and State laws. Bureau of Indian Standards and International Standards of fresh meat and poultry including their products and by-products. Detection of antibiotics, chemical residues, heavy metals and toxins in meat. Techniques for detection of adulteration of meat. HACCP concept of quality control of meat, fish, poultry and eggs.

Unit 7: Marketing

Livestock production and supply characteristics. Meat consumption and related demands. Types of market and trends in marketing livestock products and by-products, wholesale, retail and future trends. Consumer aptitude, education and awareness, and popularization of new products. Corporate bodies in regulation of markets, marketing boards, Co-operative agencies, internal trade and development of international market for livestock products. Organization, operation and sanitation of meat, poultry, fish and egg retailing units. Fast food chains and super markets. Situation and outlook and methods for promotion and marketing of livestock products.

25. LIVESTOCK PRODUCTION AND MANAGEMENT

Unit 1: General

Present status and future prospects of livestock and poultry development in India. Animal production systems in different agro-climatic zones of the country. Sustainability issue in relation to environment. Effect of industrialization and mechanization of agriculture on livestock sector. Breeds of cattle, buffalo, sheep, goat, pigs, equine, camels, rabbits and poultry. Various livestock and poultry development programmes operative in the country. Animal behaviour vis-à-vis adaptation and production. Principles of domestication and behavioral factors favouring domestication. Mating behaviour in various species of livestock and poultry. Agnostic behaviour – causes and control. Social order in farm animals. Adaptation of livestock and poultry in tropics, deserts cold and high altitudes. Mixed farming, arable farming, integrated and specialized farming systems. Biotechnology in animal improvement.

Unit 2: Breeding Management

Basic principles of inheritance. Concept of heritability, repeatability and selection. Important methods of selection and systems of breeding in farm animals and birds. Importance of maintaining breeding records and their scientific interpretation.

Unit 3: Feeding Management

Nutrients and their functions. Nutritional requirements and feeding managements of different categories of livestock and poultry. Feed additives including antibiotic and probiotic feeding in farm animals and birds. Formulation and compounding of rations for various categories of livestock and poultry. Least cost ration formulation. Systems of feeding livestock and birds. Feeding standards for livestock and poultry. Feed conversion efficiency of various categories of livestock and poultry. Processing and storage of conventional and non-conventional feed ingredients. Agro-industrial by-products in animal feeds.

Unit 4: Reproduction Management

Reproductive systems of farm animals and birds. Climate and nutrition affecting reproductive performance in farm animals. Importance of early pregnancy diagnosis. Methods of heat detection. Artificial insemination. Oestrous prediction and synchronization. Causes of disturbed fertility and its prevention in farm animals. Management factors affecting reproductive efficiency. Summer and winter management problems and their solutions.

Unit 5: Shelter Management

Housing systems, Selection of site and lay out of animal and poultry houses. Space requirement for livestock and poultry, Housing designs in different agro-climatic regions. Macro and micro- climatic changes affecting designs of animal and poultry houses. BIS (standards) for livestock and poultry housing. Construction of cheap animal and poultry housing utilizing local resources. Automation in livestock farming. Disposal of animal wastes under urban and rural conditions. Disposal of carcasses.

Unit 6: Health Management

General approach to livestock health programmes. Prevention of diseases. Hygiene and sanitation on animal farm. Symptoms of ill health, important infectious diseases of livestock and poultry and their control. Vaccination schedules in animals and

