# PG Syllabus

## DAIRY MICROBIOLOGY

### PG Courses

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tr>
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<tr>
<td>1</td>
<td>DM 611</td>
<td>Microbial Morphology and Taxonomy</td>
<td>2+1</td>
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<tr>
<td>2</td>
<td>DM 612</td>
<td>Microbial Physiology</td>
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<tr>
<td>3</td>
<td>DM-613</td>
<td>Microbiology of Fluid Milk and Dairy Products</td>
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<td>4</td>
<td>DM 614</td>
<td>Environmental Microbiology</td>
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<td>5</td>
<td>DM 615</td>
<td>Microbiology of Processed Dairy Foods</td>
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<td>Analytical Techniques in Microbiology</td>
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<td>7</td>
<td>DM 621</td>
<td>Starter Cultures and Fermented Dairy Products (revised in 38th meeting of AC)</td>
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<td>8</td>
<td>DM 622</td>
<td>Microbial Genetics</td>
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<td>Microbiological Quality Assurance</td>
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<td>DM 624</td>
<td>Probiotics for Health Foods</td>
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<td>DM-625</td>
<td>Research Techniques in Dairy Microbiology</td>
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<td>Advances in Microbiology Safety of Dairy Foods</td>
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<td>*DM-723</td>
<td><strong>Advances in Probiotics and Functional foods</strong></td>
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### Suggested Disciplines for Minor
- Dairy Chemistry
- Dairy Technology
- Animal Biochemistry

The contents of the following courses have been revised as approved in 29th meeting of Academic Council.

DM-614, DM-622, DM-623 and DM-722

(New course approved in 29th meeting of Academic Council):

DM-613 (Old DM- Course has been retained as DM-616), *approved in 38th meeting of AC on 12.2.2015
DM-611 Microbial Morphology and Taxonomy

Objective
To educate about the taxonomy and morphological features of the various microorganisms, viz., bacteria, fungi and viruses.

Theory
Unit I
Evolution of life on earth, history and diversity of microorganism

Unit II
Principles of classification and taxonomy of Eubacteria (Bacteria and Archaea): Major characteristics used in taxonomy: Cultural, Morphological, Biochemical, Physiological, Genetic and Molecular Characteristics; Numerical Taxonomy (Taxometrics) and Chemotaxonomy. Assessing Microbial Phylogeny: Chronometers. Phylogenetic trees, r-RNA, DNA and proteins as indicators of phylogeny.

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

Unit IV
Fungi: Distribution, Importance and recent Classification, Study of Yeasts and Moulds in Dairy Foods

Unit V

Practical
- Simple and differential staining; gram, spore, acid-fast staining, cell wall, flagella, nucleoids, capsule, and inclusion/storage bodies
- Preparation of bacterial protoplasts and spheroplasts
- Measuring dimensions of microorganisms (bacteria) using micrometry
- Study of morphology of fungi
- Detection and enumeration of bacteriophages in Cheese whey
- Application of computer software in bacterial identification
- Electron microscopic observation of Ultra-structure of Microbial Cell(Demonstration)

Suggested Readings
Manual of Determinative Bacteriology (9th edition). Williams and Wilkins, Baltimore, Maryland, USA.


List of Journals
- Antimicrobial Agents and Chemotherapy
- Applied and Environmental Microbiology
- Cellular Microbiology
- Eukaryotic Cell
- FEMS Microbiology Reviews
- FEMS Microbiology Letters
- Fungal Genetics and Biology
- Journal of Bacteriology
- Journal of Microscopy
- Journal of Virology
- International Journal of Systematic and Evolutionary Microbiology
- Letters in Applied Microbiology
- Microbiology: Bacteriology, Mycology, Parasitology and Virology
- Molecular and Cellular Biology
- World Journal of Microbiology and Biotechnology

Broad Topics for Master's and Doctoral Research
- Bioprospecting of dairy foods and related environment for identification, characterization and classification of prevailing microbiota
- Study of ultra-structure of spore forming and non-spore forming dairy/food microorganisms with the help of electron microscopy
- Detection of phages in dairy and food environment
- Study of mode of action of antibacterial substances on cellular organelles.
- Study of biofilms formation in milk handling and dairy processing environment.

DM-612 Microbial Physiology

Objective
To familiarize the student with the various aspects of growth and energy generating activities of bacteria for the betterment of human life.

Theory
Unit I
Bacterial growth: growth phases and kinetics, synchronous, continuous, and associative growth; factors affecting bacterial growth; growth measurement.
Unit II
Effect of environment on the growth of bacteria: temperature, air, osmotic pressure, pH, hydrostatic pressure, surface tension, metals, electromagnetic and other waves, sonics, various chemicals; their application in dairy industry; mechanisms of action of antimicrobials.

Unit III
Bacterial nutrition; nutrient media; nutritional groups of bacteria; role of growth factors; active and passive transport.

Unit IV
Electron transport chain: Electron transport chain; fermentation, respiration and photosynthesis

Practical
- Measurement of bacterial growth by direct methods (cell number, SPC, DMC) and indirect methods (turbidometric methods, MPN, cell mass).
- Preparation of growth curve; determination of generation time.
- Determination of cell activity; carbohydrate fermentation; acid production/pH alteration; starch, lipid, casein and gelatin hydrolysis.
- Effect of different factors viz., physical (temperature, pH, osmotic pressure, surface tension), chemical (dyes, antibiotics, phenol) and nutritional (amino acid supplements, vitamin supplements, protein hydrolysates, casamino acids) on bacterial growth.

Suggested Reading

http://www.sciencedirect.com/science/bookseries/00652911

List of Journals
- Advances in Microbial Physiology
- Antonie van Leeuwenhoek
- Applied and Environmental Microbiology
- Applied Microbiology and Biotechnology
- Archives of Microbiology
- Bioscience, Biotechnology and Biochemistry
- Current Microbiology
- Enzyme and Microbial Technology
- Food Microbiology
- Food Research International
- International Dairy Journal
- Indian Journal of Dairy and Biosciences
International Journal of Food Microbiology
International Journal of General and Molecular Microbiology
Journal of Applied Microbiology
Journal of Bacteriology
Journal of Biotechnology
Journal of Food Protection
Microbiological Research
Process Biochemistry
Systematic and Applied Microbiology

**Broad topics for Master's and Doctoral Research**

- Alternative methods of microbial quantification
- Development of indicators and biosensors from microbial metabolites
- Energy metabolism
- Formulation of novel pharmaceuticals and neutraceuticals
- Microbial stress metabolism and ecosystem
- Harnessing the potential of microbial growth in environmental depollution
- Use of microorganisms in conversion of food wastes in preparation of newer foods

**DM-613 Microbiology of Fluid Milk and Dairy Products** (2+1)

*(News course approved in 29th meeting of Academic Council)*

**Objective:** To impart current knowledge of basic and applied microbiological aspects of fluid milks and dairy products for improved quality and food safety.

**UNIT-I: Raw milk**


**UNIT-II: Processed milks:**

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

**UNIT III: Fat rich, frozen, concentrated and dried dairy products:**

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

**UNIT IV: Indigenous dairy products**  
(7)

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

**UNIT V: Pathogens in milk and dairy products**  
(4)

Definition of food poisonings, food infections and toxi-infections, pathogens associated with fluid milks, dairy products and their public health significance. Sources of pathogens and their prevention. Importance of biofilms, their role in transmission of pathogens in dairy products and preventive strategies.

**Practical:**

1. Grading of raw milk based on SPC, coliform and dye reduction tests.  
2. Effect of different storage temperatures on microbiological quality of fluid milk  
3. Tests for mastitic milk and brucellosis  
4. Microbiological quality evaluation of cream and butter for yeasts & molds, lipolytic and proteolytic bacteria.  
5. Detection of *Enterobacter sakazakii* in infant dairy foods.  
6. Microbial evaluation of Burfi and Peda for SPC, yeast and mould counts.  
7. Detection of *Bacillus cereus*, *Salmonella*, *Shigella* and coagulase positive staphylococci in milk powder  
8. Evaluation of ice cream for coliforms and *E. coli*  
9. Microbiological quality of *Paneer*  
10. Enumeration of aerobic and anaerobic spores in condensed and sterilized milk.  
11. Line testing for determining the source of contamination of dairy products.

**Suggested Readings:**

**TEXT BOOKS:**

DM-614: Environmental Microbiology (Revised in 29th meeting of AC) (2+1)

Objective
To understand the fundamentals of environmental microbiology and role of microorganisms in combating the organic pollutants in the environment.

Theory
Unit I: Microbes as component of environment
Environmental microbiology; soil as a microbial environment, microbes in surface soils and subsurface environments; Aero-microbiology; airborne pathogens, toxins, aerosols, nature and control of bio-aerosols, aero-microbiological pathway, microbial survival in air, extramural and intramural aero-microbiology; Aquatic environments and microbial habitats.

Unit II: The extreme environment and sampling
Extreme environments, low and high temperature, desiccation, UV stress, pH and environment based on chemoautotrophy; Environmental sample collection; strategies, methods, processing and storage of soil and water sample for the detection of bacteria and phages; Mechanism for the collection of air samples; Cultural methods for isolation and enumeration of bacteria and fungi.

Unit III: Biogeochemical cycling of elements
Biogeochemical cycles; carbon cycles (fixation, energy flow and respiration), nitrogen cycle (fixation, ammonia assimilation, nitrification and nitrate reduction) sulfur cycle (assimilatory sulphate reduction, sulphur mineralization, oxidation and reduction), iron cycle (in soil, sediments and marine environment); Microbially influenced metal corrosion, acid mine drainage, metal recovery and desulfurization.

Unit IV: Biodegradation and bioremediation
Microbes and organic pollutants; environmental laws and issues concerning release of genetically engineered microbes, biodegradation process, contaminant structure and toxicity (genetic potential and bioavailability), factors affecting biodegradation (redox conditions, organic matter composition, nitrogen etc); biodegradation of organic pollutants, bioremediation (addition of oxygen, nutrient, surfactant, microbes etc).

Unit V: Transmission of pathogens and treatment of wastes
Environmentally transmitted microbial pathogens (Salmonella, E. coli, Campylobacter Yersinia etc) and viruses (enteric and respiratory), Indicator microorganisms (concept, total
and fecal coliforms, fecal streptococci, bacteriophage etc). Solid wastes management and waste water treatment and bio-solids reuse in food and dairy industry.

**Practical**

1. Determination of composite micro-flora (i.e. total bacteria, coliforms, yeasts and moulds etc) of selected environmental samples from soil
2. Estimation of micro-flora (i.e. total bacteria, coliforms, yeasts and moulds etc) of selected environmental samples from water
3. Study of micro-flora (i.e. total bacteria, yeasts and moulds etc) of selected environmental samples from air
4. Isolation of dye degrading bacteria from the selected environmental samples
5. Enrichment and isolation of plastic degrading microorganisms from environmental samples
6. Isolation of industrial effluent degrading microorganisms from environmental samples
7. Characterization of bio-indicators from the environmental samples (total coliforms, faecal enterococci, and heterotrophic plate counts; total coliforms through MPN method; bacteriophage isolation etc)
8. Determination of biochemical oxygen demand in waste water sample
9. Visit to a sewage or an industrial effluent treatment plant

**Suggested Readings**

- Maier RM, Pepper IL and Gerba CP 2009 Environmental microbiology. Elsevier Academic press, USA.
- Mitchell R 1995 Introduction to environmental microbiology. 8th Ed. Prentice-Hall of India (P) Ltd., New Delhi, India.

**List of Journals**

- Applied and Environmental Microbiology
- Environmental Microbiology
- FEMS Microbiology Ecology
- FEMS Microbiology Reviews
- Archives of Environmental Health
- Critical Reviews in Environmental Science and Technology
- Environmental Microbiology
- Environmental Monitoring and Assessment
- Environmental Research
- International Journal of Environment and Pollution
- Science of the Total Environment
Objective
To understand microbiology of processed foods, significance of different food microorganisms, their control and other related aspects.

Theory:
UNIT-I
Introduction to microbes in processed dairy foods, history and development of processed foods. Microorganisms important in processed foods: spoilage and pathogens, Food borne new emerging pathogens, Microbial ecology of processed foods and food ecosystem, biofilm formation, Factors influencing microbial growth in foods: Intrinsic factors, Extrinsic factors

UNIT-II
High temperature food preservation, factors affecting heat resistance in microorganisms, thermal destruction of microorganisms, low temperature food preservation, food preservation by irradiation; food preservation by drying and fermentation, modern processing techniques-ohmic heating, hpp, infra-red heating, cold plasma, pulse electric field, ultra sound etc., biopreservation of foods; concepts: metabolites of Lactic Acid Bacteria; bacteriocins, Antifungal substances etc., biopreservation of foods : protective cultures and other antimicrobials (herbs, spices and other natural antimicrobial compounds), Nanoscience in food preservation; microencapsulation.

UNIT-III
Microbial stress response in the food environment; stress adaptation, sublethal stress & injury, antibiotic resistance in food bacteria, predictive modelling for food spoilage, industrial strategies for ensuring safe foods, HACCP; GMP etc.,

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

UNIT-V
Functional foods and nutraceuticals, functional fermented foods, bioactive proteins and bioactive peptides, genetically modified foods

PRACTICAL
D and z-value calculation of common food pathogens, production of antimicrobial substances-bacteriocin, production of antifungal substances, application of bacteriocins for biopreservation of foods, application of hurdle concepts for enhanced shelf stability of processed foods, induction of bacterial cell injury and recovery of injured cells, antibiotic resistance of food pathogens, recent and rapid methods for food pathogen detection.

Suggested Readings
• Robinson, R. K. 1998. Developments in Food Microbiology Vol. 1, 2 and 3, Elsevier Applied Sciences, New York, USA
• Motville, T.J. and Matheurs, K.R. Food microbiology: An Introduction

List of Research Journals
• International Journal Food Microbiology
• Food microbiology
• Journal of food science and technology
• Applied and Environmental microbiology
• International Journal of Dairy Technology
• British Journal of Nutrition
• International Journal of Food Science and Nutrition
• Trends in Food Science and Technology

Broad Topics for Master's and Doctoral Research
• Novel bacteriocins of lactic acid bacteria
• Anti microbial packaging and MAP of foods
• Stress induced injury: mechanism and application in hurdle technology
• Genetic modification of food through the use of food grade vectors
• Rapid method for detection and identification of food pathogens

Analytical Techniques in Microbiology (2+2)
(This was the old course as DM-613, retained as DM-616 as approved in 29th meeting of Academic Council.)

Objective
To impart knowledge and skills related to microbiological analytical systems in microbiology and related sciences

Theory
Unit I
Microscopy: principles, design and functions of bright field, dark field, phase contrast and fluorescence microscope; principle, design and application of transmission and scanning electron microscopes for the study of sub-cellular organization and microstructure of dairy foods

Unit II
Techniques for protein analysis and other molecular separation: electrophoresis, chromatography, ultracentrifugation; Enzyme analyses and substrate determination methods

Unit III
Molecular Biology Techniques for nucleic acid analysis: amplification, investigation of mutations and gene expression

Unit IV
Aerobic and Anaerobic culturing techniques for isolation of obligate and facultative organisms
Unit V
Use of animal models in toxicity studies

Practical

- Familiarization with the construction and design of a compound microscope; use of light microscope accessories; microscopic analysis of different types of bacteria by bright field and dark field; phase contrast and fluorescence microscopes
- Disruption of bacterial cells by ultra-sonification
- Demonstration of chromatographic techniques
- Demonstration of aerobic and anaerobic culturing techniques
- Demonstration of use of animal models in toxicity studies,
- Demonstration of PCR technique as a tool for identification and characterization of microorganism

Suggested Readings


List of Journals

- Annals of Clinical Biochemistry
- Antimicrobial Agents and Chemotherapy.
- British Medical Journal.
- Clinical Chemistry.
- Clinical Chemistry and Laboratory Medicine
- Clinica Chimica Acta
- Current Advances in Clinical Chemistry
- Current Contents
- European Journal of Clinical Microbiology and Infectious Diseases
- Journal of Biological Chemistry
- Journal of Chromatography A
- Journal of Clinical Microbiology
- Nature
- New England Journal of Medicine
- Scandinavian Journal of Clinical and Laboratory Investigation
- Science
Broad Topics for Master's and Doctoral Research

- Fermentation Studies for cultivation of lactic acid bacteria
- Study of probiotic organisms by growing them under anaerobic conditions and their identification by PCR method
- Study of production of functional biomolecules by lactic acid bacteria
- Animal studies of functional attributes of dairy organisms
- Detection of pathogens by molecular biological methods

DM-621 Starter Cultures and Genetic Improvement  (2 + 1)

Objective
To familiarize the students with the starter organisms, their metabolism and genetics; different types of starters, propagation, preservation and applications of starters.

Theory
Unit 1
Introduction and annual utilization of starter cultures; History and taxonomy of starter cultures; Classification of starter organisms: The genus Lactococcus; The genus Leuconostoc; The genus Streptococcus; The genus Pediococcus, The genus Lactobacillus.

Unit 2
Adjunct starter organisms; The genus Bifidobacterium; The genus Enterococcus; The genus Propionibacterium; The genus Brevibacterium. Miscellaneous microorganisms: Molds and yeasts.

Unit 3
Metabolism of starter Organisms: biochemical characterization of lactic acid bacteria; carbohydrate, citrate and protein metabolism of starter cultures.

Unit 4.
Genetics of starter cultures: plasmids and plasmid instability; industrially significant genes and systems; genetic modification of lactic acid bacteria through transduction; conjugation; protoplast transformation; electroporation and chromosomal integration, transposons and insertion sequences.

Unit 5.
Starter types: single, mixed and multiple strain starter cultures; propagation and preservation of starter cultures; commercial starter preparations: concentrated and super-concentrated starters;

Unit 6.
Growth inhibition of lactic acid bacteria by antibiotics, bacteriocins; immunoglobulins and bacteriophage: sources, types and characteristics of phages associated with starters, phage control during starter handling and growth, mechanisms of phage resistance in LAB.

Unit 7.
Probiotic cultures, health and nutritional benefits, requirements for ability to survive and grow in the intestine, control of intestinal infections. role of starter cultures in cheese making and ripening of different cheese varieties;
Practical

- Isolation of lactococcal cultures from fermented milks.
- Examination of purity and activity of starter cultures.
- Preservation of starter cultures by freeze drying and other methods.
- Preparation of concentrated starters and quality evaluation.
- Inhibition of starters by antibiotic residues and other inhibitors.
- Plasmid profiles of some lactococcal cultures.
- Identification of lactic starters by molecular biology techniques (demonstration).
- Conjugal transfer of plasmids in lactococci. (demonstration).
- Production of bacteriocins by LAB.

Suggested Readings


List of Journals

- Journal of Dairy Science
- International Dairy Journal
- Dairy Science and Technology (Le Lait)
- International Journal of Dairy Technology
- Journal of Dairy Research
- World Journal of Dairy and Food Sciences
- Journal of Food Science
- International Journal of Food Microbiology
- Food Microbiology

Broad Topics for Master's and Doctoral Research

- Regulation of metabolism for lactic acid and flavour production
- Genotypic heterogeneity and diversity of microorganisms in fermented dairy foods.
- Phage resistance in lactic acid bacteria
- Defined strain cultures for indigenous fermented milks
- Plasmid borne genes, chromosomal integration and technological properties of LAB
DM – 622 Microbial Genetics (2+1) (revised in 29th AC)

Objective
To understand the basic principles of microbial genetics with regard to DNA structure, replication and expression as well as to expose the students to recombinant DNA technology

Theory
Unit I: DNA structure and replication
Macromolecules: DNA, RNA, their structure, types, organization, function and their properties, DNA replication (4)

Unit II: Regulation of gene expression
Gene Expression and its regulation in Prokaryotes - Transcription; Genetic Code; Translation; Negative and positive regulation of gene expression; Operon Models (lac and trp operon) (7)

Unit III: Mutations
Mutations, Spontaneous and induced mutations, Types of mutations, Mutagenic agents - Physical and Chemical; Damage and Repair systems operating in prokaryotes (4)

Unit IV: Plasmids and Gene transfer systems
Plasmids and their properties; transposable elements; Bacterial Recombination - Transformation, Conjugation and Transduction (5)

Unit V: Recombinant DNA technology
Fundamental aspects of Genetic Engineering / recombinant DNA technology - Restriction enzymes, Plasmid Vectors (cloning as well as expression vectors), PCR and Real Time PCR, Application of genetic engineering in dairy and food industry (12)

Practical
- Isolation and quantitative estimation of chromosomal DNA from E. coli and Lactobacillus by mini prep method. (4)
- Isolation of plasmid DNA from E. coli by miniprep method. (3)
- Calcium chloride induced transformation of E. coli hosts with plasmids (2)
- Induction of random mutations in E. coli / Lactobacillus either by UV irradiation or chemical mutagens (2)
- Digestion of plasmid DNA with restriction enzymes and ligation into plasmid vector for transformation (2)
- PCR based detection of microorganisms (2)
- Demo of Real Time PCR machine (1)

Suggested Reading:
To impart current knowledge pertaining to Quality Assurance, Food Safety Standards, Biosafety, product/process criteria, enumeration and legal product standards.

Theory

Unit-1 Biosafety Concepts in Food Laboratory
Definition, biosafety concept, principles and safety levels; Biosafety level (BSL) -1-4, containment design and layout; Standard microbiological practices, safety equipments (primary barrier), facility design (secondary barrier), air handling units, High Efficiency Particulate air filter (HEPA); Medical surveillance criteria and biological waste disposal; Legal requirements for establishing bio-safety laboratory for handling dairy and food pathogens; aseptic techniques

Unit-2 General Principles for Establishment of Microbiological Criteria
Definition, purpose and components of Microbiological criteria; Mandatory and advisory criteria; Sampling methods - Two and three class sampling plan as per International council for microbiological standards for foods (ICMSF); Establishment of microbiological standards, guidelines and specifications for different dairy and other foods recommended by ICMSF, Codex, Prevention of Food Adulteration Act (PFA), Bureau of Indian Standards (BIS).

**Unit-3 Enumeration and Detection of Quality Indicators**

Definition; Selection criteria of Indicator Organisms as an index of Food Quality; Conventional detection methods for indicator organisms – Standard plate Count (SPC), coliforms, *E. coli*, Yeast and Mold Counts (YMC), Spore counts; Enterobacteriaceae count; faecal streptococci count; Dye reduction tests; Rapid Techniques including commercial kits for hygiene indicators – 3-M Petrifilm; D-count etc.

**Unit-4 Enumeration and Detection of Safety Indicators**

Definition; Selection criteria of Indicator Organisms as an index of Food Safety; Conventional detection methods including commercial detection kits for safety indicator organisms– *Staphylococcus aureus; B. cereus; pathogenic E.coli; Salmonella; Shigella; Listeria monocytogenes; Enterobacter sakazakii; Sulphite reducing Costridia (SRC) Campylobacter jejuni.* Rapid techniques for safety indicators – Enzyme assay; PCR; Lateral flow assay; VIDAS etc.

**Unit-5 Bio-sensors and their role in rapid monitoring of contaminants in Food Industry**

Definition, history, basic characteristics of Bio-sensors; classification based on bio-recognition molecule–Microbial, spore, Aptamer, DNA, Immune and enzyme etc.; biosensors based on Transducers–Electrochemical, Optical, Mechanical and Calorimetric etc.; Current R & D and commercial biosensors for detection of Hygiene indicators, pathogenic bacteria and other non-microbial contaminants like antibiotics, pesticides, heavy metal, mycotoxins in milk and others foods.

**Unit VI**

Public health concern associated with milk and milk products; type of microbial spoilage, defects and control measures.

**Practicals**

1. Lay out designing of BSL-2 containment and its working for pathogen handling in dairy and other food laboratory (1)
2. Aseptic technique and operation of in-built autoclave for ensuring sterility of media (1)
5. Conventional methods for enumeration of safety indicators in Dairy and other foods- *S. aureus; B. cereus; pathogenic E.coli; Salmonella; Shigella; L. monocytogenes; E. sakazakii; SRC; Campylobacter jejuni* (4)
6. Rapid Tests for safety assessment of dairy and other foods using Enzyme assay; PCR; Lateral flow assay; VIDAS etc., (3)
7. Rapid tests for detection of antibiotics, aflatoxin M1 and pesticides in milk – Microbial inhibition based assay, charm assay, ROSA test (3)
Suggested Readings


List of Journals

1. Food Control
2. Food Microbiology
3. Food Microbiology and Food Safety Journals
4. International Journal of Food Microbiology
5. Journal Microbial food safety standards
6. Journal of Food Protection
7. Journal of Food safety
8. Journal of rapid methods and automation in Microbiology
9. Biosensors and Bioelectronics
Objective: To impart current knowledge of probiotics, prebiotics and functional dairy foods for the health benefits.

1. **Probiotics:** Introduction and history of Probiotics, Probiotic microorganisms, safety of probiotic microorganisms, legal status of probiotics.

2. **Characteristics of Probiotics for selection:** Tolerance to additives, stability during storage, stability during passage to intestinal sites, minimum effective dose, maintenance of probiotic microorganisms.

3. **Role of probiotics in health and disease:** Prevention and treatment of gastrointestinal bacterial infection, treatment and prevention of constipations, treatment of hepatic encephalopathy, chronic urinary tract infection, antitumor and antihypertensive, cholesterol level.

4. **Mechanism of probiotics:** Complete exclusion, production of antimicrobial substances, modulation of immune system, alteration of intestinal bacterial metabolite action, alteration of microecology of healthy humans and patients.

5. **Prebiotics:** Concept, definition, criteria, types and sources of prebiotics, prebiotics and gut microflora.

6. **Prebiotics and health benefits:** Mineral absorption, immune response, cancer prevention, IBD, elderly health and infant health, prebiotics in foods.

7. **Functional Dairy Products:** Definition, fermented milk products, functional dairy products, functional dairy products and therapeutic applications.

8. **Health benefits of functional fermented dairy products:** Such as dahi, lassi, yoghurt, kefir, cheese, kefir, koumiss, Yakult, fermented whey drinks, and dairy based cereal foods, soy based yoghurt containing probiotics.

9. **Health benefits of functional Dairy products:** Cancer, coronary heart disease, osteoporosis, food allergy management, immune modulation.

10. **Bioactive peptides released in fermented milk:** Role and function of proteolytic, probiotic LAB, biological activities of milk protein derived BAP.

11. **Functional dairy ingredients:** CPP, Oligosachcharides, LAB, CLA,

12. **Product development:** Enhancing functionality of prebiotics and probiotics.

Practicals.

- Evaluation of LAB for probiotic attributes.
- Growth of probiotic LAB in broth, milk and whey.
- Preparation of probiotic fermented milks like dahi, yoghurt, lassi and whey drink.
- Effect of prebiotics on the growth of LAB in milk and broth.
- Survivability of probiotic organisms in fermented milks.
- Antimicrobial potential of the functional dairy products.
- Functional properties of probiotic containing fermented dairy products.

Suggested readings

- Salminen. S and Wright. A. V. 1998. Lactic Acid Bacteria, Marcel Dekker
DM-625 Research Techniques in Dairy Microbiology

Objective
To impart knowledge and skills related to microbiological analytical systems in microbiology and related sciences

Theory
Unit I
Microscopy: principles, design and functions of bright field, dark field, phase contrast and fluorescence microscope; principle, design and application of transmission and scanning electron microscopes for the study of sub-cellular organization and microstructure of dairy foods

Unit II
Techniques for protein analysis and other molecular separation: electrophoresis, chromatography, ultracentrifugation; Enzyme analyses and substrate determination methods

Unit III
Molecular Biology Techniques for nucleic acid analysis: amplification, investigation of mutations and gene expression

Unit IV
Aerobic and Anaerobic culturing techniques for isolation of obligate and facultative organisms

Unit V
Use of animal models in toxicity studies

Practical
• Familiarization with the construction and design of a compound microscope; use of light microscope accessories; microscopic analysis of different types of bacteria by bright field and dark field; phase contrast and fluorescence microscopes
• Disruption of bacterial cells by ultra-sonification
• Demonstration of chromatographic techniques
• Demonstration of aerobic and anaerobic culturing techniques
• Demonstration of use of animal models in toxicity studies,
• Demonstration of PCR technique as a tool for identification and characterization of microorganism

Suggested Readings

List of Journals
• Annals of Clinical Biochemistry
• Antimicrobial Agents and Chemotherapy.
• British Medical Journal.
• Clinical Chemistry.
• Clinical Chemistry and Laboratory Medicine
• Clinica Chimica Acta
• Current Advances in Clinical Chemistry
• Current Contents
• European Journal of Clinical Microbiology and Infectious Diseases
• Journal of Biological Chemistry
• Journal of Chromatography A
• Journal of Clinical Microbiology
• Nature
• New England Journal of Medicine
• Scandinavian Journal of Clinical and Laboratory Investigation
• Science
• The Lancet

Broad Topics for Master’s and Doctoral Research
• Fermentation Studies for cultivation of lactic acid bacteria
• Study of probiotic organisms by growing them under anaerobic conditions and their identification by PCR method
• Study of production of functional biomolecules by lactic acid bacteria
• Animal studies of functional attributes of dairy organisms
• Detection of pathogens by molecular biological methods
DM-711: Microbial Diversity and Physiology (3+0)

Objective
To understand the advances in microbial diversity and physiology for its interface with all other branches of microbiology.

Theory
Unit I
Bacterial growth: cell division, phases of bacterial growth, factors affecting microbial growth, kinetics of growth, continuous culture system, diauxic and synchronous growth, advances in growth measurement.

Unit II
Prokaryotic cellular structures, biosynthesis of bacterial cell-wall, enterobacterial common antigens, role of membrane in regulation of cell-wall and DNA synthesis, physiology and genetic aspects of sporulation.

Unit III

Unit IV
Membrane transport systems: types of transport: ion transport, iron transport, simple diffusion, facilitated diffusion, active transport, mechanosensitive channel, ATP binding cassette transporter family, chemiosmotic driven transport, phosphotransferase system.

Unit V
Environmental selection and microbial stress response: osmotic stress, aerobic to anaerobic transitions, oxidative stress, pH stress and acid tolerance, thermal stress and nutritional stress, extremophiles.

Practical
Not applicable.

Suggested Readings
- Caldwell RD 1999 Microbial physiology and metabolism. WCB publishers.
- White D 2006 The Physiology and Biochemistry of Prokaryotes. 3rd Ed. Oxford University Press, USA.
- Rhodes PM and Stanbury PF 2008 Applied microbial physiology: a practical approach.

List of Journals
- Advances in Microbial Physiology
- Advances in Applied Microbiology
- Annals of Microbiology
- Annual Review of Microbiology
Applied Biochemistry and Microbiology
Archives of Microbiology
Cellular Microbiology
Critical Reviews in Microbiology
FEMS Microbiology Reviews
Journal of Basic Microbiology
Journal of General and Applied Microbiology
Journal of Industrial Microbiology and Biotechnology
Journal of Molecular Microbiology and Biotechnology
Microbiology and Molecular Biology Reviews
Trends in Microbiology

**Broad Topics for Master's and Doctoral Research**

- Effect of natural environment on microbial growth and production.
- Studies on bacterial growth kinetics in batch and continuous culture systems.
- The biochemical and genetic regulatory mechanism of sporulation.
- Effect of different nutrients on the growth and production of microorganisms.
- Nutrient transport systems through cell-membrane of yeast and bacteria.
- Metabolic engineering

**DM-712 Advances in Microbial Genetics (3+0)**

**Objective**
To familiarize the students with basic concepts of Microbial Genetics and impart them knowledge in advancements of Microbial Genetics and Genetic Engineering

**Theory**

**Unit I**
Essentials of Microbial Genetics – Introduction, Historical perspective and principles; Nucleic Acids: Structure and Function of DNA and RNA; DNA Replication – Recent models; Genetic Code

**Unit II**
Mutations – Spontaneous and Induced mutations; Types of mutations; Mutagenic agents - Physical and Chemical; Molecular basis of Mutagenesis; DNA Damage and Repair – Molecular Mechanisms; Site Directed Mutagenesis – Methods of directed mutagenesis, mechanism and applications

**Unit III**
Gene Expression – Transcription, Translation and Regulation of Gene Expression - Operon models (Lac, Gal and Trp)

**Unit IV**
Plasmids – Structure and replication; Transposable elements – IS and Tn elements; molecular mechanism of transposition; Genetic Recombination: Transformation, Transduction and Conjugation; Recombination methods as a tool for Gene mapping

**Unit V**
Genetic Engineering / rDNA – Principles of recombinant DNA technology; Restriction Enzymes – Types, Mode of action and application as a tool for gene manipulation, Vectors –
Cloning and expression vectors; PCR cloning, Microarray technology, Gene Silencing and Gene knock out

Suggested Reading
- Michael R. Dyson and Yves Durocher 2007 Expression systems; Scion Pub. Ltd.
- Dale, J and Schantz, M. V. 2002. From gene to genome: concepts and application of DNA technology. New John Wiley and Sons, USA
- Malacinski, G. M. 2003. Essentials of Molecular Biology (4th ed), Jones and Bartlette Publishers, Massachusetts, USA

List of Journals:
- Gene
- Genome
- Plasmid
- Science
- Nature
- Nature Biotechnology
- PNAS
- Molecular and Cell Biology
- Applied and Environmental Microbiology
- Journal of Molecular Microbiology and Biotechnology
- Microbiology and Molecular Biology Reviews
- Applied Biochemistry and Microbiology

Broad Topics for Master's and Doctoral Research
- Cloning and Expression of prokaryotic and Eucaryotic genes in E. coli and yeast systems
Recombinant proteins / enzymes for application in food / dairy industry
Genomics and Proteomics of lactic acid bacteria
Biodiversity of Indian probiotic cultures
Understanding probiotic functionality at molecular level and role as potential probiotic markers
Food grade vector systems
Whole genome shuffling / DNA / Family shuffling
Molecular diagnostics for detection and identification of food pathogens and dairy micro-organisms

DM-721 Advances in Dairy and Food Microbiology (3+ 0)

Objective
To study and understand the current trends and recent concepts related microbiology of dairy and other foods products.

Theory
Unit I
Lactic acid bacteria and food fermentations important metabolic pathways of microorganisms; current status of metabolism of starters cultures; current trends in lactic starter for industrial applications, novel starter preservation techniques.

Unit II
Modern concepts in cheese ripening; Bacteriology and starter rotations, improving starter cultures for food fermentation by genetic manipulation, recombination technology.

Unit III
Bacteriocins of lactic acid bacteria, structure, function transport and mode of action; Application of bacteriocins in foods Biopreservation.

Unit IV
Current trends in food safety; newly emerging pathogens; Ecology and survival strategy of pathogens in foods. Novel technology in control of food based pathogens. Concepts in food toxicology; food borne toxins, current concepts in food quality and safety management

Suggested Readings
- DeVyust and Vandamme. 2000. Bacteriocins of lactic acid Bacteria.
Broad Topics for Master's and Doctoral Research

- Novel bacteriocins of LAB
- Genetic modification of LAB
- Genetic improvement of starter cultures
- Newly emerging pathogens - rapid method of identification
- Food toxins - bioremediation
- Metabolic engineering of LAB

List of Journals

- International Journal Food Microbiology
- Food microbiology
- Journal of food science and technology
- Applied and Environmental microbiology
- International Journal of Dairy Technology
- British Journal of Nutrition
- International Journal of Food Science and Nutrition
- Trends in Food Science and Technology

DM- 722: Advances in Microbial Safety of Dairy Foods (3+0)
(Revised in 29th AC)

Objectives

To impart current knowledge pertaining to microbial risk assessment of dairy pathogens and their safety concern in dairy foods.

Theory

Unit 1

Milk borne diseases, epidemiology and surveillance in dairy products: Current trends, incidence and surveillance of milk borne diseases; Changing patterns in epidemiology, agricultural and food manufacturing practices, transmission and susceptibility.

Unit II

General mechanism of microbial pathogenesis: Food borne infection by colonization and adhesion factors like pilli or fimbriae, adhesion proteins, biofilm formation; Invasion and intracellular residence; Phagocytosis, invasion mediated induced phagocytosis; Iron acquisition; Motility and chemotaxis, invasion of immune system; Intoxication; Toxin-infection, structure and function of exotoxins and endotoxin; Genetic regulation and secretory system for virulence factors.

Unit III

Risk assessment of dairy pathogen: Growth and survival characteristics of dairy pathogens namely E. coli, Cronobacter (Enterobacter) sakazaki, Salmonella, Shigella, Yersinia enterocolitica, Streptococcus sp., L. monocytogenes, Mycobacterium avium subsp. paratuberculosis, Brucella sp., Campylobacter jejuni, Staphylococcus aureus, Bacillus cereus, Clostridium perfringens, toxigenic fungi and viruses in milk and milk products, their pathology of illness, mode of transmission, incidence of illness, virulence and infectivity.
Unit IV

Microbiological risk profile of dairy foods; Hazard identification and characterization in dairy products; Evidence of antimicrobial resistant bacteria in milk and milk products; Risk factors affecting microbial safety of raw and processed dairy foods; Exposer assessment and risk characterization; Attribution of food-borne illness to dairy products; Risk management issues and control strategies for dairy products.

Suggested Readings

1. Bhunia AK 2008 Foodborne Microbial Pathogens: Mechanisms and Pathogenesis. Purdue University West Lafayette, IN, USA.
7. Marth EH and Steele JM 2001 Applied Dairy Microbiology. 2nd Ed. Marcel Dekker, Newyork, USA.

List of Journals

1. Microbial Pathogenesis
2. Epidemiology and Infection
3. Journal of Food Safety
4. Journal of Food Protection
5. Journal of Infectious Disease
6. Food Microbiology And Food Safety Journals
7. Indian Journal of Public Health
9. Journal of Veterinary Public Health
<table>
<thead>
<tr>
<th>Semester-wise break up of course allotment to M.Sc. Dairy Chemistry Students</th>
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<tbody>
<tr>
<td><strong>Dairy Chemistry</strong></td>
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Semester-wise break up of course allotment to Ph.D. Dairy Chemistry Students (2009-2010)

<table>
<thead>
<tr>
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<th>Course No.</th>
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<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>DC-711</td>
<td>Advances in chemistry of milk protein</td>
<td>3+0</td>
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<tr>
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<td>DC-712</td>
<td>Advances in chemistry of milk lipid</td>
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<td>3</td>
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<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>DC-713</td>
<td>Advances in Chemistry of functional dairy foods and nutraceuticals</td>
<td>3+0</td>
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<td>DT-711</td>
<td>Advances in lipid technology</td>
<td>3+0</td>
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<td>DC-721</td>
<td>Advances in Chemistry of Milk Processing</td>
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<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>DC-722</td>
<td>Advances in Analytical Techniques in Dairy Chemistry</td>
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<td>DM-721</td>
<td>Advances in Dairy &amp; Food Microbiology</td>
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<td>Product Monitoring and Process Control</td>
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<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>DT-722</td>
<td>R&amp;D Management in Dairy Industry</td>
<td>3+0</td>
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<td>GS 632*</td>
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<td>GS 633*</td>
<td>Intellectual property and its management in agriculture</td>
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<td>GS 635*</td>
<td>Disaster Management</td>
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*The Doctoral students will have to register these courses if not studied at Masters’ level.

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Syllabus of the following courses revised as per approval of academic council in its 38<sup>th</sup> meeting held on 12.2.2015

DC- 711  Advances in Chemistry of Milk Proteins  (3+0)

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Syllabus of the following courses revised as per approval of academic council in its 38<sup>th</sup> meeting held on 12.2.2015

DC- 611  Physico-chemical Aspects of Milk Constituents  (2+1)
DC- 614  Food Chemistry  (3+1)
DC- 621  Chemistry of Milk Proteins  (3+1)
DC- 622  Chemistry of Milk Products  (3+1)
DC- 624  Research Techniques  (0+3)
DC- 611 Physico-chemical Aspects of Milk Constituents (2 + 1)  
Course contents  
Objectives:  
To impart knowledge in understanding the physico-chemical aspects of milk and milk products with special reference to their processing and quality assurance.

Theory  

Unit-I – Chemical Kinetics  
Order and molecularity of a reaction; reactions obeying the kinetics of zero 1\textsuperscript{st}, 2\textsuperscript{nd} and 3\textsuperscript{rd} order; kinetics of denaturation of whey proteins; the role of enzymes as biological catalyst; factors affecting the rate of enzyme reaction- (i) concentration of substrate, (ii) concentration of enzyme, (iii) concentration of reaction products, (iv) pH, (v) Temperature, (vi) time, (vii) activators and (viii) inhibitors; Thermal inactivation of enzymes in milk, Concept of activation energy

Unit-II - Electrochemistry  
Electrolytic dissociation; activity; ionic strength and salt equilibrium in milk; dissociation constant of acids and bases; effect of ionic strength on dissociation constant; buffer; buffer capacity and buffer index of milk and milk products; Redox Reactions and photo oxidations of milk

Unit-III - Water Activity  
Adsorption at solid – vapour interphase; monolayer and multilayer adsorption; capillary condensation; adsorption isotherms; hysteresis, Sorption of water on milk constituents and milk products; it’s relation to stability of dairy products;

Unit-IV - Surface and colloid Chemistry  
Colloidal & surface phenomena in milk; adsorption at solid-liquid and liquid-liquid interphase; Gibbs equation's; interfacial tension, surface tension, adsorption, General aspects of foaming, churning and whipping in cream, emulsion and emulsion stability, coalescence and dispersion, an introduction to the concept of nano emulsion and nano micelles

Micelles: definition, critical micelle concentration formation and stability; Colloidal stability of casein micelles in milk, zeta potential , Role of salts in colloidal stability of milk; Size distribution of casein micelles and fat globules; Gel and their formation, structure and stability; importance of these phenomena in milk and milk products; acid and rennet gels;

Practicals  
Determination of the order of hydrolysis of an ester/carbohydrate and measurement of activation energy; determination of the progress curve obtained during the hydrolysis of P-nitrophenyl phosphate by milk alkaline phosphatase; determination of the Michaelis constant for the digestion of casein by trypsin; Measurement of pH and
buffering capacity of different types of milk; To study the gel formation and gel stability of milk proteins; preparation of a Tris/phosphate/citrate buffer of a given molarity/ionic strength and pH; determination of pH of the buffer; measuring the stability of an oil-in-water emulsion stabilised by milk proteins; foaming capacity and foam stability of caseins/whey proteins; drawing of an adsorption isotherm of water on casein.

Suggested Readings

List of Journals:
1. Indian Journal of Dairy Science
2. International Dairy Federation Bulletin
3. International Dairy Journal
5. International Journal of Food Composition
6. Journal of Agricultural and Food Chemistry
7. Journal of Dairy Research
9. Journal of Food Science
10. Journal of Food Science and Technology
11. Milchwissenschaft-Milk Science International
12. LWT-Food Science and Technology

DC-612 Milk carbohydrates, minerals and water soluble vitamins (2+1)

Course Contents

Objectives:
To impart basic knowledge on all aspects of milk carbohydrates, minerals and water soluble vitamins and to project the importance of these milk constituents on the quality of milk and milk products as well as in human health.
Theory

UNIT I
Lactose: occurrence, isomers; molecular structure(2);

UNIT II
Physical properties:- crystalline habits; hydrate; lactose glass(2); equilibrium of different isomers in solution; solubility; density sweetness(2);

UNIT III
Chemical properties:- hydrolysis; pyrolysis; oxidation; reduction(2); degradation with strong bases; derivatives(1); dehydration and fragmentation browning reaction(2); oligosaccharides in milk(1);

UNIT IV
Minerals: major and minor minerals(2); factors associated with variation in salt composition(2);

UNIT V
Physical equilibrium amongst milk salts(1); partitioning of salt constituents and factors affecting it(2); effect of various treatments on salt equilibrium(1);

UNIT VI
Salt balance and its importance in the processing of milk(2); protein mineral interactions(1); distribution and importance of trace elements in milk(1);

UNIT VII
Water soluble vitamins: thiamin; riboflavin; niacin(3); pantothenic acid; pyridoxine; biotin; folacin (folic acid) and cynocobalamin(3);

UNIT VIII
Molecular structure; levels in milk and milk products; biological significance; factors affecting their levels(3); ascorbic acid structure; relation to Redox potential (Eh) of milk and milk products(3).

Practical
Estimation of lactose in milk by volumetric(1); gravimetric(2); polarimetric(1) and colorimetric methods(2); estimation of sodium and potassium by (flame photometry) (2); calcium and magnesium by EDTA method(2); phosphorus by colorimetric method (Fiske and Subba Rao) (2); citric acid(2) and iron by colorimetric methods(2); vitamin C in milk by volumetric method(1) and; estimation of brown colouring matter/burnt particles in milk powder(1).

Suggested Readings


**DC-613 Chemistry of Milk Lipids (2 + 1)**

**Course Contents**

**Objectives:**

To impart the basic knowledge on all aspects of milk lipids and to project the importance of milk lipids in the quality of milk products as well as in human health.

**Theory**

**UNIT I**
Milk lipids: classification, gross composition(2) and physical properties(1); neutral and polar lipids and their role in milk and milk products(2).

**UNIT II**
Fatty acids profile(2): composition, properties and factors affecting them(2).

**UNIT III**
Unsaponifiable matter(1): composition with special reference to sterols(2) and fat soluble vitamins and carotenoids(2), chemistry, physiological functions and levels of milk(6).

**UNIT IV**
Chemical properties: hydrolysis by alkali(1)water and enzymes(1); hydrogenation and halogenation(1); transesterification and interesterification(1); oxidation by chemical reagents(1).

**UNIT V**
Auto-oxidation: Definition, theories(1), induction period(1), secondary products of auto oxidation(2), factors affecting, prevention and measurement(2); antioxidants: Definition, types, reaction mechanism and estimation(3).

**Practical:** Determination of melting point/slip point(1), peroxide value(1), TBA value(1), carbonyl value(2), unsaponifiable matter(2); estimation of total cholesterol by direct and indirect method(2); vitamin A(2), total phospholipids and free fatty acids in ghee(2); preparation of fatty acid esters and their analysis on GLC(2); estimation of antioxidants such as BHA(2).
Suggested Readings


List of Journals:

2. International Journal of Dairy Technology
3. Journal of Lipid Research
4. Journal of Dairy Research
5. Indian Journal of Dairy Science
6. Lipids
7. J. Am. Oil Chem. Soc

DC -614 Food Chemistry (3 + 1)

Course Contents

Objectives:
To impart knowledge on different aspects of food components

UNIT I:
Forms of water in foods(1), water solute interactions(1), and food stability, solute mobility and food stability(2); role of ice in the stability of food at sub-freezing temperatures(3)

UNIT II:
Starch: Forms(1), swelling, gelatinization food applications and their role in bread making(2); modification of starches for industrial applications(2), physico-chemical changes taking place during malting(2), Properties and utilization of common polysaccharides – cellulose, hemicellulose, pectin, agar, alginate, carrageenan and gums (3)

UNIT III
Functional properties of food proteins (1); structure-function relationship and their modifications (4), denaturation of food proteins (3); effect of pressure on food proteins (3),

UNIT IV
Technical enzyme preparations, Immobilized enzymes, individual enzymes & their utilization in food industry (4); physico-chemical properties of food lipids and their modifications (4);

UNIT V
Changes taking place during fermentation(3); drying and roasting of chocolate and cocoa; chemistry of tea manufacture(1); composition of coffee beans(1); physicochemical changes during roasting of coffee beans(2).

Practical
Determination of level of artificial sweeteners (saccharin & aspartame) and crude fiber in food products(3); starch in flour by polarization method(1); total amino acids and polyphenols in lemon juice(1); fat in grains(1); proteins in flour(2); tannins in coffee/tea, caffeine content in coffee(2); visit to a food industry(2).

Suggested Readings
Belitz, H.D. and Grosch, W. 1987. Food Chemistry

List of Journals:
1. International Dairy Journal
2. Journal of Dairy Science
3. Journal of Dairy Research
4. Milchwissenschaft
5. Dairy Science and Technology
6. Journal of Food Science
7. Food Chemistry
8. International Journal of Food Science and Technology
9. Analyst
10. Journal of Chromatography

DC- 621 Chemistry of Milk Proteins (3+1)

Course Contents

Objectives:
To impart knowledge on different aspects of milk proteins

Theory
Unit –I
Distribution and fractionation of different nitrogen fractions of milk proteins, nomenclature of milk proteins
Unit-II
Major milk proteins: caseins (acids and micellar), methods of isolation; fractionation of casein and heterogeneity, physico-chemical properties, glycosylation, phosphorylation, amino acid composition, primary and secondary structure of different fractions; casein micelle models.

Unit-III
Alpha-Lactalbumin and beta-lactoglobulin, Bovine Serum Albumin-distribution and methods of isolation and their physico-chemical properties.

Unit-IV
Denaturation of milk proteins, various factors affecting denaturation; casein-whey protein interactions.

Unit-V
Minor milk proteins: proteose-peptone, immunoglobulins, lactoferrin, lipoprotein and fat globule membrane proteins.

Unit-VI
Indigenous milk enzymes: properties and their significance with particular reference to lipases, proteases, phosphatases, catalase, peroxidase, xanthine oxidase, lysozyme, lactoperoxidase and galactosyltransferase.

Practical
Isolation of acid and rennet casein (2); urea fractionation of acid casein (2); isolation of alpha-lactalbumin and beta-lactoglobulin by ammonium sulphate precipitation (2); Estimation of different nitrogen fractions of milk by Kjeldahl method (2). Milk protein estimation by Folin method (1) estimation of indigenous milk enzymes like protease, lipase, alkaline phosphatase and lactoperoxidase (5); estimation of hexoses and sialic acid in casein(2) Measurement of degree of hydrolysis of milk proteins (2), Measurement of denaturation of whey proteins (1).

Suggested Readings
List of Journals:
1. Indian Journal of Dairy Science
2. International Dairy Federation Bulletin
3. International Dairy Journal
5. Journal of Agricultural and Food Chemistry
6. Journal of Dairy Research
8. Journal of Food Science
9. Journal of Food Science and Technology
10. Milchwissenschaft

DC-622 CHEMISTRY OF MILK PRODUCTS 3+1
Course Contents
Objectives
To project the physico-chemical changes and effects of various milk constituents of the milk products during manufacture and storage.
Theory
UNIT I
Physico-chemical changes taking place during manufacturing and storage of concentrated milk(4); structure and physico-chemical properties of dried milk as affected by different process treatments (4); storage stability of milk powder(1); physical properties of instant milk powder(1)
UNIT II
Role of biological active components in human milk, Standards and Compositional properties of infant milk and infant food formulations(4). Mechanism of action of stabilizers and emulsifiers in ice cream(3)
UNIT III
Heat induced changes in milk leading to coagulation(2); Heat stability of concentrated milk as affected by different process variables(2); milk constituents(2) and additives(1); Age gelation (2)
UNIT IV
milk clotting enzymes from different sources(2);Changes taking place during manufacturing and ripening of cheese(7); chemical defects in cheese(2). Lactic acid fermentation in cheese and other fermented dairy products (3).
UNIT V
Size distribution of fat globules and factors affecting it(3); creaming phenomena(1); mechanism of churning(2); grading and standards of butter and physico-chemical characteristics (3).
UNIT VI
Physico chemical constants of ghee(4), ghee flavour(2), texture (grains) in ghee(1), Storage and keeping quality of ghee(2).
Practicals
Determination of lactose and sucrose in condensed milk and ice-cream (2); determination of heat stability of milk and its concentrate (1); determination of moisture in skim milk powder/infant food by vacuum oven (1); determination of fat in cream by Gerber and Rose-Gottlieb methods (2); determination of moisture, fat (Gerber method), curd and salt in butter (2); determination of diacetyl and acetyl methyl carbinol in butter/cultured products (2); determination of RM, Polenske value (1), iodine value, saponification value of ghee (2); determination of nitrite, nitrate, free amino acids and free fatty acids in cheese (3); determination of rennet clotting time of milk (1).

Suggested Readings
8. ISI Handbook of Food Analysis S.P. 18 (Part II) Dairy Products. 1981 ISI Specifications (concerned) (ISI)

DC-623 Chemical Quality Assurance (2+1)

Objectives: To project the importance of chemical quality assurance and quality control in relation to dairy industry and impart basic knowledge on all aspects of chemical quality assurance.

Theory
Unit I
Concept of quality assurance and quality control in relation to dairy industry (2); quality management systems - ISO 9000 (2); total quality management (TQM) (2); hazard analysis
of critical control points (HACCP) (2); good manufacturing practices (GMP) (1); role of international organisations such as ISO; IDF; CAC; AOAC; WTO(2) and national organisations like BIS; CCFS; Good laboratory practices (GLP), laboratory Accreditation(2)

Unit II
PFA and Agmark(2); significance of milk and milk products order (MMPO) and APEDA (Agricultural and Processed Foods Export Development Authority) in dairy industry(3); guidelines for setting up quality control laboratory(3); sampling of milk and milk products(2); dairy detergents and sanitizers(2); calibration of milk testing glassware(2); preparation of standard reagents(2);

Unit III
Instrumentation in analysis of milk and milk products(3); detection of adulterants in milk and milk products(3); Quality of packaging material for dairy products (3)

Unit IV
Chemical contaminants /residues : pesticides; antibiotics; heavy metals; radionuclides etc. in dairy products(9).

Practical:
Preparation of standard solutions and buffers(1); testing of available chlorine content in hypochlorites/bleaching powder(1); determination of purity of common salt for butter and cheese making(1); detection of common adulterants in milk and foreign fat/oil in ghee(3); checking the calibration of lactometers; hydrometers; butyrometers; milk pipette (4)and thermometer; qualitative colour tests to distinguish between azo dyes and natural dyes in butter(2); detection of pesticide residues and antibiotics in milk(4).

Suggested Readings
IDF - Special Issue No. 9302. Quality Assurance (QA) and Good Lab. Practices (GLP) in Dairy Laboratories.
IDF - Special Issue No. 9701 1997 Monograph on Residues and Contaminants in milk and milk products
Official methods of A.O.A.C. (11th and 15th editions- revised from time to time)
ISI Handbook of Food Analysis S.P. 18 (Part II) Dairy Products. 1981 ISI Specifications (concerned) (ISI)

Journals
1. Indian J. Dairy Sci.
2. Indian Dairyman
4. J. Food Quality
Objectives:

To impart the advanced knowledge on the use of analytical techniques in Dairy Chemistry

Theory
Unit-1
Electrophoresis: principle and types, isoelectric focussing(4).

Unit-11
Column Chromatography(1), TLC(1), GLC(2), HPLC(2), gel-permeation(2), ion-exchange(2), affinity(2).

Unit-111
Spectrophotometry: UV, visible(3), IR and flame photometry(3); potentiometry: principle, various electrodes(2); buffers(1).

Unit-1V
Immunobased analytical techniques such as ELISA & Lateral flow assay (5)

Unit-V
Separation of bio-molecules using membranes; ultracentrifugation((4)).

Practical

Paper chromatography. TLC separation of amino acids(2); gel-filtration of biomolecules(2); Preparation of methyl esters of fatty acids of milk fat for GLC (1); preparation of a buffer and measurement of its pH electro-metrically and using indicators(1); SDS gel electrophoresis and molecular weight determination(2); Separation and detection of different caseins using urea-PAGE (2); Plot UV-visible absorption spectra of a standard analyte(1); Demonstration of Beer’s law using standard protein(2); Determination of sodium and potassium by flame photometry(1); Separation of milk proteins using ion-exchange chromatography and affinity chromatography(2). Detection of analytes using ELISA and lateral flow assay. Demonstration of working of HPLC, AAS and GLC(3).

Suggested Readings
Cooper, T.G. 1977. The Tools of Biochemistry, John Wiley & Sons, U.S.A.
Wilson, K and Walker, J—Practical Biochemistry, principals and techniques, Cambridge Univ. Press.

Sawheney, SK and Randhir Singh, An introduction to practical Biochemistry, Narosa Publishers, New Delhi


FOODS UNDER THE MICROSCOPE (www.magma.ca/~scimat/)

List of Journals:
1. Analytical Biochemistry
2. Journal of Chromatography
3. Journal of Biochemistry
4. Journal of Agricultural and Food Chemistry
5. Journal of Dairy Research
7. Journal of Food Science
8. Dairy Science and Technology

- Theory and practical topics to be covered by Dairy Microbiology division.

DC- 711 Advances in Chemistry of Milk Proteins (3 + 0)

Objectives: To impart knowledge on different aspects of milk proteins

UNIT I
Biosynthesis of milk proteins, milk fat globule membrane (MFGM) proteins (9)

UNIT II
Primary structure of casein, structural properties of casein and whey protein and their structure-function relationship

UNIT III
Physical, chemical and enzymatic modification of milk proteins and their functional characteristics;

UNIT IV
Mechanism of action and biological role of specific and non-specific antimicrobial factors in milk - immunoglobulins, lactoferrin, lactoperoxidase and lysozyme

UNIT V
Milk protein derived bioactive peptides – their properties; significance and application; bitter peptides in cheese; growth factors in milk
UNIT VI

Nutritive, therapeutic and allergy aspects of milk proteins; protein films and coatings; their properties and applications

Suggested Readings


List of Journals:

1. International Dairy Journal
2. Journal of Dairy Science
3. Journal of Dairy Research
4. Milchwissenschaft
5. Dairy Science and Technology
6. Journal of Food Science
7. Food Chemistry
8. International Journal of Food Science and Technology
9. Analyst

Journal of Chromatography

DC- 712  Advances in Chemistry of Milk Lipids (3 + 0)

Course Contents

Objectives:

To impart the advanced knowledge on different aspects of milk lipids with special reference to their relation with human health.

Theory

UNIT I

Origin, composition, structure and physical chemistry of milk fat globule membrane. Comparative aspects of milk lipids from different species such as human, bovine, buffalo, sheep, goat, pig and camel (12)

UNIT II

Lipolytic enzymes from different species including human; bile salts; stimulated lipase and esterases. Biosynthesis of fatty acids; glycerol; neutral lipids; phospholipids; sphingolipids; cholesterol(10)
UNIT III
Essential fatty acids, prostaglandins and flavor compounds. Conjugated linoleic acids – different isomers, factors affecting their levels in dairy products and their significance: (10)

UNIT IV
Chemistry of oxygen in relation to auto-oxidation of milk fat including effect of milk components and environmental factors, thermal oxidation, chemical and biological properties of heated and oxidized fats, (12)

UNIT V

Suggested Readings

Fox, P.F. and McSwamy, PLH 1997 Dairy Chemistry and Biochemistry London: Blackie

List of Journals:
2. International Journal of Dairy Technology
3. Journal of Lipid Research
4. Journal of Dairy Research
5. Indian Journal of Dairy Science
6. Lipids
7. J. Am. Oil Chem. Soc

DC 713 ADVANCES IN CHEMISTRY OF FUNCTIONAL DAIRY FOODS AND NUTRACEUTICALS. (3+0)

Course Contents
Objectives:
To impart knowledge to the students about the chemical aspects of functional dairy foods and nutraceuticals.
UNIT I

UNIT II
Bio-functional milk proteins and their therapeutic potential, recent advances in their bio-separation(3), Generation of bioactive peptides from casein and whey proteins, their isolation and characterization(3), technological and health aspects(2), colostrums as source of nutraceuticals(7).

UNIT III
Technological and nutritional aspects of milk lipids(3), conjugated linoleic acids (CLA) in milk(2), their variation, physiological effects and their importance in dairy foods(3). Omega fatty acid and their health attributes(2), strategies to reduce the cholesterol in dairy products(4).

UNIT IV

UNIT V
Milk oligosaccharides, structural and technological aspects(3), health promoting aspects of milk oligosaccharides(4).

DC-721 Advances In Chemistry of milk processing (3+0)
Course Contents

Objectives:
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, Milk fat replacers(12).

UNIT II:
Physical changes in the fat globules in unhomogenized and homogenized milk; cold agglutination – its mechanisms and role(9).
UNIT III
Specific and non – specific enzymatic coagulation of milk(7).

UNIT IV
Status and formation of bioactive peptides in fermented milk products(9).

UNIT V
Chemistry involved in high pressure processing of milk(9).

UNIT VI
Heavy metals, drugs, pesticides, and polybiphenyls in milk(9).

Suggested Reading:

1. IDF Special issue 9701, 1997
8. Intense Sweeteners. Handbook of food analysis, 2nd ed. (Ed. by Leo ML Nollet)

List of Journals:

1. International Dairy Journal
2. Journal of Dairy Science
3. Journal of Dairy Research
4. Milchwissenschaft
5. Dairy Science and Technology
6. Journal of Food Science
7. Food Chemistry
8. International Journal of Food Science and Technology
9. Analyst
10. Journal of Chromatography
11. Journal of Food safety
12. Journal of Food Science and Technology
13. Indian journal of Dairy Science
14. Bulletin of environmental contamination and toxicology
15. Indian Dairyman
16. Food additives and contaminants
Course Contents

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

Theory:
UNIT I:
Isoelectric focusing(4) and 2-D polyacrylamide gel electrophoresis (PAGE) (4), Capillary zone electrophoresis(4), Enzyme linked immunosorbent assay (ELISA) (4).

UNIT II:
Blotting techniques(3), High performance liquid chromatography (HPLC) (4), Protein sequencing(4), X-ray crystallography(4), Circular dichroism (CD) (5).

UNIT III:
Atomic-(3), Mass-(3), Infrared-(3), Fluorescence- Spectroscopy(4), Differential scanning calorimetry(4),

Suggested Reading:


List of Journals:
1.International Dairy Journal
2.Journal of Dairy Science
3.Journal of Dairy Research
4.Milchwissenschaft
5.Dairy Science and Technology
6.Journal of Food Science
7. Food Chemistry
8. International Journal of Food Science and Technology
9. Analyst
10. Journal of Chromatography
## Curse Structure – Dairy Technology

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Course No.</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DT-611*</td>
<td>Advanced Dairy Processing</td>
<td>3+1</td>
</tr>
<tr>
<td>2</td>
<td>DT-612*</td>
<td>Advanced Food Processing</td>
<td>3+1</td>
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<tr>
<td>3</td>
<td>DT-613</td>
<td>Rheology of Dairy and Food Products</td>
<td>2+1</td>
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<tr>
<td>4</td>
<td>DT-614*</td>
<td>Dairy Process Biotechnology</td>
<td>2+1</td>
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<tr>
<td>5</td>
<td>DT-615</td>
<td>Traditional and Value-added Dairy Products</td>
<td>2+1</td>
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<tr>
<td>6</td>
<td>DT-616</td>
<td>Advanced Food Packaging</td>
<td>2+1</td>
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<tr>
<td>7</td>
<td>DT-621</td>
<td>Membrane Technology in Dairy Processing</td>
<td>2+1</td>
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<td>8</td>
<td>DT-622</td>
<td>Alternative Processes for the Dairy &amp; Food Industries</td>
<td>2+1</td>
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<tr>
<td>9</td>
<td>DT-623</td>
<td>Technology of Food Emulsions, Foams &amp; Gels</td>
<td>2+1</td>
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<tr>
<td>10</td>
<td>DT-624*</td>
<td>Functional Foods and New Product Development</td>
<td>3+1</td>
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<td>11</td>
<td>DT-625</td>
<td>Processed Foods Regulatory Affairs</td>
<td>2+1</td>
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<tr>
<td>12</td>
<td>DT-711</td>
<td>Advances in Lipid Technology</td>
<td>3+0</td>
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<tr>
<td>13</td>
<td>DT-712</td>
<td>Advances in Protein Technology</td>
<td>3+0</td>
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<tr>
<td>14</td>
<td>DT-722</td>
<td>R &amp; D Management in Dairy Industry</td>
<td>3+0</td>
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<tr>
<td>15</td>
<td>*DT-723</td>
<td>Advances in Carbohydrates</td>
<td>3+0</td>
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</tbody>
</table>

* Compulsory for Master’s programme.

* approved in 38th meeting of AC on 12,2,2015

**NOTE:** *Doctoral students shall take a minimum of two 700-level courses.*
DETAILED COURSE CONTENTS

DT-611 ADVANCED DAIRY PROCESSING (3 + 1)

Objective

To provide in-depth knowledge in various unit operations and basic concepts in dairy processing.

Theory

Unit 1
Use of bio-protective factors for preservation of raw milk: effects on physicochemical, microbial and nutritional properties of milk and milk products, present status of preservation of raw milk by chemical preservatives; thermal processing for preservation.

Unit 2
Methods of determining lethality of thermal processing, UHT processed milk products, their properties and prospects, types of UHT plants, aseptic fillers, heat stability and deposit formation aspects, effect on milk quality; techno-economic considerations; retort processing.

Unit 3
Principles and equipment for bactofugation and Bactotherm processes, Microfluidization of milk: Principle, equipment, effects and applications, Homogenization and their applications in dairy industry.

Unit 4
Dehydration: advances in drying of milk and milk products; freeze concentration, freeze dehydration: physicochemical changes during freeze drying and industrial developments.

Unit 5
Water activity; sorption behaviour of foods, energy of binding water, control of water activity of different milk products in relation to their chemical; microbiological and textural properties; hurdle technology and its application in development of shelf-stable and intermediate-moisture foods, Use of carbonation in extending the shelf life of dairy products.

Unit 6
Current trends in cleaning and sanitization of dairy equipment: biological; detergents; Automation; Ultrasonic techniques in cleaning; bio-detergents, development of sanitizers-heat; chemical; radiation, mechanism of fouling and soil removal; Bio-films, assessing the effectiveness of cleaning and sanitization of dairy products.

Practical

LP system for extension of keeping quality raw milk, determination of pH; HCT profile of milk systems, measurement of thiocyanate in milk system; determination of water activity and sorption isotherms of milk products; determination of thermal load during retort processing of milk and milk products; heat classification of milk powders; functional properties of powders: porosity, interstitial air content, occluded air content, flowability; determination of degree of browning-chemical/physical methods; freeze drying of milk/milk products, and heat sensitive products. Homogenization efficiency; cleaning efficiency in dairy equipment; visit to a UHT Processing plant. Thermal process calculations.

Suggested Readings
Objective

To provide in-depth understanding of advances in theoretical and practical aspects of food processing.

Theory

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Lecture Topic</th>
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<tbody>
<tr>
<td>1.</td>
<td>Status of food processing industry in India and abroad; prospects and constraints in development of Indian food industry (2 lectures).</td>
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<tr>
<td>2.</td>
<td>Post harvest management of fruits and vegetables: Harvesting indices and Post harvest physiology of fruits &amp; vegetables (2 lectures)</td>
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<td>3.</td>
<td>Principles of chilling &amp; refrigeration storage of foods. Quality changes in cold stored products</td>
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<td>4.</td>
<td>Controlled and Modified atmospheric storage: Principle &amp; techniques</td>
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<td>5.</td>
<td>Advantages and limitations of CAS &amp; MAS</td>
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<td>6.</td>
<td>Application of heat energy to foods for preservation and processing, concept of drying rate of foods(2 lectures)</td>
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<td>7.</td>
<td>Industrial drying processes of foods</td>
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<td>8.</td>
<td>Changes during drying</td>
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<td>9.</td>
<td>Advanced drying processes: freeze drying, infra red drying and microwave drying (2 lectures)</td>
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<td>10.</td>
<td>Principle of thermal processing, concept of D, Z &amp; F values, Thermal Process Calculations (2 lectures)</td>
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<td>11.</td>
<td>Canning of fruits &amp; vegetables, unit processes involved in canning</td>
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<td>12.</td>
<td>Types of cans for thermal processing of foods</td>
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<td>13.</td>
<td>Basic principles involved in fermentation. Technological aspects of pickled vegetables like sauerkraut, cucumbers, etc (3 lectures)</td>
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<tr>
<td>14.</td>
<td>Technology of beer manufacture (2 lectures)</td>
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<tr>
<td>15.</td>
<td>Technology of wine making (2 lectures)</td>
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</table>
16 Technology of distilled alcoholic beverages, Defects in alcoholic beverages (2 lectures)
17 Meat animals, slaughtering of animals for meat, ante-mortem and post-mortem inspection of animals (3 lectures)
18 Conversion of muscle into meat (rigor mortis and other changes)
19 Freezing and canning of meat, curing & smoking of meat (2 lectures)
20 Fermented sausages
21 Utilization of milk ingredients in processed meat and poultry products
22 Wheat selection criteria for making different baked products, Advances in bread making (3 lectures)
23 Biscuits: role of ingredients, manufacturing process and advances
24 Cake: role of ingredients, manufacturing process and advances
25 Changes during processing of bakery products, Staling of Bread: Mechanism and methods to prevent
26 Utilization and importance of dairy ingredients in bakery products (2 lectures)
27 Definition, classification and technologies of fabricated and formulated foods and their nutritional aspects
28 Imitation dairy products and dairy analogues
29 Principle of extrusion processing, design and working of extruder, classification, application in food and dairy processing (2 lectures)
30 Important group of enzymes involved in food processing (2 lectures)
31 Application of enzymes in food processes like enzymes juice extraction, juice clarification, in bread manufacture, meat tenderization, ice cream manufacture, de-sugaring of egg, etc (4 lectures)

PRACTICALS

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Practical / Experiments</th>
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<tbody>
<tr>
<td>1</td>
<td>Chemical analyses of processed fruits and vegetable products</td>
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<tr>
<td>2</td>
<td>Modified Atmosphere Packaging and its effect on shelf-life of fresh fruits and vegetables</td>
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<tr>
<td>3</td>
<td>Preparation of squash, cordial, nectar and whey-based beverages</td>
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<td>4</td>
<td>Preparation of whey based soups</td>
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<td>5</td>
<td>Manufacture of bread &amp; pizza base</td>
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<td>6</td>
<td>Manufacture of biscuits</td>
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<td>7</td>
<td>Manufacture of cake</td>
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<tr>
<td>8</td>
<td>Application of milk ingredients in caramel</td>
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<td>9</td>
<td>Preparation of mayonnaise</td>
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<td>10</td>
<td>Canning of fruits &amp; vegetables</td>
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<td>11</td>
<td>Manufacture of chicken soup, comminuted meat products</td>
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<tr>
<td>12</td>
<td>Enzymatic extraction and clarification of fruit juices</td>
</tr>
<tr>
<td>13</td>
<td>Preparation of soymilk and tofu</td>
</tr>
<tr>
<td>14</td>
<td>Drying of fruits &amp; vegetables, efficacy of blanching treatment</td>
</tr>
</tbody>
</table>
SUGGESTED READINGS


DT-613 RHEOLOGY OF DAIRY & FOOD PRODUCTS (2 + 1)

Objective
To explain the basics of food rheology, and to familiarize the students with rheological instruments and their use in relation to dairy and food products.
Theory

Unit 1
Introduction to rheology of foods: Definition of ‘texture’, ‘rheology’ and ‘psychophysics’ – their structural basis; physical considerations in study of foods; salient definitions – Stress tensor and different kinds of stresses.

Unit 2
Rheological classification of Fluid Foods: Shear-rate dependence and time dependence of the flow-curve; Non-Newtonian fluids; thixotropy; Mechanisms and relevant models for non-Newtonian flow; Effect of temperature; Compositional factors affecting flow behaviour; Viscosity of food dispersions – dilute and semi-dilute systems, concentration effects.

Unit 3
Comparative assessment of different types of Viscometers, and their Merits and Limitations: Co-axial cylinders, Spindle- or Impeller-type viscometers, Cone-plate viscometer, Capillary viscometers, Falling-sphere viscometer, Vibratory viscometers, Extrusion viscometer, Orifice viscometer.

Unit 4
Rheology of semi-solid and solid food; Rheological characterization of foods in terms of stress-strain relationship; Viscoelasticity; Transient tests - Creep Compliance and Stress Relaxation; mechanical models for viscoelastic foods: Maxwell, Kelvin, Burgers and generalized models and their application; Dynamic measurement of viscoelasticity.

Unit 5
Large Deformations and failure in foods: Definitions of fracture, rupture and other related phenomena; Texture Profile Analysis; Instrumental measurements – Empirical and Fundamental methods; Rheometers and Texture Analyzers; Measurement of Extensional viscosity; Acoustic measurements on crunchy foods.

Unit 6
Rheological and textural properties of selected dairy products: Measurement modes and techniques; Effect of processing and additives (stabilizers and emulsifiers) on food product rheology; Relationship between instrumental and sensory data.

Practical
Study of different types of viscometers viz., co-axial cylinder viscometer, spindle viscometer, falling-ball viscometer, extrusion viscometer, impeller viscometer, orifice viscometer; Flow behaviour of fluid dairy products; Thixotropy in ice-cream mix; force-deformation study in selected dairy products using Texture Analyzer; Back extrusion; Effect of test conditions on the texture profile parameters of cheese and similar products; stress relaxation studies in solid foods; Use of Cone Penetrometer and FIRA-NIRD extruder for measurement of butter texture; Use of a Viscoamylograph for study on the gelatinization behaviour of starch/cereals flours.

Suggested Readings

DT-614 DAIRY PROCESS BIOTECHNOLOGY (2 + 1)

Objective
To project the importance of biotechnology in dairy processing and impart knowledge on all aspects of dairy process biotechnology in production and preservation of dairy products employing the principles of biotechnology.

Theory

Unit 1
Definition of biotechnology; development and impact of biotechnology on food and dairy industry.

Unit 2
Microbial rennet and recombinant chymosin, characteristics and application in cheese making; exogenous free and microencapsulated enzymes, immobilized enzymes-their application in accelerated ripening of cheese; enzymatically modified cheeses (EMC) their utilization in various food formulations.

Unit 3
Technological requirements of modified micro-organisms for production of cheese and fermented milk products; technological innovations in the development of functional dairy foods with improved nutritional therapeutic and pro-biotic attributes; physiologically active bio-peptides/ nutraceuticals; protein hydrolysates – their physicochemical, therapeutic properties, production and application in food formulations; production of bio-yoghurt, pro-biotic cheese and fermented Milks; bifidus factors in infant food formulations.

Unit 4
Protein hydrolysates-production, their physicochemical, therapeutic properties, de-bittering and application in food formulations; Enzymatic hydrolysis of lactose for preparation of whey and UF-permeate beverages.

Unit 5
Microbial polysaccharides their properties and applications in foods, production of alcoholic beverages and industrial products from starch; whey and other by-products; bio-sweeteners-types properties and their applications in dairy and food industry.

Unit 6
Bio-preservatives- characteristics and their application in enhancing the shelf life of dairy and food products.

Practical
Effect of exogenous enzymes on hydrolysis of protein and fat in culture containing milk systems; to study the various factors affecting the coagulation of milk by microbial rennets. Manufacture and evaluation of pro-biotic cheese and fermented milks; determination of glycolysis, proteolysis and lipolysis in cheese and fermented milk; enzymatic process for manufacture of low lactose milk whey products; preparation of casein hydrolysis; visit to a bio-processing unit.

Suggested Readings
DT-615 TRADITIONAL AND VALUE-ADDED DAIRY PRODUCTS (2 + 1)

Objective
To project the significance and status of traditional and value added dairy products in Indian dairy industry.

Theory

Unit 1
Present status of traditional dairy products; globalization of traditional dairy products; plans and policies of the Government and developmental agencies.

Unit 2
Process schedule of heat-desiccated, coagulated and fermented traditional dairy products; process improvement in production of milk sweets.

Unit 3
New products based on fruits, vegetables and cereals; application of membrane technology; microwave heating for industrial production of traditional dairy products.

Unit 4
Advances in industrial production of ghee, flavour and texture simulation.

Unit 5
Techno-economic aspects for establishing commercial units for traditional products.

Unit 6
Convenience traditional dairy products; use of natural and permitted synthetic preservatives and new packaging systems.

Practical
Microwave heating of traditional milk delicacies for shelf life extension; application of membrane technology for improving the quality of traditional products from cow and buffalo milk; preparation of feasibility report for establishing commercial units for traditional products.

Suggested Readings
Objective
To impart basic and advanced knowledge of dairy and food packaging.

Theory

Unit 1
Status of current packaging; types of packaging materials; criteria for selection of proper packaging; testing of packaging materials.

Unit 2
Adhesives; graphics; coding, and labeling used in food packaging.

Unit 3
Protective packaging of foods; packaging of food products sensitive to oxygen, light, moisture; Active packaging; special problems in canned foods.

Unit 4
Packaging of dairy products; packaging of convenience foods, packaging of fruits, vegetables, and fruit juices.

Unit 5
Packaging of fats and oils; packaging of spices; packaging of meat and poultry: packaging of fish and other seafoods.

Unit 6
Modified atmosphere packaging, Controlled atmosphere packaging, Shrink and stretch packaging.

Unit 7
Retort pouch technology, microwavable, biodegradable, and edible packages.

Unit 8
Industrial packaging: unitizing, palletizing, containerising, distribution systems for packaged foods including prevention of shock damage to articles during transportation.

Unit 9
Safety aspects of packaging materials; sources of toxic materials and migration of toxins into food materials.

Practical
Testing of packaging materials for quality assurance like determination of thickness, GSM, grease resistance, bursting strength, tearing resistance, WVTR, puncture resistance; estimation of shelf life of vegetables and seasonal fresh fruits; packaging of turmeric powder and ground red chilli powder, vacuum packaging of dairy products.

Suggested Readings
Blackwell, Oxford.

**DT-621 MEMBRANE TECHNOLOGY IN DAIRY PROCESSING (2 + 1)**

**Objective**
To explain the basics of membrane technology and its applications in dairy processing.

**Theory**

**Unit 1**
Membrane techniques: classification and characteristics of filtration processes; types of membranes commercially available; membrane hardware, design of membrane plants, modeling of ultrafiltration (UF) processes, mass transfer model, resistance model; membrane fouling-problem and treatment, cleaning and sanitization of different types of membranes.

**Unit 2**
Factors affecting permeate flux during ultrafiltration and reverse osmosis of milk and sweet and sour whey, energy requirements for processing of milk and whey.

**Unit 3**
Applications of ultrafiltration, reverse osmosis, nanofiltration and microfiltration in the dairy industry. Developments in the manufacture and utilization of food and pharmaceutical grade lactose from UF permeate. Preparation of special foods like low lactose powder and dairy whiteners using UF retentate, whey protein concentrates, casein and coprecipitates.

**Unit 4**
Demineralisation: Importance of demineralisation, different processes available for demineralization: their principle, plant and operation.

**Unit 5**

**Practical**
Study of the effect of types of milk, temperature of milk and trans-membrane pressure on the permeate flux during ultrafiltration process; performance of ultrafiltration membrane with respect to permeate flux and volume concentration ratio during processing of acid and sweet whey; study the effect of types of milk, temperature and applied pressure on the permeate flux during the reverse osmosis process; nanofiltration of milk, whey and permeate; microfiltration of skim milk and whey; preparation of whey protein concentrate and its utilization in dairy products; measurement of different functional properties of casein and whey protein: whipping ability; water binding; emulsification properties; gelling; viscosity and solubility.
**Suggested Readings**


**DT-622 ALTERNATIVE PROCESSES FOR DAIRY & FOOD INDUSTRY (2+1)**

**Objective**

To develop an understanding of the basic principles underlying the novel/non-conventional food processing techniques, equipment required, features and actual and potential applications.

**Theory**

**Unit 1**
Irradiation: sources and properties of ionizing radiation; mechanism of interaction with microorganisms and food components microbial inactivation in dairy and food products, chemical effects, packaging, industrial irradiation systems, benefits and limitations; safety aspects, national and international regulations.

**Unit 2**
High frequency heating: Principles of dielectric heating and factors affecting it, design and working of microwave oven, continuous microwave heating units, applications in dairy and food processing, microwavable packaging safety aspects of microwaves, merits and demerits of dielectric heating.

**Unit 3**
Infra-red heating: Interaction of infra-red (IR) radiation with penetration properties, equipment; dairy and food application, advantages and disadvantages of IR heating.

**Unit 4**
Ohmic heating: Principle of electric resistance heating, design of an ohmic heater, operational variables, power considerations, factors affecting heating efficiency, merits and limitations, food applications and future scope.

**Unit 5**
Ultrasonic treatment of food: Mechanism of ultrasound induced cell damage, generation of ultrasound equipment, design of power ultrasonic system, types of ultrasonic reactors, application of power ultrasound in food processing, effects on food constituents, ultrasound in consideration with other process alternatives - thermosonication, advantages and future prospects.

**Unit 6**
High hydrostatic pressure processing: Principle of microbial inactivation, barotolerance of microorganisms, effect on food constituents, equipment dairy and food application, merit and demerits.
Unit 7
Pulsed electric field processing: Description/ mechanism and factors affecting microbial inactivation effects on food components; present status and future scope for food applications.

Practical
Study of a microwave oven; Determination of power output of a microwave oven; Temperature profile in a microwave oven cavity; Microwave absorption by various food packaging materials; Heating behaviour of water, milk, cream and other milk products – effect of composition; Shelf-life extension of pasteurized milk employing microwave heating; Effect of shape and size of water/milk container on microwave heating; Cooking of ‘instant’ products in a microwave oven; Drying of casein, ‘instant’ wheat, ‘instant’ rice, etc.in a microwave oven; Miscellaneous food processing/heating applications of microwaves; Visit to a commercial food irradiation facility.

Suggested Readings

DT-623 TECHNOLOGY OF FOOD EMULSIONS, FOAMS & GELS (2+1)

Objective
To impart basic knowledge regarding food dispersion systems, their formation, behaviour, and factors affecting their stability.

Theory

Unit 1
Food dispersions, their characteristics and factors affecting food dispersions.

Unit 2
Food emulsions; emulsifiers and their functions in foods; the HLB concept in food emulsifiers; emulsion formation and stability; polymers and surfactants.

Unit 3
Milk foams and their applications, structure of foams, egg foams and uses, foam formation and stability.

Unit 4
Theory of gel formation; pectic substances and jellies; fruit pectin gels; milk jellies.

Unit 5
Structure of dairy foods representing emulsions, foams and gels; physical structure of fat rich, concentrated, fermented, coagulated and dried products.
Unit 6
Techniques for evaluation of structure for food emulsions, foams and gels.

Practical
Determination of the rate of formation and stability of emulsions; Emulsifying properties of milk proteins and other food ingredients; Properties of different types of emulsifiers and their role in food emulsions; Examination of foam formation and determination of foam stability; Milk proteins and other food ingredients in food foams; foaming in dairy systems; Studies on gel formation and gel properties; Food gels – Gelatin-based, pectin-based, etc.; Properties of various gelling agents for foods.

Suggested Readings

DT-624 FUNCTIONAL FOODS & NEW PRODUCT DEVELOPMENT (3+1)

Objective
To impart the knowledge of functional ingredients, nutraceuticals and their utilization in development of new food products including health foods, functional foods and specialty foods.

Theory

Unit 1
Definition, classes of functional foods, status of functional foods in world and India. Concept of new product development, classed of nutraceuticals and functional foods. Safety; marketing strategy and consumer response; economic analysis and costing of novel foods, recent advances in different categories and type of dairy product.

Unit 2
Nutritional status and dietary requirement of different target group and deficiency diseases, in special reference to micronutrients. Dietary and therapeutic significance of dairy nutrients, bioactive components in dairy products like lactose, whey proteins, milk minerals, CLA, fermented milks etc.

Unit 3
Unit 4
Infant nutrition and dietary Formulations for meeting normal and special needs of infants, current status of infant foods, additives for infant foods. Foods for aged persons, design consideration, ingredients for geriatric foods.

Unit 5
Technological aspects of reduced calorie foods, alternatives for calorie reduction, low calorie sweeteners, bulking agents and their application, fat repalcers and their utilization in low calorie dairy foods.

Unit 6

Unit 7
Sports foods, ingredients for sports foods, dairy components in sports foods, sports drinks, design consideration, ergogenic aids in sports nutrition.

Unit 8
Herbs, various classes of herbs, their therapeutic potential and application in foods with special reference to dairy products like functional drinks, herbal ghee etc.

Unit 9
Prebiotic substances and their utilization in functional foods, symbiotic foods, technological aspects and recent development in probiotics, prebiotics and synbiotics.

Unit 10
Definition and various classes of phytochemicals, their role in CVD, Cancer and immune system enhancer, utilization in functional foods, phytosterol, phytoestrogens, glucosinolates, organosulphur compounds, flavonoids, carotenoids, etc.

Unit 11
Special foods/nutrients for CVD, Cancer, IBD, diabetics, persons suffering with milk allergy and lactose intolerance with special emphasis on dairy nutrients and foods.

Practical
1. Determination of total fiber, neutral detergent fiber in foods
2. Manufacture of fiber enriched milk beverage
3. Manufacture of low calorie burfi/ice cream
4. Preparation of flavoured milk using artificial sweetener and its estimation
5. Determination of antioxidant activity of food/food components
6. Determination of bioavailability of nutrients
7. Development of malted milk food and weaning food
8. Determination of β-galactosidase activity and application of lactases for lactose free dairy products
9. Determination of prebiotic potential of certain plant/milk components and their application in synbiotics dairy foods
10. Preparation of sports beverage, herbal dairy drinks
11. Preparation of high protein products

Suggested Readings
Objective
To explain the physicochemical and nutritional characteristics of fats and oils, and their processing and utilization for food purposes.

Theory

Unit 1
Current Trends in the fats & oil Industry in India and abroad: Sources and utilization of animal, vegetable and marine fats/oils - An overview.

Unit 2
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 3
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 4
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 5
Advances in refining including degumming, bleaching and deodorization oils and fats – Existing technologies and new developments - application of membrane techniques; Winterization.

Unit 6
Physico-chemical properties of oils & fats; Polymorphism, crystallization kinetics; New antioxidants.

Unit 7
Modification of fats and oils: Physical modification – Fractionation; Chemical modification – Hydrogenation and Interesterification; enzymatic/microbial modification of fats/oils; Cholesterol reducing treatments.

Unit 8
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 9
Fat replacers, technological developments in low calories spreads and other fat-based products.

Unit 10
Advances in technologies for production of plasticisers, emulsifiers and protective coatings.

Suggested Readings
ADVANCES IN PROTEIN TECHNOLOGY

Objective
To explain 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 1
Characteristics of proteins from plant, animal and microbial origins.

Unit 2
Denaturation of proteins: Effect of processing parameters on denaturation. Effect of denaturation on the physicochemical and biological properties of proteins in food systems.

Unit 3

Unit 4

Unit 5
Protein hydrolysates-- Production and processing; De-bittering of protein products; Bioactive peptides: their production and properties.

Unit 6
Recent Technologies: Augmentation of world resources for protein foods: protein from plants, animals and microorganisms.

Unit 7
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**


**DT-721 PRODUCT MONITORING & PROCESS CONTROL**  
**3+0**

**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 1**

**Unit 2**
Process Control: Objectives; Control loop – Loop elements and their functions; Modes of process control; Control techniques; control equipment.

**Unit 3**
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 4**
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 5**
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 6

Monitoring of food structure: Application of analytical techniques to monitor the effect of processing and storage on structure of foods

Unit 7

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

Suggested Readings

DT-722 RESEARCH & DEVELOPMENT MANAGEMENT IN DAIRY INDUSTRY (3+0)

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 1
Current Status of R&D Efforts in Dairy Processing in India and abroad.

Unit 2
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 3

Unit 4
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 5
Project proposal writing for research funding, Development of feasibility and technical report for dairy plant establishment, evaluation and report writing of projects.

Suggested Readings
4. IPR Bulletins (TIFAC) (www.tifac.org.in)

List of Journals
1. American Journal of Clinical Nutrition
3. Bioprocess and Biosystems Engineering
4. Comprehensive Reviews in Food Science and Food Safety
5. CRC Critical Reviews in Food Science and Nutrition
6. Food Engineering
7. Food Research International
8. Food Science & Technology (LWT)
10. Food Technology
11. Indian Dairyman
12. Indian Food Packer
13. Indian Journal of Dairy Science
15. International Journal of Dairy Technology
16. International Journal of Food Properties
17. International Journal of Food Science and Technology
18. Journal of American Oil Chemists’ Society
20. Journal of Biotechnology
21. Journal of Chemical Technology and Biotechnology
22. Journal of Dairy Research
23. Journal of Dairy Science
24. Journal of Food Biotechnology
25. Journal of Food Engineering
26. Journal of Food Processing and Preservation
27. Journal of Food Protection
28. Journal of Food Science
29. Journal of Food Science and Biotechnology
30. Journal of Food Science and Technology
31. Journal of Food Technology
32. Journal of Human Nutrition and Dietetics
33. Journal of Lipid Research
34. Journal of Texture Studies
35. Packaging Abstracts
36. Packaging India
37. Trends in Food Science and Technology

**Broad Topics of Research**

1. Application of UF retentates in value added products and health foods.
2. Application of reverse osmosis in dairy industry.
3. Application of microfiltration in dairy industry.
5. Application of modified microorganisms in the manufacture of improved quality dairy products.
7. Characteristics of newly developed microbial rennet in relation to curd forming behavior of ripened and unripened cheeses.
9. Development of kinetic data on physicochemical changes in different dairy/food products during processing and storage.
12. Development of newer variety of cheeses from microbial/recombinant rennet using cow and buffalo milk systems.
15. Development of casein/ whey protein hydrolysates with enhanced functionality for food application.
17. Development of indigenous detergents for cleaning and sanitization of membranes.
18. Development of mechanized systems for the production of heat desiccated milk sweets/desserts, such as rabri, basundi, kheer/payasam, kalakand, milk cake, etc.
20. Effects of processing variables on the textural properties of certain indigenous milk products.
23. Effects of ultrasonic treatment of milk products on their properties and microbial inactivation.
24. Effect of bactofugation keeping quality of milk under Indian conditions.
25. Extension of shelf life of dairy products by applying Hurdle Technology.
26. Effect of season on the compositional profile and physicochemical properties of milk-fat.
27. Flavour characteristics of fats from cows, buffaloes, goats and sheep.
28. Foaming properties of milk as influenced by its constituents
30. Investigation on quality improvement of dairy foods using novel ingredients.
31. Incorporation of fruits for value addition and improvement of nutritional value of traditional milk products.
32. Incorporation of cereals for value addition and improvement of nutritional value of traditional milk products.
33. Infra-red heating behaviour of milk and milk products.
34. Investigation of prebiotic potential of milk molecules and their utilization in development of synbiotic foods
35. Isolation and purification of natural antibacterial substances of milk for preservation of milk products
36. Low-temperature irradiation of dairy products.
37. Process modification of manufacture and storage of ghee to improve granulation and flavour of ghee.
40. Process development for herbal dairy products
41. Physicochemical properties of buffalo, goat and sheep milk-fats.
42. Rheological and textural characterization of certain traditional dairy foods.
43. Relationship between instrumental measurements of dairy/food product characteristics and their sensory assessment.
44. Shelf life extension of traditional milk sweets through use of bio preservatives.
45. Structure-texture relationships in selected dairy products.
46. Studies on extrusion cooking of high protein foods.
47. Studies on UHT processing of concentrated milk.
49. Studies on process development for health foods utilizing milk/milk by-products
50. Studies on development of low calorie dairy foods
51. Study of moisture sorption isotherms of traditional dairy products and milk sweets
52. Study of functional properties of UF retentates.
53. Study of fouling behaviour during UHT processing of buffalo milk.
54. Technology development for manufacture of specialty foods for aged/sports/diseased persons
55. Technology for development of milk-cereal fermented foods
56. Technology for production of bioactive milk components and their application in functional foods
57. Use of antimicrobial packaging material for shelf life extension of traditional and value
added dairy products
58. Utilization of dairy by-products in formulated foods
60. Viscoelastic behaviour of buffalo-milk cheeses and other semi-solid products
61. Viscometric characterization of flowable buffalo-milk products.

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<td>Introduction to Carbohydrates</td>
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<td>Emerging concepts on nutritional and therapeutic aspects of carbohydrates</td>
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<td>Carbohydrates as Hydrocolloids</td>
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<td>Application of carbohydrases in brewing, bakery, fruits &amp; vegetable industry</td>
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# DAIRY ENGINEERING

## SEMESTER-WISE DISTRIBUTION OF COURSES-MASTER'S PROGRAMME

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<td>DAIRY AND FOOD ENGINEERING-I</td>
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<td>HEAT TRANSFER</td>
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<td>REFRIGERATION ENGINEERING</td>
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<td>DE 615</td>
<td>DESIGN OF PROCESS EQUIPMENT</td>
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<td>DE-616</td>
<td>Engineering properties of dairy and food products</td>
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## PRE-REQUISITE COURSES

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DE 611 DAIRY AND FOOD ENGINEERING-I 3+0

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

Theory

UNIT I
Concept of rheology: ideal elastic, plastic and viscous behaviour, viscoelasticity, rheological models and constitutive equations, Maxwell model, Kelvin model and Burgers model, viscoelastic characteristion of materials, stress-strain behaviour, creep, stress relaxation, non-Newtonian fluids and viscometry.

UNIT II
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 III
Freezing, freezing curves, freezing time calculations, design of freezing equipment, freeze drying, freeze concentration.

UNIT IV
Design of single and multi-effect evaporators: design of spray dryer and its components, separation and recovery of dried product, design of recovery system, selection and design of auxiliary equipment

UNIT V
Novel processing methods and equipments: high pressure processing, ohmic heating, ultraviolet light, pulsed electric field, pulsed light field, micro and nano encapsulation, microw

Suggested Readings

DE 612 HEAT AND MASS TRANSFER 3+0

Objective
To develop competence in Heat Transfer Analysis.

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

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

UNIT III
Unsteady state heat conduction: analytical solution.

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

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

UNIT VI
Condensation and Boiling Heat transfer: Film wise condensation on vertical surface; Nusselt equation, Boiling liquids.

UNIT VII

UNIT VIII
Mass transfer - Fick's law of diffusion, diffusion of gases and liquids through solids, equimodal diffusion, isothermal evaporation of water into air, mass transfer coefficients.

Suggested Readings

DE 613 TRANSPORT PHENOMENA 2+0

Objective
To develop competence in momentum, energy and mass transfer analysis.

Theory

UNIT I
Introduction to transport phenomena – Molecular transport mechanism, transport
properties and their proportionality constants in momentum, energy and mass transfer.

UNIT II
Steady-state equations - Momentum transport equations for Newtonian and non-Newtonian fluids, continuity equation in different co-ordinates.

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

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

UNIT V
Dimensional analysis – Buckingham Pi-theorem and matrix method, application to transport phenomena, analysis among mass, heat and momentum transfer, Reynolds’ analogy.

UNIT VI
Boundary layer concept - Theoretical and exact solutions for heat, mass and momentum transfer.

Suggested Readings

DE 614 REFRIGERATION ENGINEERING 2+1

Objective
To impart knowledge of design, construction, operation, control and maintenance of commercial refrigeration systems: cold storages and Air conditioning plants.

Theory
UNIT I
Vapour compression refrigeration system: major components and their different types; theoretical vapour compression cycle, theoretical COP; Effect of operating parameters on COP; actual vapour compression cycle; multi-pressure commercial refrigeration systems.
UNIT II
Vapour absorption refrigeration system: Ammonia-Water system, Vapour absorption refrigeration cycle and its representation on Enthalpycomposition diagram; Absorption system calculations.

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

UNIT IV
Non-conventional refrigeration systems: Thermo electric refrigeration, vortex tube, cooling by adiabatic demagnetization.

UNIT V
Design elements of Refrigeration equipments: compressor condenser, evaporator, cooling tower, spray pond etc. Balancing of different components.

UNIT VI
Design of cold storage and air-conditioning systems: types of cooling loads and their calculation, design of cold storage for food products, construction of cold storage, equipment selection, insulating materials, vapour barriers, Ice bank tank.

UNIT VII
Control and maintenance of a commercial refrigeration plant: Pressure regulating valves, Thermostatic valves, LP/ HP cutouts, high to low side bypass valve, condenser water regulating valve, capacity control devices, pump down control, defrosting methods, liquid charging; General preventive maintenance of refrigeration plant.

Practical
• To find and compare the theoretical and actual COP of a small refrigeration unit on Refrigeration Tutor.
• Study and design of refrigeration components of a bulk milk chiller
• Visit to a commercial refrigeration plant for cold storage/ ice bank unit and calculation of its theoretical COP by making cycle on P-h chart.
• Calculation of theoretical work and comparing it with actual work for some specified cooling job in a commercial plant.
• Study of various control and safety devices in a commercial refrigeration plant.
• Design problems on cold storage for different food/ dairy products.
• Use of Computer software specific to cold store AC design
• Study the working of an actual heat pump system.

Suggested Readings
Objective
To provide basic knowledge of various procedures for the design of dairy equipment.

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

UNIT II
Design of milk storage tank: horizontal and vertical silos, insulated and uninsulated, nozzles and mountings.

UNIT III
High-pressure vessels: constructional features, material for high pressure, multi shell construction, solid walled vessel.

UNIT IV
Supports for vessel: bracket support, leg support, skirt support, saddle support.

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
Design of reactor vessel: material of construction, agitation, classification, heating systems, design consideration tank coils.

Suggested Readings

DE-616 Engineering properties of dairy and food products (2+1)
Unit1:
Shape, size, volume, density, porosity, surface areas, friction, rolling resistance, angle of repose, specific surface area, mean diameter, sphericity, particle size analysis.

Unit2:
Aerodynamics properties, drag coefficient and terminal velocity. Pressure drop through packed beds.

Unit3:
Specific heat, thermal conductivity, thermal diffusivity, enthalpy, surface heat transfer coefficient freezing point. Measurement of thermal properties and prediction techniques.

**Unit 3:**
Electrical conductivity, capacitance, inductance, Dielectric properties viz. dielectric and microwave, dielectric constant, Dielectric loss factor, loss tangent, energy absorption, heating, Optical properties, colorimetry, transmittance and reflectance.

**Unit 4:**
Non-destructive quality evaluation techniques, Measurement techniques and instruments for food quality determination, destructive and non-destructive quality evaluation, UV VIS NIR spectroscopy, X-ray, CT, NMR, machine vision system.

**Unit 5:** Application of engineering properties in equipment design, processing and handling of dairy and food products.

**Practical**
Determination of geometric mean diameter and sphericity, Methods to compute surface area, Determination of angle of repose, Particle size analysis, Use of empirical equations for determination of thermal properties, Determination of thermal conductivity, Estimation of surface heat transfer coefficient, Measurement of electrical conductivity, Determination of electrical properties, Colour measurement, Determination of colour difference, Study of machine vision system.

**Suggested books**

**DE 621**
**DAIRY AND FOOD ENGINEERING-II**

**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**
Permeability and shelf-life: theoretical considerations, permeability to gases and vapours, measurement methods, permeability of multiplayer materials, permeability in relation to packaging requirements of food products.

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

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

Suggested Reading

**DE 622 BIO-THERMAL PROCESS ENGINEERING**

**Objective**
To teach the students on biological processes associated with food and dairy industries.

**Theory**
UNIT I
Introduction to biochemical engineering: Biochemical kinetics, kinetics of substrate utilization, enzyme reaction, growth of microorganisms, fermentors, pasteurization and sterilization and thermal destruction.

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

UNIT III

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

UNIT V
Thermo-bacteriology: Survivor curve, thermal death curve, Arrheneous 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.

**Suggested Readings**
Objective
To disseminate the knowledge pertaining to waste treatment in dairy and food processing plants.

Theory
UNIT 1
Waste water sources, characteristics, standards for disposal of dairy waste water.
UNIT II
Physical, chemical and biological characteristics of waste water, measurement of organic content in waste water.
UNIT III
Physical unit operations in waste water treatment: screening, racks, mixing, flocculation, sedimentation, floatation, elutriation, vacuum filtration & incineration.
UNIT IV
Chemical unit operations in waste water treatment: reaction kinetics, chemical precipitation, aeration and gas transfer process, rate of gas transfer, adsorption & disinfection.
UNIT V
Biological unit operations- aerobic and anaerobic cycles; kinetics of biological growth, application of kinetics to treatment systems, aerobic waste treatment, anaerobic waste treatment.
UNIT VI
Air conditioning systems: clean – room air conditioning; important pollutants of air; properties of particulate matter and air pollution control methods.

Suggested Readings

Objective
To impart basic knowledge on principles of measurements and process control, understanding the working and selection of instruments and devices for simple applications.

**Theory**

**UNIT I**
Instrument Terminology: Elements of generalized measurement system, static and dynamic characteristics of instruments.

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

**UNIT III**
Indicating and Recording Devices: Digital indicators, strip and circular chart recorders.

**UNIT IV**
Principles of Automatic Process Control: Process characteristics, control system parameters, discontinuous, continuous and composite control modes. Final controlling elements, pneumatic and electric controllers.

**UNIT V**
Introduction to Computer Based Control: Computer based controller, data logging, supervisory control, flow chart, control system networks, basic structure and operation of programmable logic controllers (PLCs).

**Practical**
Study of various transducers for measurement of pressure, flow, level, humidity; temperature; study the controller and recorder of pasteurizer; the working of controllers in constant temperature water baths; to make ladder diagrams and flow sheet diagrams for control logics; to programme a PLC; computer interface of a PLC.

**Suggested Readings**

**DE-626 Industrial automation and robotics (3+0)**
**Unit I**

**Unit II**

**Unit III**

Unit IV

Unit V

Unit VI

Suggested books
Hollender, M. 2010. Collaborative process automation systems. ISA.

Pre-requisite Courses in Dairy Engineering for M. Tech. (DE) Students with B. Tech. (Dairy Technology) background

DE 412  STRENGTH OF MATERIALS  2+0

Objective
To develop competence in stress analysis of machine parts.

Theory
UNIT I
Engineering requirement of materials such as Properties of materials such as mechanical, Thermal and Technological etc. Mechanical properties – Tensile strength, yield strength,
creep, impact strength. Technological properties – Hardness, Weld-ability, Machinability, formability, Castability etc.

UNIT II
Review of stresses in machine parts, temperature stresses, principal planes and stresses, Mohr’s circle of stress.

UNIT III
Bending of beams, stress analysis in beams of two different materials, shear stresses in beams.

UNIT IV
Strain energy in tension, compression, shear, bending and torsion. Impact loads on tension members, strength of biomaterials.

Suggested Readings

DE 423 MACHINE TOOL ENGINEERING 2+1

Objective
To provide basic knowledge of construction and operation of various machine tools and metal cutting.

Theory
UNIT I
Principles of metal cutting: Geometry of single point cutting tools, drills and milling cutters, normal and effective rake, chip formation, shear plane and shear zone analysis. Cutting tool materials heating of tools and use of cutting fluids.

UNIT II
Types of grinding machines, grinding wheels, their selection, speed, and wheel materials, shaper and planer machines.

UNIT III
Types of lathe machines and lathe operations, Turret and Capstan lathes, lathe tools, types of milling machines, milling cutters, cutting speed, calculation of milling time.

UNIT IV
Types of drills and drilling machines, sawing machines, abrasive cutting, power hacksaw, speed and feed for drilling, shaping, milling and lathe operations.

Practical
Lathe operations such as facing, turning, taper turning and thread cutting, Use of radial drilling machine. Study the construction and operation of milling machine, plain milling on milling machine. Study the operation of a shaper and prepare a square job from a given round bar.
Objective
To impart engineering knowledge of various unit operations related to agricultural and dairy processing.

Theory
New Syllabus
UNIT I
Grading, cleaning, washing, sorting, shelling, dehusking, decortication, milling, polishing, pearling, drying (evaporative, osmotic and freeze drying), Mixing, clarification, coagulation, mechanical separation, sedimentation.
UNIT II
Handling of food products – Mechanics of bulk solids, selection of bulk handling equipment, operation and construction of conveyors and elevators viz. belt conveyors, screw/auger conveyors, bucket elevators and drag/chain conveyors. Estimation of energy requirement, damage to products during mechanical handling. Operation and maintenance of conveying equipment.
UNIT III
Mechanical cleaning and sizing of food products – Size reduction, size characteristics, particle geometry, energy for size reduction of granular materials and dry powders, size-reduction equipment, performance characteristics of size reducers. Different milling methods, cryogenic grinding.
UNIT IV
Crystallization – Material and energy balance in crystallizers, principles of crystal growth, super saturation and nuclei formation, operation of batch and continuous crystallizers.
UNIT V
Distillation – Flash distillation of binary mixtures, differential distillation, steam distillation.
UNIT VI
Flow through porous media --- Absorption, pressing, expelling, leaching, extraction, palleting, extrusion.

Suggested Readings
DE-411  MATERIAL SCIENCE  (2+0)

Objectives: - To provide basic knowledge about the basic structure of material and their change in mechanical properties as a result of operation of various heat treatment processes.

THEORY

Unit I
Structure of atoms and molecules, Binding in solids, Types of bonds, Covalent, Ionic, metallic and molecular binding. Defects or imperfections and dislocations, Solid solutions and characteristics of solid solutions, inter-metallic compounds.

Unit II
Engineering requirement of materials such as Properties of materials such as mechanical, Thermal and Technological etc. Mechanical properties – Tensile strength, yield strength, creep, impact strength. Technological properties – Hardness, Weld-ability, Machinability, formability, Castability etc.

Unit III
Deformation of metals; elastic and plastic deformation, theory (dislocation) Bauschinger effect, work hardening, recovery, recrystallisation and grain growth, cold and hot working. Effect of grain size, heat treatment, atmospheric exposure and low temperature on the properties of metal.

Unit IV
Heat treatment, Necessity of heat treatment processes, Microstructure of carbon steel, behaviour of steel when heated, critical points, Fe-C equilibrium diagrams, Critical cooling rate, Different heat treatment such as stress relieving, annealing, normalizing, hardening, tempering, case hardening, surface hardening etc. factors affecting harden ability, martensitic transformation, alloy steels, effect of alloying element on structure, mechanical properties and heat treatment.

REFERENCE BOOKS

4. Material Science by R.B Gupta-Pub. Satya Prakashan, Tech-India Publications----7698 New Market, New Rohtak Road, Ne Delhi
## Major courses – Ph D (Dairy Engineering)

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<tr>
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<td>ADVANCES IN DAIRY PROCESS ENGINEERING</td>
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<td>DE 712</td>
<td>ADVANCED HEAT TRANSFER</td>
<td>3+0</td>
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<tr>
<td>DE 713</td>
<td>PHYSICO-CHEMICAL PROCESSES</td>
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<td>DE 721</td>
<td>ADVANCES IN FOOD PROCESS ENGINEERING</td>
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<tr>
<td>DE-722</td>
<td>PACKAGE PERMEABILITY AND SHELF-LIFE</td>
<td>3+0</td>
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</table>
DE 711 ADVANCES IN DAIRY PROCESS ENGINEERING 3+1
Theory

UNIT I
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 II
Drying: Design data, performance and selection and design of dryer.

UNIT III
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 IV
Material handling: System and devices, design of screw, belt, flight, apron conveyors, bucket elevators, power requirements, and applications, feeders and feeding mechanism.

Suggested Readings
Ellis Horwood.
DE 712 ADVANCED HEAT TRANSFER 3+0

Theory

UNIT I

UNIT II

UNIT III

UNIT IV
Heat transfer in turbulent flow: turbulent flow, boundary layer, Prandtl analogy, temperature distribution in turbulent flow, empirical and practical correlation for convection heat transfer, heat transfer in packed beds.

Suggested Readings
UNIT I

UNIT II
Separation processes. Reverse osmosis, water and solute diffusion, nanofiltration, microfiltration, membrane properties, concentration polarization, mathematical description of flow through a membrane, extractions, supercritical fluid extraction.

UNIT III
Electrodialysis. Minimum energy requirements, selective ion transport, design of an electrodialysis system, ion-exchange process, exchange materials, kinetics of exchange, exchange isotherm, ion-selectivity.

UNIT IV
Aeration and gas transfer, gas transfer processes, rates of gas transfer, film transfer, liquid-phase transport.

Suggested Readings

UNIT 1

• High pressure processing (HPP): Effect of HP on microorganisms, Equipments for HPP – batch and continuous systems, pressure vessel consideration & HP pumps and control systems, potential applications for foods

UNIT 2

• Microwave heating: Principles of energy absorption, microwave heating systems, applications

UNIT 3

• Irradiation: Principles of irradiation, physical, chemical and biological effects, isotope and machine sources, Irradiation facility, safety aspects

UNIT 4

• Process control in food processing: Process Simulation, Real time instrumentation, Automatic Process control Systems

SUGGESTED READINGS

1. J G Brennan (Editor) 2006 Food Processing handbook WILEY-VCHVerlag GmbH & Co. KGaA, Weinheim, Germany
2. A.G. Gaonkar, ed. 1995 Food processing: Recent developments, Elsevier Science B V
4. Xiao Dong Chen (Editor), Arun S. Mujumdar (Editor) 2008 Drying Technologies in Food Processing. Wiley-Blackwell, West Sussex UK
Unit-1
Water activity in food processing and preservation: Moisture sorption phenomenon in foods; thermodynamics of water activity; composition based water activity prediction models; sorption isotherms, determination of sorption isotherms, moisture sorption hysteresis and models for prediction of sorption isotherms.

Unit-2
Temperature and moisture control in foods. Adiabatic saturation of air & its application

Unit 3

Unit-4
Iterative procedures for moisture sensitive products, oxygen sensitive products; error analysis, water vapour permeability and oxygen barrier properties of composite packaging materials and fabricated package systems.

Suggested Readings:

Additional Readings:
### PhD- Animal Biochemistry

**With Minor-Animal Biotechnology**

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<td>AB-711  Advanced Enzymology (2+0)</td>
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<tr>
<td>BT-711  Gene Cloning and Expression (3+0)</td>
<td>BT-722  Advances in Animal Cell Culture (3+0)</td>
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<td>BT-713  Advances in Reproductive Biotechnology (3+0)</td>
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<tr>
<td>BT-611  Fundamentals of Cell &amp; Molecular Biology (3+0)</td>
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<td>CS-621  Statistical packages for Statistical Computing (3+0)</td>
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<td></td>
<td>DM-622  Microbial Genetics (2+1)</td>
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<td><strong>Total credits = 18</strong></td>
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Grand total credit = 33  
Thesis credit = 45

The minimum credit requirement for Doctoral degree as per requirement of Dairy Science College

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# PhD- Animal Biochemistry
## With Minor-Animal Physiology

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<td>AB-722 Current Topics in Biochemistry (2+0)</td>
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<td>AB-714 Biomembranes (2+0)</td>
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<td>AP-714 Advances in Biosynthesis &amp; Secretion of milk (3+0)</td>
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**PhD- Animal Biochemistry**  
*With Minor-Dairy Microbiology*

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<td>CS-621 Statistical packages for Statistical Computing (3+0)</td>
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**Total credits = 18**  
**Total credit = 15**
Grand total credit = 33
Thesis credit = 45

The minimum credit requirement for Doctoral degree as per requirement of Dairy Science College

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### M.Sc.- Animal Biochemistry
**With Minor-Animal Biotechnology**

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<tr>
<td>AB-611 Basic Biochemistry (3+1)</td>
<td>AB-621 Intermediary metabolism (3+0)</td>
<td>GS-601 Library and information services (0+1)</td>
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<td>AB-612 Enzymology (2+1)</td>
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<td>GS 602 Technical writing (1+1)</td>
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<td>AB-613 Biochemical Techniques (3+1)</td>
<td>AB-623 Immunochemistry (2+1)</td>
<td>GS 603 Intellectual Property and its management in agriculture (1+0)</td>
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<td>AB-614 Food &amp; Nutritional Biochemistry (3+0)</td>
<td>AB-624 Animal Biochemistry (3+0)</td>
<td>GS 604 Basic concepts in laboratory techniques/practices (0+1)</td>
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Grand total credit = 45  
Thesis credit = 20

The minimum credit requirement for Master degree as per requirement of Dairy Science College

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### M.Sc.- Animal Biochemistry
**With Minor-Animal Physiology**

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<td>AB-621 Intermediary metabolism (4+0)</td>
<td>ES-629 Design of Experiments (3+1)</td>
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**Grand total credit = 45**

**Thesis credit = 20**

The minimum credit requirement for Master degree as per requirement of Dairy Science College

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**M.Sc.- Animal Biochemistry**
**With Minor-Dairy Microbiology**

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Grand total credit = 45

Thesis credit = 20

The minimum credit requirement for Master I degree as per requirement of Dairy Science College
COURSE CONTENTS (BIOCHEMISTRY)

Ist Semester

AB- 611 BASIC BIOCHEMISTRY 3+1

Objectives
To provide elementary knowledge/overview of structure and functions and metabolism of biomolecules.

Theory

UNIT I
Scope and importance of biochemistry in agriculture; fundamental principles governing life; structure of water; acid base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waals forces; General introduction to techniques for determination of structure of biopolymers.

UNIT II
Classification, structure and function of carbohydrates, lipids, amino acids, proteins, nucleic acids and biomembranes.

UNIT III
Classification, structure, functions and mechanism of action of vitamins and hormones and enzymes. Vitamins as hormones. Principles of Bioenergetics; concepts of entropy and free energy changes related to biological process.

UNIT IV

Practical
1. Preparation of standard solutions.
2. Preparation of buffer solutions.
5. Estimation of Proteins by Lowry’s method.
6. Estimation of DNA by Diphenylamine
7. Estimation of RNA by orcinol.
8. Estimation of Ascorbic acid using dye.
9. Separation of lipids by silicic acid column chromatography.

Suggested Readings

AB-612 ENZYMEOLOGY 2+1
Theory

UNIT I
Introduction and historical perspective, Enzyme nomenclature and IUPAC classification, enzyme compartmentalization in cell organelles, isolation, and purification of enzymes, measurement of enzyme activity. ribozymes, isozymes, abzymes, restriction endonucleases.

UNIT II
Enzyme structure, enzyme specificity, active site, active site mapping, mechanism of enzyme catalysis. cofactors, coenzymes- their structure and role.

UNIT III
Enzyme kinetics, enzyme inhibition and activation, multienzyme, complexes, allosteric enzymes and their kinetics, regulation of enzyme, activity. **qualitative description of “concerted” & “sequential” models for allosteric enzymes. Half site reactivity, Flip-flop mechanism, positive and negative co-operativity.**

**Concept of ES complex, active site, specificity derivation of Michaelis-Menten equation for uni- substrate reactions. Different plots for the determination of Km & Vmax and their physiological significances. Importance of Kcat/Km.**
**Kinetics of zero & first order reactions. Significance and evaluation of energy of activation.**

UNIT IV
Isolation and purification of enzymes, Applications of enzymes in chemical and food industry, enzyme immobilization, biosensors and clinical applications of enzymes.

Practical
1. Enzyme assay by taking any model enzyme like alpha-amylase or alkaline phosphatase.
2. Isolation and purification of any model enzyme like B-galactosidase or acid phosphatase.
3. Study of the effect of enzyme and substrate concentrations and determination of Km and Vmax.
4. Determination of pH and temperature optima of alkaline phosphatase.
5. To study the effect of various inhibitors of enzymatic activity.

Suggested Readings
AB-613 BIOCHEMICAL TECHNIQUES 3+1

Objective
To impart practical knowledge about various techniques used in purification and characterization and estimation of cellular constituents

Theory
Unit I
Spectroscopy: Principles and applications of UV, Visible, fluorescence, NMR, ESR. X-ray diffraction, mass spectrometry.

Unit II
Chromatographic Techniques: Principles and applications of chromatographic techniques viz., TLC, HPLC, GLC, ion-exchange, gel-filtration, affinity, hydrophobic interaction chromatography, metal chelate chromatography.

Unit III
Electrophoretic Techniques: Concepts in electrophoresis, PAGE, SDS-PAGE, molecular weight determination; isoelectrofocussing, 2D-PAGE, Agarose electrophoresis, Capillary Electrophoresis;

Unit IV
Principles and applications of Northern blot, Western Blot and Southern Blot: ELISA, RIA, PCR. Protein sequencing

Unit V

Practicals:
1. Determination of absorption maxima and molar extinction coefficient of p-Nitrophenol from its absorption spectrum.
2. Effect of pH and solvent polarity on absorption spectrum of p-Nitrophenol.
3. Effect of slit width on absorption spectrum.
4. Estimation of proteins using Bradford/BCA method
5. Separation of proteins and M, Determination using SDS-PAGE.
6. Separation of Lipids using TLC
7. Separation of fatty acid methyl esters using GLC
8. Separation of proteins using gel filtration
9. Separation of proteins using ion-exchange chromatography
10. Demonstration of HPLC for separation of Biomolecules
Objective
To impart knowledge regarding the biochemical aspects of various nutrients and their interactions in foods during processing, storage and deterioration.

Theory
UNIT I

UNIT II
Nutritional requirements for different age groups and physiological status, factors effecting nutritional requirements. Biochemical and nutritional aspects of vitamins, minerals. Nutraceuticals, antioxidants, food toxins, antinutritional factors, probiotics and cultured dairy products.

UNIT III
Carbohydrates with special references to nutritional importance of lactose and dietary fibers, Fats-types of fatty acids and their significance in obesity and cardiovascular diseases, role of calcium in hypertension, cancer and osteoporosis, Biological availability of calcium.

UNIT IV
Effect of cooking, processing and preservation of different food products on nutrients, Biochemical aspect of post harvest storage specifically food spoilage. Enzymes in food industry, food additives (coloring agents, preservatives etc.), biogenesis of food flavours and aroma.

Suggested Readings
Swaminathan, M.S. Essentials of Foods and Nutrition VoL-I and II
Goodhart and Shils. Modern Nutrition in Health and Diseases
Wildwan and Mederios. Advanced Human Nutrition
Martin, East wood and Edenburg. Principles of Human Nutrition
Viswanath M. Sardesai. Introduction to Clinical Nutrition
II\textsuperscript{nd} Semester

**AB-621**  INTERMEDIARY METABOLISM  4+0

**Objective**
To teach metabolic pathways, their regulation, and methods used in their elucidation.

**Theory**

**UNIT I**
Introduction to metabolism, methods of studying metabolism, transport mechanism, bioenergetics, biological oxidation.

**UNIT II**
Catabolic and anabolic pathways of carbohydrates: glycolysis, citric acid cycle, pentose phosphate pathway, glyoxylate cycle, gluconeogenesis, metabolism of glycogen.

**UNIT III**
Fatty acid catabolism & biosynthesis, lipid biosynthesis, Electron transport and oxidative phosphorylation.

**UNIT IV**

**UNIT V**
Compartmentation of metabolic pathways, regulation of different metabolic pathways, major metabolic disorders, integration of metabolism, metabolic profiles of major organs, regulation of body mass, altered metabolism in starvation & diabetes mellitus

**Suggested Readings**
Objective
To provide knowledge regarding genes, their functions, expression, regulation and transfer in heterologous systems.

Theory
UNIT I
Historical development of molecular biology, nucleic acids as genetic material, chemistry and structure of DNA and RNA, Genome organization in prokaryotes and eukaryotes, repetitive and non-repetitive DNA, satellite DNA; chromatin structure and function.

UNIT II
DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase, RNA polymerases, transcription process, RNA editing, RNA processing. molecular mechanism of mutation.

UNIT III
Ribosomes structure and function, organization of ribosomal proteins genetic code, aminoacyl tRNA synthases’ inhibitors of replication, transcription and translation; translation and Post translational modification; nucleases and restriction enzymes, regulation of gene expression in prokaryotes and eukaryotes, translation in eukaryotes.

UNIT IV
DNA sequencing, recombinant DNA technology, vectors, isolation of genes, recombinants vector, selection of recombinants, PCR and its variants; site directed mutagenesis, in vitro transcription, gene silencing. Introduction to bioinformatics tools for primer designing, sequence blast and NCBI data bases.

Practical
1. Isolation and purification of DNA
2. Isolation and purification of RNA
3. Purity check of isolated DNA and RNA
4. Restriction fragmentation of DNA and agarose gel electrophoresis
5. RAPD analysis of DNA,
6. cDNA synthesis using PCR,
7. Plasmid isolation
Objective
To give an insight into the biochemical basis of immunity.

Theory
UNIT I
History and scope of immunology, cellular basis of immunity-adaptive and non-adaptive immunity, memory, specificity and diversity, self and non self discrimination, immune system, organs, tissues and cells, cell mediated vs humoral immunity, immunoglobulins, concept of antigen, immunogen, adjuvant, hapten.

UNIT II
Classes of antibodies, Antibody diversity, theories of generation of antibody diversity, Monoclonal antibodies, polyclonal antibodies, Hybridoma, Recombinant antibodies, complement system- classical and alternate.

UNIT III
Cellular interactions in the immune response, affinity, avidity, B-cell and T-cell response, major histocompatibility complex, cell mediated immune response, cytokines, Vaccine.

UNIT IV

Practical
1. Handling, inoculation and bleeding of laboratory animals,
2. Preparation of antigens and antiserum,
3. Separation of lymphocytes from blood, viable lymphocyte count,
4. Phagocytosis,
5. Detection of antibody by precipitation, agglutination, immunodiffusion,
6. Immunoelectrophoresis,
7. Quantitation of immunoglobulins by zinc sulphate turbidity and by ELISA,
8. Selective salt fractionation of immunoglobulins and removal of salts from precipitated immunoglobulins using dialysis,
9. Characterization of immunoglobulins by PAGE.

Suggested Readings
Abbas AK & Lichtman AH. 2003. Cellular and Molecular Immunology. 5th Ed. WB Saunders.
AB-624 ANIMAL BIOCHEMISTRY 3+0

Objectives
To impart knowledge regarding biochemistry of various physiological processes, specialized tissues and hormone action in animal system.

Theory

UNIT I
Digestion and absorption of food, Vitamins, Detoxification, Biochemistry of specialized tissues–connective tissue, skin, muscle, nervous tissue, blood and other body fluids, Biochemistry of Rumen functions.

UNIT II
Water, electrolyte and acid-base balance, Biochemistry of respiration, Structure, function and mechanism of action major trace elements.

UNIT III
Hormones of hypothalamus, pituitary, thyroid, pancreas, adrenals, gut, kidney and sex hormones. Membrane receptors of hormones.

UNIT IV
Molecular mechanism of signal transduction pathways; structure, function and regulation of production of male and female gametes; in vitro fertilization. Molecular mechanism of milk biosynthesis in mammary gland; Potent biological tissue effectors viz Eicosanoids, interleukins, interferons, bioactive peptides and growth factors.


Suggested Readings
Ph.D
1st Semester

AB- 711 ADVANCED ENZYMEOLOGY 2+0

Objective:
To provide advanced knowledge about the models, mechanisms, kinetics, regulation and engineering of enzymes

Unit I
Various models for enzyme action, Enzyme catalysis in terms transition state theory, Active site titration, Identification of active site residues. Factors associated with catalytic efficiency: proximity and orientation, distortion and strain

Unit II
Pre-steady state kinetics, direct measurements of enzyme rate constants, continuous and stopped flow methods, relaxation techniques (pH jump, denaturation and temperature), kinetics for regulation of enzyme activity with allosteric effectors.

Unit III
Determination of energy of activation, Arrhenius equation, eyering equation. Determination of $pK_a$ factors affecting $pK_a$ value. Determination of free energy, enthalpy and entropy of enzymatic reaction.

Unit IV
Enzyme stabilization, bifunctional enzymes, enzymes from extremophiles. Enzyme catalysis in abnormal aqueous and non-aqueous environment. Enzyme engineering.

Suggested readings

2. Review articles from research journals

AB-712 ADVANCED MOLECULAR BIOLOGY 2+0

Objective
To impart latest information on the molecular biochemistry of isolation, transfer and expression of genes in plants and biochemical approaches employed in gene therapy.

Theory

UNIT I
Organization of prokaryotic genome, nuclear and organelle genes, concept of genome mapping and Organization, molecular evolution

UNIT II
Prokaryotic and Eukaryotic gene regulation, RNA editing, Molecular Biology of viruses.
UNIT III
Methods of gene isolation and transfer in animals, molecular basis of male sterility, Applications of genetic engineering.

UNIT IV
Site directed mutagenesis, gene targeting and gene therapy, bioethics and biosafety guidelines and IPR in recombinant DNA research.

Suggested Readings
Selected articles from journals.

AB-713 FUNCTIONAL GENOMICS, PROTEOMICS AND METABOLOMICS

Objective
To impart knowledge in the upcoming areas of biochemistry, and to acquaint the students with the recent developments of job opportunities in pharmaceutical and other industries.

Theory
UNIT I
Protein and nucleic acid sequencing: Various methods of sequencing including automated sequencing and microarrays, whole genome sequence, co-regulated genes

UNIT II
Comparative genomics, functional genomics, transcriptomics and transcriptional network, gene identification, application of genomics, Quantitative PCR, SAGE, Massively Parallel Signature Sequencing (MPSS), Cap Analysis of Gene Expression (CAGE)/deep CAGE, Chip-Chip assay, epigenetic regulation

UNIT III
Proteome technology- 2D-PAGE, MSMS, MALDI-TOF, and Protein-protein interaction (Hybrid assay, DNA-Protein interaction and gene regulation (EMSA and Chip assay), comparative proteomics.

UNIT IV
Metabolic pathway engineering, Metabolomic definition, Metabolic fingerprinting, Metabolomics library, Application of Metabolomics for Translational and Biological Research, Introduction to nutrigenomics and nutrigenetics.

AB- 714 BIOMEMBRANES

Objective
To teach structure and functions of biomembranes, structure-function relationships, membrane biogenesis.

Theory
UNIT I
Concept of biomembranes and their classification based on cellular organelles; physico-chemical properties of different biological and artificial membranes, cell surface receptors and antigen.

UNIT II
Membrane biogenesis and differentiation; membrane components-lipids, their distribution and organization; proteins, intrinsic and extrinsic, their arrangement; carbohydrates in membranes and their function.

UNIT III
Various membrane movements; transport across membrane and energy transduction.

UNIT IV
Role of membrane in cellular metabolism, cell recognition and cell–to–cell interaction; signal transduction, recent trends and tools in membrane research.

Suggested Readings

2nd Semester

AB-721 BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES 2+0

Theory

UNIT I
Metabolism of Xenobiotics: Classification, properties and isoforms of cytochrome P450; Phase I and Phase II reactions,

UNIT II
Oxidative stress and diseases: Biomarkers of oxidative stress, Adhesion, activation and respiratory burst by phagocytes, Molecular basis of hypertension, diabetes, obesity and cancer
UNIT III
Biochemical and genetic basis of disease: Monogenic and multifactorial disorders; Isolation of genes causing disease; Human genome project and diseases; Protein misfolding during diseases

UNIT IV
Thermal & Cold tolerance: Molecular chaperones; Anti freeze proteins; Heat and cold adaptive enzymes; Biochemistry of animal hibernation; Biochemistry of cryo protection

UNIT V
Cytotoxic and genotoxic assays; Bioindicators, Biomarkers and Biosensors

Suggested Readings
Functional metabolism: Regulation and Adaptation by Kenneth B. Storey

AB-722 CURRENT TOPICS IN BIOCHEMISTRY 1+0

AB-723 ADVANCED TECHNIQUES IN BIOCHEMISTRY 2+0

UNIT I
Tissue Culture: Setting up a cell culture laboratory; Principles of aseptic handling; Cell line derivation; Cell freezing and quantitation; Contamination control; Cell freezing and thawings; Cell culture media constituents and their functions; Designing serum-free medium. Techniques for short-term and long-term culture of organs.

UNIT II
Enzyme–linked immunosorbent assay (ELISA: Basic principle and methodology; Classification and types of ELISA; Preparation of enzyme-immune body conjugates and their purification; ELISA versus RIA techniques for assay of hormones.

UNIT III
Hybridoma techniques: Principle of development of hybrids producing monoclonal antibodies; Fusion of myeloma cells with antibody producing B cells; Selection, screening and cloning methods; In vitro and in vivo for production of monoclonal antibodies; Purification and characterization of monoclonal antibodies.

UNIT IV
High performance liquid chromatography: Basic principle and theory. Types of pumping systems and their essential features; Column packing; Detection systems; Normal and modified stationary phases for adsorption, gel filtration and ion exchange chromatography.

UNIT V
Affinity chromatography: Basic principle and theory; matrices, spacer arms and ligands; Coupling gels; Group specific adsorbents; Preparation of different affinity media, Purification of biomolecules and applications.
UNIT VI
Radiotracer techniques: Basic principles for use of radiotracers in study of biological processes; Ionization based radiotracer techniques- Principle and historical perspectives of proportional and Gieger Muller counters; Liquid scintillation counting (LSC): Principle, Instrumentation; and technique; Double isotope counting; Scintillation cocktails and function of its constituents; Tissue solublization and sample preparation; Quinching and quinch correction; Principle of gamma ray detection

Suggested Readings:
1. Introduction to Radioimmunoassay and related techniques by T.Chard
2. Enzyme Immunoassay by Edward T.Maggio.
4. Animal Cell culture: A Practical Approach by Freshney, R.I.
6. Instrumental Methods of Analysis by Willard et al.

AB-724 ADVANCED BIOINFORMATICS 2+0
Theory
Unit I
Database Concepts, nucleic acid and protein sequence databases, Structure databases, and integration of databases,
Unit II
Genome organization, human genome, livestock and bacterial genomes
Unit III
Computational gene discovery, pair wise & multiple sequence alignments, sequence similarity search, phylogenetic analysis
Unit IV
Protein Structure analysis, Protein Secondary structure prediction, Homology modeling Principles and Procedures, Protein-protein docking.

Suggested Readings:
S. B. Primrose and R.M. Twyman, Blackwell Publishing
Ralph Rapley and Stuart Harbron (Eds.), John Wiley and Sons
Andreas D. Baxevanis and B. F. Francis Ouellette(Eds.)  
Wiley Interscience
Richard J. Simpson, Cold Spring Harbor Laboratory
5. Online Resources over the Internet

AB- 719 DOCTORAL SEMINAR I 1+0
AB- 729 DOCTORAL SEMINAR II 1+0
AB-799 DOCTORAL RESEARCH
ANIMAL BIOTECHNOLOGY

Course Structure – at a Glance for M.Sc./M.V.Sc.

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Course Structure for Ph.D.

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Minor Subjects to be chosen from following disciplines:
1. Animal Biochemistry
2. Animal physiology
3. Animal Genetics and Breeding
ANIMAL BIOTECHNOLOGY
First Semester M.Sc./ M. V. Sc.

Course Contents

BT 611 FUNDAMENTALS OF CELL & MOLECULAR BIOLOGY 3+0

Objective: Molecular structure and functions of cells and molecules such as DNA, RNA and proteins.

Theory
UNIT I

UNIT II
Cell signaling: Endocrine, exocrine and synaptic signalling molecules, surface and intracellular receptors, G proteins and generation of secondary messengers, mode of action of cAMP and Ca++ calmodulin, target cell adaptation. Cell growth and divisions: Cell cycle, cell division controls and transformation, growth factors, genes for social control of cell division, mechanism of cell division, cell adhesion, cell junctions and the extra cellular matrix, growth, development and differentiation.

UNIT III
History of molecular biology, nucleic acid as hereditary material, structure of DNA, chromatin, rRNA, tRNA and mRNA, proteins. DNA replication, transcription, translation, genetic code, operon, positive and negative control of gene expression.

BT-611
Molecular basis of mutation, Types of mutation, Examples of genetic disorder caused by mutation in livestock, Structure of eukaryotic genomes, Fundamentals of molecular evolution., Forces driving molecular evolution, Molecular clock and estimation of species divergence time, Molecular markers and DNA polymorphism.

Suggested Readings

BT 612 ANIMAL CELL CULTURE: PRINCIPLES AND APPLICATIONS 2+1

Objective: Understanding the principles of animal cell culture and its application.

Theory
UNIT I
Introduction, importance, history of cell culture development, different tissue culture techniques including primary and secondary culture, continuous cell lines, suspension culture, organ culture, hybridoma technology, culture of lymphocyte, oviductal, epithelial cell culture, stem cell and iPS cells.

UNIT II
Different type of cell culture media, growth supplements, serum free media, balanced salt solution, other cell culture reagents, culture of different tissues and its application.

UNIT III
Behavior of cells in culture, division, their growth pattern, metabolism of estimation of cell number. Scaling up the cell culture to large scale/industrial level production.

UNIT IV
Development of cell lines, characterization and maintenance of cell lines, cryopreservation, common cell culture contaminants. Culture of cells for production of various biologicals.

Practical
i. Packing and sterilization of glass and plastic wares for cell culture.
ii. Preparation of reagents and media for cell culture.
iii. Primary culture of oviductal, epithelial and fibroblast cell.
iv. Cultivation of continuous cell lines.
v. Quantification of cells by trypan blue exclusion dye.
vi. Isolation and cultivation of lymphocytes
vii. Study of effect of toxic chemicals on cultured mammalian cells
viii. Suspension culture technique
ix. Cryopreservation of primary cultures and cell lines.

Suggested Readings

BT 613 IMMUNOLOGY APPLIED TO BIOTECHNOLOGY 2+1

Objective: Understanding the application of immunological techniques in biotechnology.

Theory
UNIT I
Introduction, principles of immunology, immune system, immune response, major histocompatibility complex, antigen, antibody, immunoglobulin diversity.

UNIT II
Application of antibodies in purification, immunoblotting, expression of recombinant proteins and detection in different expression systems, industrial production of cytokines and interferon, expression of immunoglobulin genes in plants and production of antibodies.

UNIT III
Introduction to newer vaccine approaches namely sub-unit vaccines, synthetic vaccines, DNA vaccines, virus like particles, recombinant vaccines, edible vaccines, Nano particles in vaccine delivery systems, etc.

UNIT IV
Somatic cell hybridization, hybridoma technology, commercial production of antibodies using monoclonal antibodies.
Practical
i. Immunodiffusion.
ii. Immunoelectrophoresis.
iii. Fluorescent antibody test.
iv. Enzyme immunoassays including ELISA.
v. Immunoblotting.
vi. Affinity chromatography,
vii. Bioinformatics tools for immunological research.
viii. Cultivation of normal lymphocytes and myeloma cell line.
ix. Somatic cell hybridization and production of hybridoma.
x. Screening of hybrids for production of monoclonal antibodies.

Suggested Readings

BT 614 REPRODUCTIVE BIOTECHNOLOGY 2+1

Objective: Understanding in-vitro reproductive techniques for ovum and embryo manipulation.

Theory
UNIT I
Genome organization in mammalian nucleus. Chromosome number evolution in mammalian species. Repeat sequences in the mammalian genome. Mitochondrial DNA of farm animals. Gene expression methods.

UNIT II
Tools to analyse the mammalian genome: Karyotyping, PFGE, genomic DNA cloning vectors, Cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, in-situ hybridization

Unit III
DNA markers- RAPD, STR, SSCP, RFLP, DNA fingerprinting, SNP, EST etc. Different types of PCR. NCBI and bioinformatics basics related to animal genomics.

UNIT IV
Current status of gene maps on domestic animals, comparative gene mapping, evolutionary significance, applications of genome analysis of animals in breeding. Disease resistance and immune response genes and genes influencing production traits. Concept of QTL. Genetic distance analysis, breed characterization on the basis of DNA markers

Practical
i. Synchronization and superovulation protocols.
ii. Collection of embryos using non-surgical procedures.
iii. Transferring embryos using non-surgical procedures.
iv. Oocyte/Embryo freezing protocols.
v. Oocyte collection and evaluation from slaughterhouse ovaries.
vi. In vitro fertilization protocols.
vii. Micromanipulation of early embryos.
viii. Monitoring reproductive organ using ultrasonography

**Suggested Readings**

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**Second Semester M.Sc./ M. V. Sc.**

**BT 621 APPLIED MOLECULAR BIOLOGY 2+1**

**Objective:** Understanding the principle and application of recombinant DNA in biotechnology.

**Theory**

**UNIT I**
Enzymes used in molecular biology and recombinant DNA research, important enzymes such as RNA replicase, reverse transcriptase, ligase, polymerase, ribozyme, restrictions etc., cloning and expression vectors: plasmid, Lamda (\( \lambda \)), Cosmid, M13, phagmid and viral vector for animal cells, *synthetic chromosomes BAC, YAC and PAC*.

**UNIT II**
Genomic and cDNA libraries: Construction of gene libraries, gene identification, gene mapping and DNA structure analysis, synthesis of complementary DNA, cDNA library construction, identification and screening of genomic and cDNA library, subtractive hybridization for tissue specific cDNA library.

**UNIT III**
Methods for transfer of cloned DNA, analysis and expression of recombinant DNA, site directed DNA alterations and gene manipulations, *gene expression* in bacteria, yeast and animal cells. **Principle of protein engineering, Phage display technology and panning, Principle of metabolic engineering.**

**UNIT IV**
Application of genetic engineering: **Studying regulation of gene expression by reporter gene assays, DNA sequencing, DNA protein interaction studies (EMSA, DNasel foot printing), protein-protein interaction studies.** Application of genetic engineering in veterinary and medical sciences for production of high value and industrial products, Biohazard and safety aspects in genetic engineering.
Suggested Readings


**BT 622 MOLECULAR DIAGNOSTICS**

**Objective:** Understanding the molecular techniques involved in diagnosis of diseases.

**Theory**

**UNIT I**
Introduction, importance and historical perspective of development of molecular diagnostic technology, concept of development of group specific and strain specific nucleic acid based diagnostics, basis for selection of gene/nucleotide sequence of pathogenic organism to target for detection.

**UNIT II**
Application of restriction endonuclease analysis for identification of pathogens, principle of development of pathogen specific DNA probes, Southern and Northern hybridization.

**UNIT III**
Theoretical background of development of PCR and Real time PCR and its variations, application of PCR for diagnosis of infectious diseases of animals and poultry, nucleic acid sequence based diagnostics.

**UNIT IV**
Advancements in diagnostic technology including DNA array technology, biosensors and nanotechnology. OIE guidelines in development of diagnostics.

**Practical**

i. Preparations of buffers and reagents.
ii. Extraction of nucleic acids from bacteria and clinical specimens.
iii. Restriction endonuclease digestion and analysis in agarose electrophoresis.
iv. Development of animal pathogen specific nucleic acid probes.
v. Southern blotting for detection of pathogens.
vi. Polymerase chain reaction for detection of pathogens in blood and other animal tissues.
vii. RT-PCR for detection.
viii. Real time PCR for detection of pathogens in semen and other animal tissues.
ix. DNA fingerprinting for identification of animal species.
x. PCR based detection of meat adulteration in processed and unprocessed meats.
xi. PCR based detection of potential pathogens in milk, eggs and meat.

**Suggested Readings**

BT 623 ANIMAL GENOMICS 2+1

Objective: Understanding structural, functional and comparative genomics of farm animals and its application for livestock improvement.

Theory

UNIT I
Genome organization in mammalian nucleus. Chromosome number evolution in mammalian species. Repeat sequences in the mammalian genome. Mitochondrial DNA of farm animals. Gene expression methods.

UNIT II
Tools to analyse the mammalian genome: Karyotyping, PFGE, genomic DNA cloning vectors, Cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, in-situ hybridization

Unit III
DNA markers- RAPD, STR, SSCP, RFLP, DNA fingerprinting, SNP, EST etc. Different types of PCR. NCBI and bioinformatics basics related to animal genomics.

UNIT IV
Current status of gene maps on domestic animals, comparative gene mapping, evolutionary significance, applications of genome analysis of animals in breeding. Disease resistance and immune response genes and genes influencing production traits. Concept of QTL. Genetic distance analysis, breed characterization on the basis of DNA markers

Practical
i. Chromosome preparation (normal karyotyping, different types of banding) in farm animals.
ii. Isolation and purification of animal genomic DNA from blood lymphocytes.
iii. Analysis of DNA by agarose or polyacrylamide gel electrophoresis.
iv. Checking the quality and quantity of genomic DNA.
v. Techniques for revealing polymorphism- RFLP, SSCP etc.
vi. Genomic DNA cloning.
vii. Differentiation of tissues of different species by mitochondrial genome analysis.
viii. Computational method for Nucleic acid and protein sequence analysis.

Suggested Readings
BT 624 TECHNIQUES IN MOLECULAR BIOLOGY AND GENETIC ENGINEERING 0+3

Objective: To provide comprehensive hands-on training on techniques of molecular biology and genetic engineering.

Practical
UNIT I
Isolation of bacterial plasmids and chromosomal DNA. Isolation of DNA from mammalian cells. Isolation of mRNA/RNA. Quantitation of nucleic acids.
UNIT II
Plasmid minprep; Restriction endonuclease digestion of plasmid and chromosomal DNA. Agarose gel electrophoresis of RE digested DNA; Isolation of DNA; cDNA synthesis
UNIT III
Polymerase Chain Reaction using random primers as well as specific primers. Different types of PCR, Real time polymerase chain reaction
UNIT IV
Cloning of DNA into plasmid vectors. DNA ligation and transformation; Confirmation of insert by RE digestion and PCR; Synthesis of nucleic acid probes; Nucleic acid hybridization

Suggested Readings

ANIMAL BIOTECHNOLOGY
First Semester Ph. D. Syllabuses

BT 711 GENE CLONING AND EXPRESSION 3+0

Objective
Understanding the concept of gene cloning and expression.

Theory
UNIT I
Cloning vectors- plasmids, phages, cosmids, BAC, YAC, PAC, expression vectors-viral, baculo and yeast vectors, shuttle vectors, transformation, transfection and recombinant selection methods, construction of genomic and cDNA library, construction of full length cDNA DNA labelling methods.
UNIT II
Directional cloning, in frame cloning, ligase independent cloning. DNA shuffling. Rational designing of next generation recombinant proteins with improved functionality/novel utility: Enzyme engineering, antibody engineering etc., Protein engineering tools.
UNIT III
Expression of genes, prokaryotic and eukaryotic expression, identification and purification of expressed proteins.

UNIT IV
Genome editing tools; homologous recombination, Cri-lox recombination, knock-in, knock out/down technologies, gene targeting by TALEN, Crisper/Cas9 technologies, Biohazards and safety aspects in genetic engineering

Suggested Readings

BT 712 FUNCTIONAL GENOMICS AND PROTEOMICS 3+0

Objective: Understanding gene expression at different conditions/organs.

Theory
Mitochondrial genome, Protein coding genes, RNA genes and repeat sequences. Variations in the mammalian genome. Expression of mammalian genome. Different methods to study gene expression, single gene analysis, northern blots, quantitative PCR, SAGE, MPSS and SSH. Introduction to basic microarray technology, Design of experiments, Types of microarray.

UNIT II

UNIT III
Databases such as NCBI, EBI, Nucleotide, Genome, SNP, Gene, Unigene, Homologene, Protein etc under NCBI. Service databases under EBI. Genome browsers, The concept of Comparative genomics, Genome BLAST and BLAT.

UNIT IV
Proteomics technology, identification and analysis of proteins by 2D analysis, mass spectrophotometry, MALDI-TOF, Differential display proteomics, Protein -protein interaction, yeast two hybrid system and phage display. Circular dichroism, Fluorescence Spectroscopy, NMR and X-ray crystallography.

Suggested Readings
Objective
Understanding the new developments in reproductive technology.

Theory
UNIT I
Folliculogenesis. **Immunomodulation of reproduction.** Recent advances in *in vitro* embryo production and cryopreservation of gametes **and embryos.**

UNIT II
Introduction to stem cells of different types. Production and characterization of embryonic, adult and **spermatogonial stem cells** and iPS cells. **Differentiation and applications of stem cells.** Signalling pathways regulating pluripotency in **embryonic stem cells.** Social, ethical and regulatory issues related to stem cells.

UNIT III
Reproductive **and therapeutic** cloning. Somatic cell nuclear transfer (SCNT). **Applications, limitations and current status of SCNT.** Nuclear reprogramming. Intra-cytoplasmic sperm injection. Embryo micromanipulation. **Sperm sexing by FACS.**

UNIT IV
**Principles and** applications of transgenesis technology. Production of transgenic animals. **Designing and construction of transgenes.** Gene transfer by calcium phosphate co-precipitation, lipofection, electroporation, nucleofection and **viral vectors.** Microinjection of recombinant DNA into fertilized eggs.

Suggested Readings
Selected articles from journals.
BT 721 TRENDS IN VACCINOLOGY 3+0

Objective
Understanding the latest developments in vaccine production technologies.

Theory
UNIT I
Molecular approaches to development of vaccines including: Conventional vaccines, Therapeutic vs. preventive vaccines, recombinant peptide vaccines, vectored vaccines, DNA vaccines, genetically manipulated live vaccines, glycoconjugate vaccines.

UNIT II
Plant expression system based vaccines, idiotype and synthetic peptide based vaccines, reverse genetic approach and computational vaccinology.

UNIT III
Immunomodulators including cytokines and new adjuvants, Immunomodulation, innovative methods of delivery of immunogens through liposomes, microspheres, ISCOMS, etc.

UNIT IV
Large scale production technology and quality control, regulatory issues, vaccines testing, environmental concerns with the use of recombinant vaccines, challenges in vaccines development.

Suggested Readings
Selected articles from journals.

BT 722 ADVANCES IN ANIMAL CELL CULTURE 3+0

Objective
Understanding the latest developments in cell culture techniques.

Theory
UNIT I
Generation of embryonic and induced pluripotent stem cells and their differentiation into different lineages. Development of cell lines, three-dimensional culture system, characterization of cell lines by morphology, chromosome analysis, DNA content, enzyme activity and antigenic markers.

UNIT II
Cultivation requirements of different types of cells, flow cytometry, cell counting. Effect of physical parameters on cultures, mechanical damage of animal cell culture, hydrodynamic stress under continuous culture condition, Chemical effect on cell physiology.

UNIT III
Gene transfer into cultured cells with different methods and expression of recombinant proteins in mammalian cell lines. **Cell engineering and expression of antibodies in cell lines.**

UNIT IV

Cell culture bioreactors, up-stream and downstream processing of culture cells for large scale production of vaccines, diagnostic antigens, antibodies and other pharmaceutical agents. **Use of commercially available cell lines in research.**

**Suggested Readings**
Selected articles from journals.
COURSES FOR ANIMAL GENETICS AND BREEDING

AGB 611 ANIMAL CYTOGENETICS AND IMMUNOGENETICS (2+1)
AGB 612 POPULATIONS AND QUANTITATIVE GENETICS IN ANIMAL BREEDING (3+1)
AGB 613 SELECTION METHODS AND BREEDING SYSTEMS (3+1)
AGB 614** BIOMETRICAL TECHNIQUES IN ANIMAL BREEDING (3+1)
AGB 621 MOLECULAR GENETICS IN ANIMAL BREEDING (2+1)
AGB 622 CONSERVATION OF ANIMAL GENETIC RESOURCES (2+0)
AGB 623 LINEAR MODELS IN ANIMAL BREEDING (2+1)

AGB 624 CATTLE AND BUFFALO BREEDING (2+1)
*AGB-625 LABPRATATORY ANIMAL BREEDING (1+1)(introduced from 2015-16 session)approved in 38th AC on 12.2.2015
AGB 626 SHEEP AND GOAT BREEDING (2+0)
AGB 619 MASTER'S SEMINAR (1+0)
AGB 629 MASTER’S SEMINAR (1+0)
AGB 699 MASTER’S RESEARCH (20)
AGB 711 RECENT ADVANCES IN ANIMAL GENETICS (2+0)
AGB 712 RECENT TRENDS IN ANIMAL BREEDING (2+0)
AGB 713 ADVANCES IN BIOMETRICAL GENETICS (3+0)
AGB 721 ADVANCES IN SELECTION METHODOLOGY (3+0)
AGB 722 ADVANCES IN MOLECULAR CYTOGENETICS (2+0)
AGB 723 UTILISATION OF NON-ADDITIVE GENETIC VARIANCE IN FARM ANIMALS (3+0)
AGB 719 DOCTORAL SEMINAR (1+0)
AGB 729 DOCTORAL SEMINAR (1+0)
AGB 799 DOCTORAL RESEARCH (45)
# Semester-Wise Distribution of Revised Courses

## M.Sc / M.V.Sc

<table>
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<td>AGB 612</td>
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## Ph.D

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<td>AGB 723</td>
<td>UTILISATION OF NON-ADDITIVE GENETIC VARIANCE IN FARM ANIMALS</td>
<td>3+0</td>
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AGB 614 (Biometrical techniques in animal breeding) presently offered as course No. AGB 605 in II semester will be shifted to I semester from next academic session 2010-11

- Introduced from 2015-16 session

AGB 611 ANIMAL CYTOGENETICS AND IMMUNOGENETICS (2+1)

Theory:

UNIT I
Development in animal cytogenetics and immunogenetics of farm animals. Immunoglobulins and their types: antigen-antibody interactions, immune response, ELISA.

UNIT II
Major histocompatibility complex; genetics of biochemical variants and their applications; Irgenes and concepts of disease resistance including major genes; hybridoma and its significance; concept of immuno-fertility, BoLA, BuLA, TLRs, Interleukins.

UNIT III
Chromatin structure of eukaryotes; chromosome number and morphology in farm animals; banding and karyotyping; chromosomal and genetic syndromes, DNA packing in chromosomes, Z+B DNA, FISH chromosome painting and PRINS. RH Panel Mapping.

UNIT IV
Mutation and assays of mutAGBENesis; sister chromatid exchanges; recombinant DNA technique and its application in animal improvement programme.

Practical:
In vitro preparation of somatic metaphase chromosomes; screening of chromosomal abnormalities; microphotography and karyotyping; banding procedures for comparing the chromosomal complement, FISH and PRINS. In vivo preparation of somatic metaphase chromosomes; screening of chromosomal abnormalities; microphotography and karyotyping; banding procedures for comparing the chromosomal complement.

Suggested Readings:
Hare WCD & Elizabeth L Singh 1999. Cytogenetics in Animal Reproduction. CABI.

AGB 612 POPULATION AND QUANTITATIVE GENETICS IN ANIMAL BREEDING (3+1)

Theory:

UNIT I
Individual versus population. Genetic structure of population. Factors affecting changes in gene and genotypic frequencies and their effect on genetic structure of animal populations. Approach to equilibrium under different situations: viz. single autosomal locus with two alleles, single sex-linked locus, two pairs of autosomal linked and unlinked loci.
UNIT II
Small population: random genetic drift, effective population size, pedigreed populations, regular and irregular inbreeding systems.

UNIT III
Quantitative genetics-gene effects, population mean and variance and its partitioning, biometric relations between relatives.

UNIT IV
Genetic and phenotypic parameters-their methods of estimation, uses, possible biases and precision. Scale effects and threshold traits.

Practical:


Suggested Readings:


AGB 613 SELECTION METHODS AND BREEDING SYSTEMS  (3+1)

Theory:

UNIT I
Type of selection and their genetic consequences. Response to selection and its prediction and improvement of response to selection.

UNIT II

UNIT III
Selection of several traits. Evaluation of short term and long term selection experiments viz: bidirectional selection and asymmetry of response, selection plateau and limit.
UNIT IV

**Practical:**


**Suggested Readings:**


**AGB 614 BIOMETRICAL TECHNIQUES IN ANIMAL BREEDING** (3+1)

**Theory:**

UNIT I
Review of basic concepts in statistical inference and balanced experimental designs. Nature of structure of animal breeding data and sources of variation.

UNIT II
Introduction to matrix algebra, types of matrices and matrix operations. Determinants and their properties, methods of finding inverse of a matrix and their application.

UNIT III

UNIT IV

**Practical:**

Matrix applications, determinant and inverse of matrices. Estimation of variance components; Least squares method for analysis of research data; Collection, compilation,
coding, transformation and analysis of animal breeding data by using above biometrical techniques.

Suggested Readings:


AGB 621 MOLECULAR GENETICS IN ANIMAL BREEDING (2+1)
Theory:
UNIT I
Basic concept: Genesis and importance of molecular techniques; Genome organization – physical and genetic map, current status of genome maps of livestock.
UNIT II
Molecular markers and their application; RFLP, RAPD, Microsatellite/Minisatellite markers, SNP marker, DNA fingerprinting
UNIT III
DNA sequencing, Genome sequencing, Genomic Library, Polymerase Chain Reaction (PCR), its types (PCR-RFLP, AS-PCR etc.) and applications; Transgenesis and methods of gene transfer
UNIT IV
Quantitative Trait Loci (QTL) mapping and its application in animal breeding, Genome scan, Candidate gene approach, Genomic selection, Marker Assisted Selection- basic concept

Practical:
Extraction and purification of genomic DNA, Gel electrophoresis, Restriction enzyme digestion of DNA and analysis, PCR, PCR-RFLP, PCR-SSCP. Bioinformatics tool for DNA sequence analysis, Design of primer, Isolation of RNA, cDNA synthesis.

Suggested Readings:

AGB 622 CONSERVATION OF ANIMAL GENETIC RESOURCES (2+0)
Theory:

UNIT I
Domestic Animal Diversity in India, its origin, history and utilization. Present status and flow of Animal Genetic Resources and its contribution to livelihood security. Methodology for genotypic characterization of livestock and poultry breeds through systematic surveys. ManAGBement of breed; physical, biochemical and performance traits and uniqueness of animals of a breed; social, cultural and economic aspects of their owners/communities rearing the breed.
UNIT II
Concept of conservation, *In-situ* and *ex-situ* (*invivo* and *in-vitro*); models of conservation; prioritization of breeds for conservation. National and international strategies for conservation of Animal Genetic Resources.

UNIT III
Status, opportunities and challenges in conservation of AnGR. IPR issues pertaining to animal genetic resources/animal products or by-products. Registration of livestock breeds and protection of livestock owner’s rights in India.

**Suggested Readings:**

Lasley JF. 1987. *Genetics of Livestock Improvement*. 3rd Ed. IBH.

**AGB 623 LINEAR MODELS IN ANIMAL BREEDING**

(2+1)

**Theory:**

UNIT I
Introduction to linear models. Construction and assumptions of linear models. Fixed, random and mixed models.

UNIT II
Least squares procedure for fitting the linear models. One-way classification, one-way classification with a co-variable, two-way classification (with and without interaction).

UNIT III
Henderson’s methods for estimation of variance components, Basic concepts of maximum likelihood method. BLUE and BLUP.

UNIT IV
Models of full rank and not of full rank. Generalized inverse of a matrix.

**Practical:**

Building of models for various types of data; fitting one-way model, one-way model with a co-variable and two-way models (with and without interaction). BLUE and BLUP estimates. Generalized inverse of a matrix.

**Suggested readings:**

Linear Models by S R Searle, John Wiley and Sons Inc., New York, USA.
Applications of Linear Models in Animal Breeding by C R Henderson, University of Guelph, Canada.
Least Squares Analysis of data with Unequal Subclass Number by W R Harvey, ARS, USDA, Maryland, USA.
Theory:

UNIT I
History of dairy cattle and buffalo breeding. Breeds of cattle and buffalo and their characterization. Inheritance of important economic traits. Recording and handling of breeding data. Standardization of records. Computation of correction factors for the adjustment of the data. Estimation of breeding values of the cows and bulls.

UNIT II
Sire evaluation methods using single trait and multiple traits: construction of Sire indices, Sire evaluation under animal model, sire model; and maternal grand sire model. Open nucleus breeding systems with MOET.

UNIT III

UNIT IV
Considerations in the import of exotic germplasm for breeding cattle in the tropics. Appraisal of buffalo and cattle breeding programmes. Role of breed associations in dairy improvement.

Practical:

Suggested Readings:
Lasley JF. 1987. *Genetics of Livestock Improvement*. 3rd Ed. IBH.
Unit III
Pedigree recording, selection and mating methods / systems, short term and long term selection experiments in laboratory animals, breeding records of laboratory animals.

Unit IV
Effective population size, development of inbred strains, ethics and legislation for management of laboratory animals.

Unit V
Specific utility of different laboratory species/ animals for different requirements, Laboratory animal model for livestock and human diseases.

PRACTICAL:
Identification and handling of laboratory animals. Weighing, sexing and managing of laboratory animals. Maintenance of breeding records of laboratory animals. Karyotyping of laboratory animals and comparing the chromosomal complement of laboratory animals. Estimation of inbreeding coefficient and effective population size based on records. Computational modelling for short term and long term selection experiments in laboratory animals.

Suggested Readings

Proposed Course to be offered: In II\textsuperscript{nd} Semester as Major Course

Justification:
The new M.V.Sc course entitled “Laboratory Animal Breeding” is proposed, as Laboratory Animal Breeding includes as a part of syllabus in Agricultural Research Service Examination in the discipline of Animal Genetics and Breeding (Unit-10: copy enclosed).

AGB 626 SHEEP AND GOAT BREEDING (2+0)

Theory:

UNIT I
Breeds–Economic traits–Prolificacy-Breeding records and standardization.

UNIT II
Genetic parameters – Selection of males and females – Breeding systems. Development of new breeds.
UNIT III
Breeding policy – Breeding research – Conservation of breeds.
UNIT IV
Culling and replacement – EADR.

Suggested Readings:

**AGB 711 RECENT ADVANCES IN ANIMAL GENETICS (2+0)**
Theory:

UNIT I
Eukaryotic genome: Gene families, Pseudogenes SnRNPs, Gene conversion, tandemly repeated genes, Nuclear Organiser region, mRNA splicing, Minisatellites, Microsatellites and its usAGBe.

UNIT II

UNIT III
Transgenic animals their benefits in livestock production, somatic cell nuclear transfer, transgenic animals in biomedical research, ethical consideration of transgenic animals; gene therapy and transgenic animal production. Pharming of Pharmaceutical.

UNIT IV
Radiation hybrid panels and their usAGBe in livestock, microdissection of chromosomes, *In-situ* hybridization, chromosome painting, meiotic crossing over, genome selection; Structure and functions of major histocompatibility complex, T Cell receptor, CD4, Toll Like Receptors and their functions.

Suggested Readings
Selected articles from journals

**AGB 712 RECENT TRENDS IN ANIMAL BREEDING (2+0)**
Theory:

UNIT I
Biometrical models and their analytical techniques for animal breeding data using computer application and use of programmes in the field of animal breeding.

UNIT II
Formulation of detailed breeding plans, ongoing breed improvement programmes and their impact analysis in various species of livestock under different situations.

UNIT III
Advanced techniques in genetic manipulation for multiplication and improvement of livestock species.

Suggested Readings
Selected articles from journals.
AGB 713 ADVANCES IN BIOMETRICAL GENETICS (3+0)

Theory:

UNIT I
Analysis of longitudinal data, fixed ad random regression models. Regression on dummy variable.

UNIT II
Classificatory problems; discriminant function, D² analysis; principal component analysis.

UNIT III
Use of genetic parameters for prediction of recombinant inbred lines; advances in studies of genotype environment interaction and selection indices.

UNIT IV
Generation matrix and its use in population genetics; gene mapping of QTL (quantitative trait loci).

Suggested Readings
Selected articles from journals.

AGB 721 ADVANCES IN SELECTION METHODOLOGY (3+0)

Theory:

UNIT I
Fundamental theorem of natural selection; Selection in finite populations effect on genetic structure and variance. Optimum designs for the estimation of genetic parameters. Design of selection experiments for testing selection theory.

UNIT II
Methods of measurement of genetic and environmental trends. Advances in selection indices MultistAGBe, Restricted and retrospective selection indices.

UNIT III
Multi-information, Empirical evaluation of selection theory: genetic slippAGBe, limits to selection, asymmetry of response, selection experiments, effect of selection on variance.

UNIT IV
Selection for threshold traits; single and multiple trait best linear unbiased estimation (BLUE) and prediction (BLUP); selection under single and multiple trait animal models; direct and correlated response through various selection indices, relationship between BLUP and selection index; fundamentals of marker assisted selections.

Suggested Readings:
Selected articles from journals
AGB 722 ADVANCES IN MOLECULAR CYTOGENETICS (2+0)

Theory:
UNIT I

UNIT II
Somatic cell genetics – Stem cell genetics – Molecular cytogenetics and gene mapping – ISH, FISH, Radiation hybrid mapping, Fibre-FISH, PRINS.

UNIT III
Positional cloning – Spectral karyotyping.

UNIT IV
ImAGBe analysis – Chromosome walking – Chromosome painting.

Suggested Readings:
Selected articles from journals.

AGB 723 UTILISATION OF NON-ADDITIVE GENETIC VARIANCE IN FARM ANIMALS (3+0)

Theory:
UNIT I
Heterosis – forms and genetic basis; detection and estimation of non-additive genetic variance – averAGBe dominance, overdominance.

UNIT II
Partitioning of between cross variance – general combining ability, specific combining ability and reciprocal effects; methods of analyzing diallel crosses; utilization of non-additive genetic variance.

UNIT III
Crossbreeding systems – crossbreeding effects; recurrent and reciprocal recurrent selection and their forms.

UNIT IV
Development of specialized sire and dam lines; inbred lines and their maintenance; inbreeding and hybridization.

Suggested Readings:
Selected articles from journals.
# LIVESTOCK PRODUCTION AND MANAGEMENT

## Course Structure

### First Semester

<table>
<thead>
<tr>
<th>Major Courses</th>
<th>COURSE TITLE</th>
<th>CREDITS</th>
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<tbody>
<tr>
<td>LPM 611</td>
<td>Cattle and Buffalo Production and Management</td>
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<tr>
<td>LPM 612</td>
<td>Livestock Reproduction Management</td>
<td>2+1</td>
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<tr>
<td>LPM 613</td>
<td>Livestock Shelter Management</td>
<td>1+1</td>
</tr>
<tr>
<td>LPM 614</td>
<td>Poultry and Rabbit Production and Management</td>
<td>2+1</td>
</tr>
<tr>
<td>LPM 615</td>
<td>Climatology and animal production</td>
<td>1+0</td>
</tr>
<tr>
<td>LPM 619</td>
<td>Seminar</td>
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**Minor disciplines**

| DCB / DCN / DCP (Any course from the chosen minor discipline) | 6 |

### 2nd Semester

<table>
<thead>
<tr>
<th>Major Course</th>
<th>COURSE TITLE</th>
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<tbody>
<tr>
<td>LPM 621</td>
<td>Sheep and Goat Production and Management</td>
<td>2+1</td>
</tr>
<tr>
<td>LPM 622</td>
<td>Management of Swine, Equine and Wildlife</td>
<td>2+1</td>
</tr>
<tr>
<td>LPM 623</td>
<td>Principles of Environmental Hygiene and Waste Management</td>
<td>2+0</td>
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<tr>
<td>LPM 624</td>
<td>Farm Animal Behaviour</td>
<td>2+1</td>
</tr>
<tr>
<td>LPM 625</td>
<td>Integrated Livestock Farming System</td>
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<tr>
<td>LPM 626</td>
<td>Livestock business management</td>
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**Supporting**

(DCB/DCN/DCP/DESM) Courses depending upon requirement of student from other than minor/major discipline of the student

### NON CREDIT COURSES:

For master degree to be covered in third semester.

- **GS-632** Technical writing (1+1)
- **GS-633** Intellectual property and its management in agriculture (1+0)
- **GS-634** Basic concepts in laboratory techniques/practices (0+1)
- **GS-635** Disaster Management (1+0)
### Ph.D. 1st Semester

<table>
<thead>
<tr>
<th>CODE</th>
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<tr>
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<tr>
<td>LPM 712</td>
<td>Advances in Swine and Equine Management</td>
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<tr>
<td>LPM 713</td>
<td>Advances in Applied Ethology</td>
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<td>LPM 719</td>
<td>Seminar - I</td>
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**Minor disciplines**

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### 2nd Semester

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<tbody>
<tr>
<td>LPM 721</td>
<td>Advances in Sheep and Goat Production and Management</td>
<td>3+0</td>
</tr>
<tr>
<td>LPM 722</td>
<td>Advances in Poultry Production and Management</td>
<td>2+1</td>
</tr>
<tr>
<td>LPM 723</td>
<td>Advances in Environmental Management</td>
<td>3+0</td>
</tr>
<tr>
<td>LPM 729</td>
<td>Seminar - II</td>
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</table>

**Supporting**

(Any course from the chosen minor discipline)

DCB / DCN / DCP (Any course from the chosen minor discipline)
Objective
To acquaint students on basic aspects of dairying in India compared with developed countries, problems and prospectus of dairying, detailed aspects of care and management of different classes of dairy cattle and buffaloes.

Theory
UNIT I
Introduction – Development of Dairy Industry in India and world – Present status and future prospects of livestock development in India
UNIT II
Important breeds of cattle and buffalo, traits of economic importance and their inter-relationships - Selection of high quality animals - Role of management in improving the reproduction efficiency in farm animals. - Housing and rearing systems.
UNIT III
Breeding Management: System of breeding Economic traits. Methods of Breeding - Prenatal and postnatal care and management of cattle and buffalo - Care of neonate and young calves - Management strategies for reducing mortality in calves, age at first calving and calving interval in cattle and buffaloes.
UNIT IV
Management of labour, Milking management, Machine milking and hand milking, Different laws governing the livestock sectors to produce quality products on par with international standards - Technique of harvesting clean and hygienic livestock products, transportation of animals, health management. Wallowing in buffaloes- Management of draught animals and summer management
UNIT V
Feed and fodder resources used for feeding of cattle and buffaloes– Scientific technique of feeding, watering – Computation of practical and economical ration, supply of green fodder around the year and enrichment of poor quality roughages.

Practical:
Visits to cattle farms and critical analysis of various types of managerial practices - Study of breeding management in the farm- Analysis of practical feeding management- milking - calf, heifer and adult management- Dairy Cattle and Buffalo judging and body condition scoring - Project preparation for external funding and commercial farms and enterprises for dairy products –marketing strategies for milk and milk products and meat. Management of labour, labour norms. Use of computers for record keeping, care and maintenance of dairy farm equipments.

Suggested Readings
Arora SP. 1997. Feeding of Dairy Cattle and Buffaloes. Kalyani.45
Dutta G. 1994. Care and Management of Dairy Cattle and Buffaloes. 3rd Ed. ICAR.
Objectives:
To acquaint students with knowledge in principles, planning, technical approach for reproduction management in different farm animals. Controlled reproduction in farm animals.

Theory:
UNIT I
Functional morphology of male and female reproductive organs of farm animals.
UNIT II
Managemental strategies for attaining early maturity in farm animals
UNIT III
Heat detection methods, associated problems and their management. Oestrus synchronization, needs, methods and limitations. Artificial breeding and its economic importance.
UNIT IV
Post A.I. management, pregnancy development and diagnosis. Management of down calvers.
UNIT V
UNIT VI
UNIT VII
Planning and management of frozen semen bank and bull station. Handling of frozen semen. Maintenance of records for artificial breeding and frozen semen bank.

Practical:

Suggested Readings
Hafez, E.S. E.( 2002). Reproduction in Farm Animals
LPM 613 LIVESTOCK SHELTER MANAGEMENT (1+1)

Objective
To familiarize students with type of houses suited for different livestock under varying climatic conditions.

Theory
UNIT I
General principles in planning animal houses- farmstead and animal houses - Selection of site and planning; layouts for livestock farm of different sizes in different climatic zones in India - Farm structures - General principles of construction of enclosures, floor and road.

UNIT II
Housing requirements of different classes of Livestock - Preparation of layouts, plans, arrangement of alleys- Fitting and facilities in the houses for horses, dairy cattle, calves, bulls, work cattle, dogs, pigs, sheep, goats, and poultry.

UNIT III
Improvement of existing buildings; water supply; feed and fodder delivery systems - Economics of Livestock housing.

UNIT IV
Housing - Disease control measures and sanitation of all classes of livestock

Practical
Score card for animal houses - Time and motion study in Animal houses - Preparation of plans for Animal houses for horses, cattle, sheep, pigs, goats, and other livestock - Dogs and other pet animals - Economics of livestock housing - Preparation of plan for animal houses of different sizes and climatic zones of India.

Suggested Readings
Wathes CM & Charles DR. 1994. Livestock Housing. CABI.

LPM 614 POULTRY AND RABBIT PRODUCTION AND MANAGEMENT (2+1)

Objective
To acquaint students on basic aspects of housing, feeding, breeding and health care of poultry and rabbit. Comparing the performance under cage and
floor system of management of poultry, biosecurity measures to be followed
to reduce mortality and efficient hatchery management to produce healthy
young ones.

Theory

UNIT I
Poultry housing systems Cage Vs floor system, litter management and lights
for poultry, rearing turkey, duck and quails. Management of chicks, growing,
laying and breeding flocks, broiler production, selection and culling of laying
flocks.

UNIT II
Procuring, care and pre-incubation storage of hatching eggs - Method of
incubation, sanitation disinfection and management of hatchery. Embryonic
development and factors effecting fertility and hatchability of eggs. Chick
sexing, packing and hatchery business -

UNIT III
Introduction - Importance of rabbit for meat and fur production, - Common
breeds and strains. System of housing – Common diseases and their control
measure.

UNIT IV
Management of specific pathogen free and gnotobiotic animals, concepts to
related to welfare of laboratory animals.

UNIT V
Breeding - Age at maturity, litter size - Weaning – Feeding of growers –
Selection of replacement stock, transportation of rabbit. Transportation of
poultry and rabbit – marketing of meat and fur.

Practical
Poultry Farm management - Brooding of chicks; selection of laying flocks -
Disease preventive measures - Selection and care of hatching eggs;
incubator operation, fumigation and candling setting and hatching, packaging
of chicks -Waste management.

Handling and restraining of laboratory animals - Visits to Rabbit farms and
critical analysis of various types of managerial practices- Analysis of practical
breeding management methods - practical disease control management and
special management methods - Ageing and identification – Judging -
Economics of production.

Suggested Readings
Bhujabaruah et. al. 1995. Rabbit Production
LPM 615  CLIMATOLOGY AND ANIMAL PRODUCTION  (1+0)

Objective
To familiarize students on climate, weather, various climatic factors and their role in production and health of animals in both temperate and tropics, micro and macroclimatic conditions of animal house and assessing the heat tolerance of bovines.

Theory
UNIT I
Definition of climate - Classification of climatic regions - Climatic factors - Assessment of climate - Study of climatic factors in relation to animal production.
UNIT II
Light, natural and artificial light-mechanism of light action-photo period and light responses – Applications - Importance of light in production of animals and birds.
UNIT III
Introduction of breeds into different climatic regions - Agro meteorology and weather forecasting for Animal Husbandry activities - Micro climate modification in animal houses.
UNIT IV
Estimation of microclimatic conditions in Animal house - Measurement of Temperature, Relative humidity, Air Velocity and Mean temperature of the surrounding, measurement of intensity of light in animal houses – Construction of climographs and hythergraphs - Estimation of cooling power of atmosphere heat tolerance test in bovines.

Suggested Readings
Siddhartha K & Roger B. 1996. Atmosphere, Weather and Climate. ELBS.

LPM 621  SHEEP AND GOAT PRODUCTION AND MANAGEMENT  (2+1)

Objective
To acquaint students on status of sheep and goat farming in India, importance of record keeping, principles of housing and feeding, breeding management to improve the reproductive efficiency and detailed account on care and management of different classes of sheep and goat.

Theory
UNIT I
Introduction - Population structure and importance- Advantages and disadvantages of sheep farming under different systems of management – type of housing and equipments- Important sheep and goat breeds- Advantages and disadvantages of sheep and goat farming.
UNIT II
Breeding Management: Breeding seasons - fitness of purchase for first breeding - methods of detection of heat - Natural Service and artificial insemination - Care of the pregnant Animals - Breeding stock - Use of teaser - Culling.

UNIT III

Feeding Management: Feeding methods - Principles to be followed in feeding and watering - feeder space, waterer space, Designing feeders and waterers. - Range management - Stocking rate and pasture improvement and utilization; management under stall fed conditions, Transportation of sheep and goat.

UNIT IV

Disease Management: Role of management in the prevention and control of diseases. Special Management: Deworming - Dipping and spraying - shearing - Avoidance of goatry odour in milk, Tupping

UNIT V

Wool: Importance of wool - Fiber structure - Fleece characters - Goat fibers - Characters of mohair and pashmina, fur and Angora - Marketing of goat fibers/ wool. - Planning of sheep and goat farm of various sizes - Economics of sheep and goat farming.

Practical

Visit to sheep and goat farms and critical analysis of various managerial practices under different conditions. Study of practical housing management - Analysis of practical diseases control management - Shearing management - Record keeping. - Preparation of project for commercial farming - Characterization of sheep and goats; handling of sheep and goat; daily and periodical operations for sheep and goats - Methods of identification of sheep and goat. Cost of rearing sheep and goat for mutton and wool - Housing plans for various age and categories of sheep and goat - Dipping; Vaccination of sheep and goat - Shearing of wool.

Suggested Readings


LPM 622 MANAGEMENT OF SWINE, EQUINE AND WILDLIFE (2+1)

Objective

To impart knowledge on various aspects of swine and equine in India, principles of housing, breeding, feeding and health care of swine, equine species, management practices at different stages of growth and economic pig and equine production systems. Wildlife it’s significance and management.

Theory

UNIT I

Introduction - Population and importance - Economic contribution of pigs and equine species-Advantages and disadvantages of swine and equine keeping
- Systems of management - Problems in swine and equine farming. Principle and concept – ecology of wildlife sanctuaries and national parks.

UNIT II
Breeds of pigs and equine species - Selection of breeding stock - Breeding seasons - Age and weight at first services - Methods for detection of heat – Natural service and artificial insemination - Care of pregnant animals young ones and growing stocks. - Care of breeding males. Biological and ecological basis of management of wild animals.

UNIT III
Housing, sanitation and hygiene, disease prevention measures - Housing and equipment – Wallowing - Sanitation and hygiene - Role of management in the prevention and the control of diseases. Wildlife protection acts – zoological classification of wild animals.

UNIT IV
Feeding and management of new born, weaner and finishers, dry, pregnant and farrowing and foaling animals - Feeding principles to be followed - Methods of watering – Feeder space – Water space, etc - Record keeping. Breeding season pregnancies – parturition, lactation in wild animals.

Practical
Visits to Pig, Stud Farms, wildlife Institute and critical Analysis of various types of managerial practices - Analysis of practical breeding management methods, practical disease control management - Ageing and identification – Judging – Practical care and management at farrowing and foaling. Economics of production - Project preparation for research and commercial farms.

Suggested Readings

LPM 623 PRINCIPLES OF ENVIRONMENTAL HYGIENE AND WASTE MANAGEMENT

Objective
To familiarize students on principles of air and water hygiene with reference to impurities and inclusions of water, collection and disposal of waste from the
animal house, modern techniques in manure disposal and biosecurity measures to be adapted for hygienic production of livestock products.

**Theory**

UNIT I

Animal air hygiene: Definition - Composition of air - Air pollution – Factors affecting outdoor and indoor pollution - Assessment of these factors on animal health and production - Methods to control these factors.

UNIT II

Water Hygiene: Importance of water - Impurities and inclusions - Sterilization - Examination of water and water supplies - Collection of samples - Topographical physical, chemical, bacteriological and microscopic examination of water - Hygienic requirements and standards for drinking water - Quantity of water required by domestic animals - Methods of watering.

UNIT III

Manure - Quantity of manure voided by domestic animals - Animal excreta a factor in spread of disease - Hygienic and economic disposal of farm waste - Modern techniques used in automation / semi-automation in disposal of farm waste.

UNIT IV

Environmental protection act, Air (Prevention and control of pollution) act and water (Prevention and control of pollution) act - Biosecurity measures to be adapted for efficient and healthy production

UNIT V

Effect of environmental pollution on livestock and its products directly and indirectly - Controlling environmental pollution - Different factors affecting the quality of livestock and its products meant for human consumption

**Suggested Readings**


**LPM 624 FARM ANIMAL BEHAVIOR (2+1)**

**Objective**

To make acquainted students on principles of farm animal behaviour with regard to environmental influence, group formation, social behaviour and behavioural adaptations under domestication.

**Theory**

UNIT I

Introduction to Animal behaviour - Importance of animal behaviour studies - Patterns of behaviour - Daily and seasonal cycles of behaviour – Physiological basis of behaviour.

UNIT II

Environmental modification of behaviour - Developmental changes in behaviour - genetic differences in behaviour - Behavioural disorders.

UNIT III
Group formation - Social relationship, process of socialisation locality and behaviour - Practical application - Behavioural character for Managemental practices - Favourable and unfavourable behaviour for domestication - Behavioural adaptations under domestication.

UNIT IV

Practical


Suggested Readings
Fraser AF & Broom DM. 1997. Farm Animal Behaviour and Welfare. CABI.

LPM 625 INTEGRATED LIVESTOCK FARMING SYSTEM (2+1)

Objective
To familiarize on various aspects viz., scope and limitations of integrated livestock farming system, recent approach and economic feasibility of different integration models for sustainable production

Theory
UNIT I
Scope and limitation of integrated farming systems - Sustainability of integrated Livestock Farming Systems and their economic importance.

UNIT II
Integration of fish, arable farming and different livestock enterprises vis-à-vis gobar gas plant, FYM, solar and wind energy utilization, cattle, buffalo sheep, goat, pig, poultry, rabbit, silk worm, bee keeping etc.

UNIT III
New approach for changing farming systems in present energy crises.

UNIT IV
Project formulation and evaluation of various livestock enterprises.

Practical
Various livestock farming units and their economic analysis - Evaluation of
different farming systems and their economic importance – Preparing feasibility report for various farming projects.

**Suggested Readings**


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**LPM 626 LIVESTOCK BUSINESS MANAGEMENT (1+1)**

**Objective**

To acquaint students with knowledge in principles, planning, technical approach and preparing financial statement in Livestock Business Management and preparing projects for financing.

**Theory**

UNIT I

Management principles - Planning - Techniques, strategic planning, organization structure, co-ordination and controlling techniques – Approaches to management.

UNIT II

SWOT analysis, financial accounting - Accounting records - Balance sheet, fund flow statement - Cost and analysis for managerial decisions – Budgeting and control .

UNIT III


UNIT IV

Marketing - Objectives, strategies - Selecting and managing marketing channels - Pricing strategies - Sales promotion - Legislation relating licensing - Company law.

**Practical**

Preparation of financial statements, depreciation accounting methods, trend and variance analysis, cost-volume profit analysis - Financial planning and forecasting - Estimation of working capital requirement - Break even analysis - Visit to livestock business firms and banks - Preparing projects for financing.

**Suggested Readings**


LPM 711 ADVANCES IN CATTLE AND BUFFALO PRODUCTION (3+0) AND MANAGEMENT

Objective
To acquaint students on latest developments on dairying in India compared with developed countries, problems and prospectus of dairying, detailed aspects of care and management of different classes of dairy cattle and buffaloes.

Theory
UNIT I
Dairy farming in India – Global scenario - Present status and reasons for the same – Avenues for progress – The needs of the nation and how to achieve it.
UNIT II
Advances in housing management of dairy cattle and buffaloes in various agroclimatic zones of India - Management systems for cattle and buffaloes.
UNIT III
UNIT IV
Advances in Feeding Management of cattle and buffalo, Feed for milking herd, dry cows, bulls and calves, Management of high yielding animals.
UNIT V
UNIT VI
Advance in health management of dairy animals, metabolic diseases of high yielders- advances in preventive measures for production related diseases

Suggested Readings
Selected articles from journals.

LPM 712 ADVANCES IN SWINE AND EQUINE MANAGEMENT (2+1)

Objective
To educate about the latest advances of swine farming in India, principles of housing, breeding, feeding and health care of pigs, management practices at different stages of swine. To familiarize the students on latest aspects of principles of housing, breeding, feeding and health care of different classes of horse, stable routines and measures to reduce the mortality in young ones at different seasons.

Theory
UNIT I
The past, present and future of Swine production systems in India and production policies adopted in advanced countries. New indigenous and exotic horses breeds - Types and classes of light and work horses.

UNIT II
Advances in breeding and selection – Prenatal and postnatal development - Growth reproduction and lactation - Economic traits of swine production. New indigenous and exotic horses breeds - Types and classes of light and work horses. Advances in health management & diseases control in swine and horses.

UNIT III
Advances in feeding and nutrition in pigs; automatic feeding and watering techniques, Feed stuffs, Energy, protein, minerals and vitamin sources, metabolic and nutritional disorders – Toxic substances.

UNIT IV

UNIT V
Mode of transport, Facilities requirement, Cleaning, disinfection and preparation of vehicles Transport stress, Management during transport, Regulatory acts of states and centre in animal disease control and welfare. Precautions and requirements before, during and after transport, Laws governing the import and export of livestock and its products, Horse passport and trading

Practical
Visit to leading stud farms, Marketing - Study of population trend and structure. Analysis of breeding, feeding, housing, health care, farrowing management, summer management and special management principles practiced. Foot care and shoeing care, Stud farms, Race clubs, Race horses and their care, Horse behaviour and training, Exercising , Basic Horsemanship.

Suggested Readings
Selected articles from journals.

LPM 713 ADVANCES IN APPLIED ETHOLOGY (2+0)

Objective
To make acquainted students on advanced concepts of farm animal behaviour with regard to environmental influence, group formation, social behaviour and behavioural adaptations under domestication.

UNIT I
Recent advances and development in applied ethology, role of ethology in animal science, philosophies and ethics in ethology. Ethology in Agriculture
UNIT II
Thermo regulation, communicative behaviour, emotions, man animal interaction, motivation, behavioural chemistry, innate and learned aspects, Quotidian behaviour.

UNIT III
Behavioural developments-Kinetic behaviour of the foetus and neonate, neonatal sensory developments, Imprinting, changes in group formation, bonding and play. Behaviour of maintenance-reactivity, ingestive, exploratory, kinetic, body care and territoriality. Dynamics of reproductive behaviour-nursing and maternal care.

UNIT-IV
Behavioural disorders-Vices, their etiology, prevention and cure. Management of behaviour-Building of animal ethograms. Ethology and international Animal regulations

Suggested Readings:
- Fraser, A.F. and Broom D.M. Farm Animal Behaviour and Welfare. by ELBS Bailliere Tindall
- Albright J.L. and Arave C.W. The Behaviour of Cattle. CABI publication.

LPM 722 ADVANCES IN SHEEP AND GOAT PRODUCTION AND MANAGEMENT (3+0)

Objective
To educate the students on advances in sheep and goat farming for improving their productivity through different management practices.

Theory
UNIT I
Utility origin – Domestication - Numbers and distribution of meat and dual purpose breeds - Methods of rearing – Range sheep production –

UNIT II
The farm flock – Pure bred flock - Management during breeding season - The sexual seasons and its control - Puberty – Time of the year to breed – Flushing – Ram-Ewe ratio.

UNIT III
Advances in feeding management, Nutrient deficiencies in range forage, Feed
to supplement range forage, General feeding practices, Feeding materials, Lamb feeding, Use of antibiotics and hormones, Hand feeding, Self feeding, Pellet feeding, Feeding lambs and ewes during lactation.

UNIT IV
Recent development in sheep and goat management and their relevance under Indian economic conditions, needs and possibilities for future research.

UNIT V
Role of sheep husbandry in dry farming in India, Present development programmes in sheep and goat production, Advances in reproduction, housing, feeding and watering, diseases, Shearing methods and culling of sheep and goat.

UNIT VI
Role of goat in animal agriculture, Goat farming in India, selection of Breeding stock, Breeding problems, Housing, Principles of feeding, Practices, Crops and crop residues for goats, Milking practices.

Suggested Readings
Gupta JL. 2006. Sheep Production and Management. CBS.
Selected articles from journals.

LPM 723 ADVANCES IN POULTRY PRODUCTION MANAGEMENT (3+0)

Objective
To educate the students on advances in housing, feeding, breeding and health care in poultry farming.

Theory
UNIT I
Planning, organisation, executive and management of poultry farms and hatcheries of various sizes - alternative in poultry production
UNIT II
Demand, supply, present status of poultry production.
UNIT III
Problems and new management techniques in poultry for egg and meat in India vis-à-vis in other countries of the world, automation in poultry houses, management of specific pathogen free flocks.
UNIT IV
Poultry development policies and planning for higher production constraints in development and solutions, Ethology and entology in relation to poultry production

Practical
Visit to commercial poultry farms and hatcheries. Planning and preparation of research and commercial projects on broiler and layer production management.

Suggested Readings
Selected articles from journals.
Objective

To educate the students on advances in climate, weather, various climatic factors monitoring and their role in production and health of animals in both temperate and tropics, micro and macroclimatic conditions of animal house and environmental influences on the performance of farm animal production.

Theory

UNIT I
The animal Industry and the quality of the environment – Management of the living environment - Microenvironment and macro environment.

UNIT II
Air Pollution: Indoor and out door - Chemical, physical and bacteriological changes - Causes – Standards and the extent tolerated by animals - Effects on animal production.

UNIT III
Fixing standards in relation to CO2 - Air supply in relation to cubic space, temperature, air, velocity, relative humidity, dust particles, bacterial count, effective temperature and cooling power - Methods to get over pollution – Cleaning and washing - Air conditioning.

UNIT IV

UNIT V
Water Pollution: Significance, treatment and control - Funding agencies for animal welfare

Practical

Assessment of various factors in Indoor and outdoor environment- Assessment of CO2, air supply, dust particles and bacterial count in air - Visit to sewage treatment plant - Planning farm waste disposals - Physical chemical and bacteriological examination of water watering of farm animals.

Suggested Readings


List of Journals

- Asian Journal of Buffalo Production and Management
- Australian Journal of Animal Science
Suggested Broad Topics for Master's and Doctoral Research

Dairy cattle and buffalo Production
- Pre and postpartum management of dairy animals
- Reducing age at first calving
- Reducing calf mortality
- Reducing calving intervals
- Increasing reproductive efficiency
- Farming system research / extension approach
- System approach to livestock development
- Housing management of animals in semi arid region

Poultry Production
- Poultry housing system
- Stocking density in poultry
- Environmental effects on poultry
- Feeding management of poultry
- Methods of processing poultry manure
- System of approach for poultry development

**Small ruminant production**
- Sheep and goat housing system
- Impact study on scientific management of sheep and goat
- Environmental effects on sheep and goat
- Feeding management of sheep and goat

**Rabbit production**
- Rabbit housing system
- Feeding management of rabbit
- Productive and reproductive performance of rabbit under tropical climate

**Swine production**
- Swine housing system
- Feeding management of swine
- Productive and reproductive performance of pigs under tropical climate
LIST OF COURSES TO BE OFFERED TO M.V.SC STUDENTS (ANIMAL NUTRITION)

SEMESTER 1

MAJOR DISCIPLINE (Animal Nutrition)
AN-611(2+1) Energy and Protein
AN 612(2+1) Non conventional Feed stuffs and toxic consitutents/ antinemetabolites in animal feedstuffs
AN 613(1+1) Feed Technology
AN 614  (2+2) Feeds and Forages for livestock
AN 615(2+1) Ruminant Nutrition

SUPPORTING COURSE
AB 601(3+1) Basic Biochemistry

Total credits : 19
Total credits : Major : 15
Supporting (Animal Biochemistry): 4
Total : 19

SEMESTER 11

MAJOR COURSES
AN 621(3+1) Animal Nutrition-Minerals,vitamins and Feed additives
AN 622 (1+1) Non- Ruminant Nutrition
AN 623 (2+1) Nutrition of companion/laboratory, wild and zoo animals
AN 624 (1+3) Research Techniques in Animal Nutrition
AN-625 (3+1) Principles and Practices in Animal Nutrition
AN- 629 (1+0) Masters Seminar

MINOR DISCIPLINE (Animal Physiology)
AP 608 (2+1) Chemical Bioregulation in Physiological Processes
AP 609 (2+1) Enviromental Physiology

SUPPORTING COURSES
ES 629 (3+1) Design of experiment

Total credits (Semester 11):  Major 13
Minor 6
Supporting 4
Seminar: 1
Total: 24

Overall credits during sem 1 and 11  Major : 15+13=28  Required: Major:24
Minor :6
Supporting: 8
Seminar :1
Thesis:20
Total : 63
# LIST OF COURSES TO BE OFFERED TO Ph.D STUDENTS (ANIMAL NUTRITION)

## SEMESTER 1

### MAJOR DISCIPLINE
- **AN 711 (2+0)** Modern concepts of feeding monogastric animals
- **AN 712 (2+0)** Nutrition and rumen fermentation
- **AN 713 (1+0)** Advances in micronutrients
- **AN 714 (1+2)** Advanced techniques in nutrition and research
- **AN 719 (1+0)** Doctoral seminar

### MINOR DISCIPLINE
- **AP 706 (3+0)** Advances in Biosynthesis and secretion of milk

### SUPPORTING COURSE
- **BT 602 (3+0)** Fundamentals of cell and molecular biology.

**Total Credits (Semester 1):**
- **Major:** 8
- **Minor:** 3
- **Supporting:** 3
- **Seminar:** 1
- **Total:** **15**

## SEMESTER 11

### MAJOR COURSES
- **AN 721 (3+0)** Modern concepts of feeding ruminants and Forage utilization
- **AN 722 (1+0)** Advances in Feed technology
- **AN 723 (1+0)** Clinical Nutrition
- **AN 724 (2+0)** Nutrient and Drug interaction
- **AN 725 (2+0)** New feed resources and toxicants in animal feeding
- **AN 729 (1+0)** Doctoral seminar

### MINOR COURSES
- **AP 705 ( 3+0)** Advances in Reproductive Physiology

### SUPPORTING COURSE
- **CS 621 (2+1)** Computer software package for statistical analysis

**Total Credits (Semester 2):**
- **Major:** 9
- **Minor:** 3
- **Supporting:** 3
- **Seminar:** 1
- **Total:** **16**

**Overall credits during Sem 1 and 11:**
- **Major:** 17
- **Minor:** 6
- **Supporting:** 6
- **Seminar:** 2
- **Thesis:** 45
- **Total:** 76

**Required Major:** 15
- **Minor:** 6
- **Supporting:** 3
- **Seminar:** 2
- **Thesis:** 45
- **Total:** 75
Objective
Familiarization with fundamental concepts of energy and proteins, metabolism of carbohydrate, fat and protein and their efficiency of utilization. Requirement of carbohydrates, fat and proteins for various physiological functions.

Theory

UNIT I
The classification and chemistry of carbohydrates, fats, proteins and their sources. Chemistry of cell wall constituents. Recent methods such as CNCP for feed analysis. Fundamental concepts of Digestion and metabolism of Carbohydrate Fat and Protein in different species of animals. Metabolism of Volatile fatty acids. Gluconeogenesis. Recent advances in glucogenic precursors on acetate utilization. NPN metabolism, urea fermentation potential and metabolizable protein. Amino acids imbalance, antagonism and toxicity.

UNIT II

UNIT III
Rumen degradable Protein (RDP), and rumen undegradable protein (UDN) and Kinetics. Energetics of protein synthesis and turn over. Quantification of microbial protein synthesis. Protein quality determination in monogastrics and ruminants.

UNIT IV

Suggested Readings
Nutrients and their metabolism with special reference to milk, meat and wool production.

UNIT II
Feeding standards, their history, comparative appraisal and limitations. Classification of feedstuffs. Nutrient requirements for calves, heifers, dry, pregnant and lactating cows, buffaloes, sheep and goat.

UNIT III
Introduction to rumen microflora and fauna. Development of rumen. Defaunation and animal productivity: rumen fungi, NPN compounds, microbial Protein synthesis. Role of milk replacers and calf starters.

UNIT IV
Feed formulation of large and small ruminants for different physiological stages. Concept of complete feed. Limiting nutrients and strategic feeding of high yielding ruminants. Concept of by-pass nutrients and their impact on production, reproduction and immune status. Importance of CLA, omega fatty acids, Scope for value addition in milk. Different systems of feeding buffalo for beef production.. Feeding during natural calamities, feeding in various agro-climatic zones of India.

Practical
Design and planning of feeding experiments. Identification of feed and fodder on the basis of its composition. Artificial rumen technique, Methods for evaluation of feedstuffs- in vitro gas, in sacco digestion kinetics. Determination of nutritive value of feeds and fodders by metabolism trial in dairy cattle, determination of nutritive value of pastures by the use of range techniques, study of rumen metabolic profile. Preparation of Bypass Nutrients Identification of rumen microbes and rumen studies.

Suggested Readings

AN 613 Forages and Feeds for livestock production 2+2

Objective
To acquaint with inherent nutritional quality of feeds and forages and forages grown in different agro climatic regions of country. Forage preservation techniques and nutritional evaluation.

Theory
UNIT I

UNIT II
pasture. Forage production from silvo pasture/multi-storeyed system. Raising and planting desirable species of tree/shrubs.

UNIT III

UNIT IV

UNIT V

UNIT VI

Energy and protein supplements to forage diets. Cereals and cereal by products – the nutrient composition of grains, barley, maize, oats, wheat, other cereals, root crops and by products of horticultural sources. Protein concentrates – oilseed cakes and meals, oilseed residues of minor importance, leguminous seeds, animal protein concentrates, milk products, single-cell protein, synthetic amino acids, non-protein nitrogen compounds as protein sources. Oil and legumes seeds and their by products, their feeding values and limitations.

Practicals

AN 614 NON CONVENTIONAL FEEDSTUFFS AND TOXIC CONSTITUENTS / ANTIMETABOLITES IN ANIMAL FEEDSTUFFS

Objective
To understand the importance of alternate feeds and their use in augmenting profit in livestock farm. Different toxins present in feed stuffs, their properties and detoxification techniques.

Theory
UNIT I
Present and future feed requirements and current availability for livestock and poultry. Use of non-traditional feeds - By-products of agricultural, industrial, food processing units and forest by-products. Evaluation by chemical and biological methods. Formulation of economical rations. Level of inclusion of various non conventional feeds in livestock ration
UNIT II
Classification of toxic principles in animal feedstuffs. Chemico-physical properties of various toxins. Effect of toxins on biological system and nutrients utilization in different species of livestock. Detoxification of toxin principles by various physical, chemical and biological techniques. Insecticide and pesticide residue detection.

Practical
Estimation of various protease inhibitors; tannins; and mycotoxins in various feeds and feedstuffs. Nitrates, HCN, oxalates, insecticide and pesticide residues, saponins, Gossypol, mimosine, heavy metals.

Suggested Readings


AN 615 FEED TECHNOLOGY 1+1

Objective
Introduction to the subject, formula feed manufacturing and different operations involved. Layout, designing, operation and management of feed mill.

Theory
UNIT I
Importance of feed technology in relation to animal productivity and constraints in India. Procurement, sampling, quality control, storage of feeds and Inventory control. Familiarisation of various feed mill equipments, layout and operations. Problems of feed manufacturing units and control measures. Safety aspects.

UNIT II
Introduction to least cost formula feed manufacturing including principals of material handling, grinding, mixing, pelleting block (frequents) and other major processing operations. Testing of efficiency of equipments, Crumbling, Flaking, Popping, Extrusion. BIS specifications of feeds and good manufacturing practices.

UNIT III

Practical
Identification of feed ingredients and their specifications, as well as compound feed for different categories of livestock and poultry. Prorata deductions on the bases of feed quality. Feed microscopy, Formulating premixes. Introduction to Pulverisers, pelletisers, complete feed blocks equipments, visit to feed plant for plant layout and design of different capacity of feed mills, problems related to feasibility, records keeping in different sections of feed mill.
Experimental learning at the feed plant for preparing feed, urea molasses mineral blocks, mineral mixture.

Suggested Readings
Gohl BO. 1985. Teopical Feeds . FAO
Ponds WG, Church DC & Pond KR. Basic Animal Nutrition and Feeding John Wiley & sons

AN 621 ANIMAL NUTRITION - MINERALS, VITAMINS AND FEED ADDITIVES

Objective

Theory
UNIT I
Definition, history, classification, chemistry, functions, deficiencies and excesses, requirements and sources of water soluble and fat-soluble vitamins. Vitamin content of different feeds.

UNIT II

UNIT III

Practical

Suggested Readings

**AN 622**

**NON-RUMINANT NUTRITION**

Objective
Requirement of nutrients and feeding of various non-ruminants species for efficient quality production.

Theory

**UNIT I**
Nutrients, their metabolism and requirements for poultry and swine during different stages of growth and production. Limiting iminoacids-lysine and methionine.

**UNIT II**
Feeding systems and feed additives, feed formulations for different purposes including least cost rations.

**UNIT III**

**UNIT IV**
Nutritional factors affecting quality of the products. Hind gut fermentation and its importance, Nutrient requirements of rabbits and equines, Nutritional manipulation for producing value added egg, meat / pork

Practical
Design and planning for poultry and swine feeding experiments, formulation and compounding of general and least cost rations, determination of nutritive value of poultry and swine feeds by balance experiments, evaluation of protein quality, Visit to poultry and piggery units, feed and fodder stores, Use of software in least cost feed formulations. Basic principles governing the least cost formulation software's.

Suggested Readings
Objective
Preparation, storage and evaluation of feeds and feeding standards of companion/laboratory/wild and zoo animals.

Theory
UNIT I
Feed Habbits, food patterns, digestive structure and functions companion laboratory, wild and zoo animals, Neutral dietary habits. Nutritional requirements of various species of animals.

UNIT II
Feeding standards and feeds habits of companion/ laboratory animals, Importance of colostrums and feeding of neonates and growing animals. Feeding and care of nursing mothers. Feeding of sick and old animals. Post Surgical nutrition.

UNIT III

UNIT IV
Composition, presentation, sterilization, palatability, assessment and storage of companion/laboratory animals diets, companion food tables and their nutritional assessment. Mistakes and misleading information on companion food labels and labelling.

UNIT V
Nutraceuticals in companion/ laboratory foods and animals foods. Nutritional deficiency diseases. Geriatric nutrition- corrective measures.

Practical
Formulation and preparation of hygienic, balanced diets and feeding for companion/laboratory animals. Characteristics of ration formulation and feeding schedules wild and zoo animals. Feeding schedules for sick and orphan wild/zoo animals. Artificial and emerging feeding. General feeding habits and different feed constituents of wild and captive animals. Research methodology of companion/laboratory animals. Processing and storage of companion/ laboratory diets. Visit to Zoological parks and wildlife sanctuary.

Suggested Readings

AN 624  RESEARCH TECHNIQUES IN ANIMAL NUTRITION  1+3
Objective
Planning and designing of experiments, use of various techniques in estimating chemical and bio-chemical constituents in fodders, blood milk, rumen liquor, meat, wool etc.

Theory
UNIT 1.

UNIT II
Criterion for the selection of techniques, application of tracer technique for the in vivo measurement of methane emission, VFA production rate, Principles and procedures for estimating the nutrient digestibility by the application of markers.

Practical
Preparation of buffers and measurement of pH, pKa, mineral estimation by AAS, Ions estimation in feeds and biological fluids, Determination of gross energy in feeds, faeces and urine using Bomb calorimeter, Interpretation and presentation of results, VFA fractionation using GLC, Amino acid determination using HPLC, measurement of aflatoxins and urea in feeds.

Suggested Readings

AN-625 Principle and Practices in Animal Nutrition 3+1

PART 1 : INTRODUCTION TO ANIMAL NUTRITION

1. Farm Animal and their Feed
2. Animal Nutrition: Its Role in Modern Agriculture and Society
3. Common Methods of Analysis for Nutrients and Feedstuffs
4. The Gastrointestinal Tract and Nutrition
5. Measurement of Feed and Nutrient Utilization

PART 2 : NUTRIENT METABOLISM

1. Carbohydrates and their sources
2. Lipids and their sources
3. Protein and their sources
4. Energy Metabolism
5. Mineral Elements
6. Mineral Toxicities and Organic Toxins in the Food Chain
7. Vitamins
8. Regulation of Nutrient Partitioning
9. Water

PART 3 : APPLIED ANIMAL NUTRITION AND FEEDING
1. Factors Affecting Feed Consumption
2. Feeding standards and Productivity
3. Feed Stuffs
4. Feed Preparation and Processing
5. Diet Formulation
6. Cattle and Buffalo Feeding
7. Sheep and Goats Feeding
8. Swine and Poultry Feeding

PART 4 : PRACTICALS

1. Identification of Common Feeds
2. Feeding Analysis, Detergent system
3. In-vitro Techniques for DM Digestibility
4. Ration Computations
5. Conducting Digestibility trial

Suggested Reading:

2. Animal Nutrition Science by Gordon M.C.L. Dryden
LIST OF COURSES TO BE OFFERED TO M.V.SC STUDENTS (ANIMAL NUTRITION)

SEMESTER 1

MAJOR DISCIPLINE (Animal Nutrition)

AN-611(3+0) Energy and Protein
AN 612(2+1) Non conventional Feed stuffs and toxic constitutents/ antimetabolites in animal feedstuffs
AN 613(1+1) Feed Technology
AN 614 (2+2) Feeds and Forages for livestock
AN 615(2+1) Ruminant Nutrition

SUPPORTING COURSE

AB  601(3+1) Basic Biochemistry

Total credits : 19

Total credits : Major : 15
Supporting (Animal Biochemistry): 4
Total : 19

SEMESTER 11

MAJOR COURSES

AN 621(3+1) Animal Nutrition-Minerals,vitamins and Feed additives
AN 622 (1+1) Non- Ruminant Nutrition
AN 623 (2+1) Nutrition of companion/laboratory, wild and zoo animals
AN 624 (1+3) Research Techniques in Animal Nutrition
ANN 629 (1+0) Masters Seminar

MINOR DISCIPLINE (Animal Physiology)

AP 608 (2+1) Chemical Bioregulation in Physiological Processes
AP 609 (2+1) Enviromental Physiology

SUPPORTING COURSES

ES 629 (3+1) Design of experiment

Total credits (Semester 11):  Major 13
                                Minor 6
                                Supporting 4
                                Seminar: 1
                                Total: 24

Overall credits during sem 1 and 11 Major : 15+13=28 Required: Major:24
                                        Minor :6         Minor : 6
                                        Supporting: 8    Supporting: 3
                                        Seminar :1        Seminar: 1
                                        Thesis:20         Thesis: 20
                                        Total : 63       Total : 60
LIST OF COURSES TO BE OFFERED TO Ph.D STUDENTS (ANIMAL NUTRITION)

SEMESTER 1

MAJOR DISCIPLINE

AN 711 (2+0) Modern concepts of feeding monogastric animals
AN 712 (2+0) Nutrition and rumen fermentation
AN 713 (1+0) Advances in micronutrients
AN 714 (1+2) Advanced techniques in nutrition and research
AN 719 (1+0) Doctoral seminar

MINOR DISCIPLINE

AP 706 (3+0) Advances in Biosynthesis and secretion of milk

SUPPORTING COURSE

BT 602 (3+0) Fundamentals of cell and molecular biology.

Total Credits (Semester 1): Major: 8
Minor: 3
Supporting: 3
Seminar 1
Total: 15

SEMESTER 11

MAJOR COURSES

AN 721 (3+0) Modern concepts of feeding ruminants and forage utilization
AN 722 (1+0) Advances in Feed technology
AN 723 (1+0) Clinical Nutrition
AN 724 (2+0) Nutrient and Drug interaction
AN 725 (2+0) New feed resources and toxicants in animal feeding
AN 729 (1+0) Doctoral seminar

MINOR COURSES

AP 705 (3+0) Advances in Reproductive Physiology

SUPPORTING COURSE

CS 621 (2+1) Computer software package for statistical analysis

Total Credits (Semester 2): Major: 9
Minor: 3
Supporting: 3
Seminar: 1
Total: 16

Overall credits during Sem 1 and 11

Major: 17 Required Major: 15
Minor: 6 Minor: 6
Supporting: 6 Supporting: 3
Seminar: 2 Seminar: 2
Thesis: 45 Thesis: 45
Total: 76 Total: 75
AN 711  MODERN CONCEPTS OF FEEDING MONOGASTRIC ANIMALS  (2+0)

Objective
To impart knowledge on modern concepts in nutrient requirement and feeding of monogastric livestock

Theory
Unit I
Total feed stuff availability, ingredients commonly used in Poultry and Swine feeds, feed related issues and new challenges Nutrients and their functions feeding managements Nutritional factors affecting egg quality, hatchability and meat production in poultry. Feeding for designer eggs. Role of essential fatty acids, amino acids imbalance, toxicity and interactions in monogastrics.

UNIT II
Developments in digestive physiology of swine –equines-Measurement of protein and energy requirements- Influence of processing of feed and fodders in mono-gestric animal nutrition.

UNIT III
Modern concepts of amino acid nutrition at various physiological status –Role of vitamins and minerals in health and disease. Advances in new generation feeds and feed additives.

Suggested Readings
Selected article from Journals

AN 712  NUTRITION AND RUMEN FERMENTATION  2+0

Objective
To impart knowledge on nutrient requirements for neonatal and post natal development of livestock, recent concepts of rumen fermentation and its manipulation

Theory
UNIT I
Nutrient requirements for fertility and gestation, prenatal growth and foetal nutrition. Postnatal feeding, growth and developments - Body composition at prenatal and postnatal stages, abnormalities due to malnutrition.

UNIT II

AN 713  ADVANCES IN MICRONUTRIENTS  1+0

Objective
Recent concepts of mineral and vitamin nutrition and their role in immunity, reproduction and other functions in animals
Theory

UNIT I

UNIT II
Developments in vitamin and mineral requirements for growth, reproduction and lactation. Synthesis of vitamins by microbials in rumen and digestive tract. Identification and correction of deficiencies and toxicities of minerals in farm animals. Deficiency of minerals in different agro-climatic zones and area–specific mineral mixture, Micronutrients and immunity.

UNIT III

Suggested Readings
Selected articles from journals.

AN 714 ADVANCED TECHNIQUES IN NUTRITION AND RESEARCH (1+2)

Objective
To impart knowledge on use of advanced analytical techniques in nutrition research

Theory

Unit 1
Developments in analysis of nutrients in feeds (NCP) methods. Estimation of toxins and mycotoxins – Application of atomic absorption spectrophotometer, HPLC - Enzymatic methods of feed analysis – Isotopes in nutrition research terms, types od decay, units, proportional counting, Gamma counting and beta counting, Handling of isotopes, precaution and safety – Analytical aspect of feeds and fodders using N.I.R.

Unit II
Faecal inoculums as alternative to rumen liquor in in vitro studies – Degradability of feeds by various techniques – rates of VFA and microbial production.

Practical
Estimation of major, minor and toxic minerals by atomic absorption spectrophotometer, Estimation of mycotoxin by HPLC, Estimation of oxalate, nitrates, tannin and mimosine, VFA
fractionation by GC. Methane estimation using SF₆ Technique, amino acid analysis using HPLC, Microbial protein synthesis using purine derivatives, milk fat and FA estimation including CLA, Estimation of Pesticides.

**AN 721 MODERN CONCEPTS OF FEEDING RUMINANTS AND FORAGE UTILIZATION (3+0)**

**Objective**
To impart knowledge of modern concepts in nutrient requirement and feeding and enhanced utilization in ruminant and recent development in analysis of forages.

**Theory**

**UNIT I**
Dairy cows in intensive systems - environmental concerns. Recent developments in ruminant digestive physiology - Energy protein requirement and measurement - Requirements of other nutrients. Synchronization of energy and protein in rumen for maximum utilization of nutrients for enhancement in productivity. Importance of energy and protein quantity and quality Feed input and milk output relationship. Net energy model tropics. Details of CNCP system for evaluation of feed stuffs modelling of digestion and metabolism and nutrient requirements. Ghrelin and feed intake, Genetic potential redefined, in MOLLY Equation for lactating ruminants.

**UNIT II**

**UNIT III**

**UNIT IV**
Seminars on current topics of special interest. **Suggested Readings**
Selected articles from journals

**AN 722 ADVANCES IN FEED TECHNOLOGY (1+0)**

**Objective**
To impart knowledge on modern feed processing methods and automated feed plant layout
Theory

UNIT I
Current status of feed industry, Feed and fodder processing - Particle size reduction - bulk density - processing of grains and oil seeds - processing of roughages - feed plant layout and design - feed plant management - storage of feeds. Computer based control system. Sanitation and pest management.

UNIT II
Non conventional feed resources - Formulation of concentrates, premixes and rations - improvement of nutritive value of poor quality roughages – liquid feed supplements. Solid state fermentation (SSF) technology. Codex alimentarius, HACCP, Quarantine measures.

AN 723 CLINICAL NUTRITION 1+0
Objective
Impact of nutrition on health, immunity, digestive/metabolic disorders, reproductive performance, bacterial and parasitic infestations, organic toxins and stress nutrition, feeding management of sick animals

Theory

UNIT I
Nutritional factors responsible for disorders. Metabolic disorders and production diseases in farm animals. Prevention of metabolic disorders – recommended dietary regimen.

UNIT II
Effect of coccidiostats and dietary antigens in early weaned livestock Nutrition in relation to emerging diseases. Nutrition and immunity Effect of nutrition on fertility, reproduction and lactation. Toxic minerals (Selenium and fluorine). and counter action of their adverse effects

UNIT III
Stress nutrition and post surgical nutrition. Nutritional manipulation and feeding of sick animals. Pesticides residues in feed and fodder and their impact on animal health, reproduction and production.

Suggested Reading
Selected articles from journals.

AN 724 NUTRIENT AND DRUG INTERACTION 2+0
Objective

UNIT I
Effect of drugs on digestion and absorption of nutrients - Drugs and intestinal microbial interaction - Effect of drug and antibiotics as feed additives Physiological effects – Use and abuse.

UNIT II

Suggested Readings
Selected articles from journals
AN 725    NEW FEED RESOURCE AND TOXICANTS IN ANIMAL FEEDING 2+0

Objective
To impart knowledge on newer feed resources and their value in animal feeding and various toxic substances prevalent in feed and fodders.

Theory
UNIT I
Demand and availability of feed – formulation of database in computer- strategy in food animal production- agricultural by- products- Agro industrial by- products, Farm waste, crop residues, organic wastes of animals origin. Slaughter house waste, industrial waste and their feeding value in animals.

UNIT II
Processing to enhance feed utilization and availability Possible health hazards due to waste utilization chemical and nutritional changes in waste product due to processing. Quality standard and their acceptance.

UNIT III
Naturally occurring toxicants-Toxicants of plants and non-microbial origin. Naturally occurring alkaloids (Phyrolizidine alkaloids, Nicotiana alkaloids, Piperidine alkaloid, Quinolizidine alkaloid, Indole, Solanum Glycoalkaloid, Swainonine, Tall fescue toxis), Glycosides (Glucosinoals, Cyanogenic Glycosides, Cardiac glycosides, Saponine, Vicine, Convicine, Calcinogenic glycosides, Carcinogenic Braken Glycosides, Carboxyata glycoside), Proteins & Amino Acids (Proteinase inhibitors, lectine, Thiaminase, legume blood, Heterocyclic (mimosine, etc.), Selenocompounds, Cathyrogens, Hypoglycin), Phenolics (Gossypol, phytoestrogen, Antifertility agents of plant origin, Sty Pandol, Sorghum polyphenols, Phenolic compounds in forages and fibrous feeds tuffs, polyphenolics and the Nutritional Ecology of herbinores) mycotoxins and other toxicity – Acquired toxicants, pesticides, weedicides and heavy metals.

UNIT IV

Suggested Readings
Selected articles from journals
Animal Physiology

Course Structure – At a Glance

M.V.Sc. (Animal Physiology)

A. Major (24+1 credits)

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<tr>
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<tbody>
<tr>
<td>AP 611</td>
<td>Haematology, Cardiovascular and Respiratory Physiology</td>
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<tr>
<td>AP 612</td>
<td>Renal Physiology and Body Fluid Dynamics</td>
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<td>AP 613</td>
<td>Bioenergetics of Productive Processes</td>
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<td>AP 614</td>
<td>Physiology of Animal Reproduction</td>
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<td>AP 621</td>
<td>Physiology of Digestion</td>
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<tr>
<td>AP 622</td>
<td>Physiology of Lactation</td>
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<td>AP 623</td>
<td>Neuromuscular Physiology</td>
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<td>AP 624</td>
<td>Chemical Bioregulation in Physiological Functions</td>
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<td>AP 625</td>
<td>Environmental Physiology</td>
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<td>AP 629</td>
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<tr>
<td>AP 699</td>
<td>Master’s Research</td>
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B. Minor Courses to be taken up by M.V.Sc. students of Animal Physiology from any one of the following disciplines (Minimum 6 credits).

- Animal Nutrition
- Animal Biochemistry
- Animal Biotechnology

C. Supporting Courses (Minimum 3 credits)

- DES&M
- Animal Biochemistry
- Animal Biotechnology

Note: Total credit hours should be minimum 40 in both Semester I and II.
Ph.D. (Animal Physiology)

A. Major (15+2 credits)

**SEMESTER - I**

<table>
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<tr>
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<td>AP 711</td>
<td>Biotechniques in Animal Production</td>
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<td>AP 712</td>
<td>Comparative Physiology of Ruminant Digestion</td>
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<td>AP 713</td>
<td>Advances in Neuro-endocrinology</td>
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<td>AP 714</td>
<td>Advances in Biosynthesis and Secretion of milk</td>
<td>3+0</td>
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<td>AP 715</td>
<td>Physiology of Stress</td>
<td>3+0</td>
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<tr>
<td>AP 719</td>
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**SEMESTER -II**

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<td>Physiology of Animal Behaviour</td>
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<td>Advances in Reproductive Physiology</td>
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<tr>
<td>AP 723</td>
<td>Advances in Bioenergetics and Growth</td>
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</table>

B. Minor Courses to be taken up by Ph.D. students of Animal Physiology from any one of the following disciplines (Minimum 6 credits).

- Animal Nutrition
- Animal Biochemistry
- Animal Biotechnology

C. Supporting Courses (Minimum 3 credits)

- DES&M
- Animal Biochemistry
- Animal Biotechnology

**Non-credit courses for M.V.Sc., Ph.D.(if not done in M.V.Sc.) in 3rd Semester**

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<td>GS-632</td>
<td>Technical Writing</td>
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<td>GS-633</td>
<td>Intellectual Property and its Management in Agriculture</td>
<td>1+0</td>
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<tr>
<td>GS-634</td>
<td>Basic concepts in Laboratory Techniques/Practices</td>
<td>0+1</td>
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<tr>
<td>GS-635</td>
<td>Disaster Management</td>
<td>1+0</td>
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**Note:** Total credit hours should be minimum 30 in both Semester I and II.
AP 611 HAEMATOLOGY, CARDIOVASCULAR AND RESPIRATORY PHYSIOLOGY (2+1)

Objective
To acquaint the students about haematology of different animals and to teach function and regulation of heart, recording of ECG and respiration in ruminants

Theory
UNIT I
Red blood cells, anaemia, different types of anaemia, polycythemia and their effect on circulation in ruminants
UNIT II
Resistance of the body to infection, leukocytes, tissue macrophage system and inflammation, immunity, immunoglobulins
UNIT III
Hemostasis and coagulation factors, role of platelets, fibrinolysis. Blood groups, transfusion of blood.
UNIT IV
Heart muscle, heart as pump, origin and propagation of heart beat. Electrophysiology of heart, rhythmic excitation of heart, cardiac cycle, heart sound.
UNIT V
UNIT VII
Respiration, mechanism of ventilation, hemoglobin, oxygen and carbondioxide transport. Respiratory gas exchange. Respiratory adjustment at high altitude. Neural and chemical control of respiration.

Practical
Collection of blood, separation of plasma and serum
Enumeration of RBC, WBC, DLC
Estimation of Hb, PCV and ESR
Blood group typing
Measurement of blood pressure
Determiniation and recording of cardiac output and Electrocardiogram
Estimation of lung volumes and capacities by spirometry
Estimation of blood gases.

Suggested Readings
Panima.
Objective
To impart knowledge regarding excretory system of mammals and maintenance of body fluid homeostasis.

Theory
UNIT I
An overview of nephron structure and function. Renal homeostatic function and renal excretory function.

UNIT II
Renal haemodynamics. Glomerular filtration- its mechanism and measurement. Permselectivity of the glomerular capillary wall, structural basis of GFR, tubular reabsorption and transport.

UNIT III

UNIT IV
Skin- general anatomy of epidermis, dermis, hypodermis, mechanical protection, permeability, sweat glands, sebaceous glands. Immune properties of skin.

UNIT V
Composition of body fluids and their regulation.

Practical
Collection and preservation of urine. Physical and chemical analysis of urine. Qualitative urine analysis, Body fluid estimation - Total body water, blood volume and extra cellular blood volumes, Examination of urine sediments

Suggested Readings

AP 613 BIOENERGETICS OF PRODUCTIVE PROCESSES (2+1)

Objective
To acquaint the students about energetics of different productive processes.

Theory
UNIT I

UNIT II

UNIT III
Physiological interpretation of ageing, control mechanisms and exercise. Adaptation to stressors.

UNIT IV
Physiology and energetics of work production, interrelationship between load, speed, horsepower and efficiency. Factors affecting work efficiency, muscle fatigue and hypoxia.

UNIT V
Physiological efficiency of milk production, relationship between net energy and energetic efficiency of productive processes, Factors contributing to efficiency complex of productive processes.

Practical
Measurement of surface area in animals.
Measurement of heat production by open (Mask) and closed circuit spirographic methods.
Animal growth measurements and growth constants.
Blood lactic acid estimation
Calculation of efficiency of work, milk and growth.

Suggested Readings
Bioenergetics and Growth
S. Brody (1945), Publisher- Reinhold Publ.Co,. USA
Bioenergetics, A.L. Lehninger (1965) Publisher WA Benjamin, New York
The fire of life, Max Kliber Publ. John Willy and sons Inc.

AP 614 Physiology of Animal Reproduction (2+1)
Objective
To impart knowledge of male and female reproductive system of different species of animals.

Theory
Unit – I
Functional histomorphology of male and female reproductive system, development of male and female sex organs. Hormones and growth factors in reproduction.

Unit – II
Sexual cycles and mating behaviours in females. Oogenesis, folliculogenesis and ovulation. Secretions of female reproductive tract in different species of animals.

Unit - III
Male mating behavior, spermatogenesis, spermiogenesis, Seminiferous epithelial cycles. Spermatozoa – structure and composition, maturation and transportation. Secretions of male reproductive tract.

Unit IV

Unit V

Practical
Heat detection in rats (vaginal smear techniques).
Palpation of reproductive organs.
Physical and biochemical evaluation of semen.
Determination of sperm enzyme, (acrosomal enzymes & transaminase activity).
Preservation of semen
RIA of steroid hormones.
Preparation of Semen extenders.

Suggested Readings

AP 621                                   PHYSIOLOGY OF DIGESTION ( 2+1)
Objective
To teach comparative physiology of digestive system of monogastric animals and ruminants.

Theory
UNIT I
Basic characteristics and comparative physiology of digestive system of domestic animals.
UNIT II
Gastro-intestinal motility, secretary functions of gastro-intestinal tract, their regulation and gastro-intestinal hormones.
UNIT III
Absorption, metabolism and excretion of various nutrients, appetite and control of feed intake.
UNIT IV
Development of ruminant system and rumen environment, Ruminant microbial digestion, its advantages and disadvantages. Rumino-recticular motility and its control and significance.

Practical
Recording of rumen movements.
Estimation of digestive metabolites such as glucose, ketone bodies, triglycerides, cholesterol, urea nitrogen alpha amino nitrogen, NEFA and total proteins.
Liver function tests-sGOT, sGPT and alkaline Phosphatase.
Suggested Readings

AP 622 Physiology of Lactation (2+1)

Objective: To teach comparative aspects of mammary development, milk synthesis and secretion in laboratory animals, small and large ruminants

Theory
UNIT I

UNIT II

UNIT III

Practical

Suggesting Readings:
Biology of Lactation
Objective
To impart knowledge of coordination of body functions and regulation of brain functions and sense organs.

Theory
UNIT I
Types and classification of muscles, comparative histopathology of muscles. Skeletal muscle fibers, membrane and action potential at myoneuronal junction. Molecular characteristics of contractile filaments, molecular mechanism of muscle contraction, relationship between actin and myosin filaments, overlap and tension developed by the contracting muscles. Contractile process of smooth muscles.
UNIT II
UNIT III
Nervous system, synapse, transmission and processing of information, receptors, brain and spinal reflexes, motor functions of brain stem, limbic system, memory, sleep, learning, autonomic nervous system.
UNIT IV
Special senses and somatic senses.

Suggested Readings

UNIT II
Methods of study bioregulation including endocrine methodologies. Hormone assay. Manipulation and disruption of biorhythms in homeostatic and natural ecosystem

UNIT III
Regulation and metabolism of hypothalamic, hypophyseal, thyroid and adrenal hormones. Endocrine control of carbohydrate and calcium homeostasis. Hormonal regulation of gastro-intestinal activity.

UNIT IV

UNIT V
Hormones and adaptation to environment. Hormones in fertility regulation and production augmentation.

Practical
Examination of endocrine glands.
Histological examination of endocrine glands.
RIA and EIA of hormones.
Detection of stages of estrous cycle in rats.
Ovariectomy and Adrenalectomy

Suggested Readings

AP-625 Environmental Physiology (2+1)

Objective
Impart knowledge regarding Environmental Stress on Physiological functions in ruminants.

Theory
UNIT I
Introduction to environmental physiology; climate, weather definition and classification. Components of physical environment, energy exchange between animal and its environment. Heat tolerance, its concept and measurement.

UNIT II
Principles of thermo regulation in dairy animals, hameothermy, homeostasis body temperature and its neural control. Thermal gradient, thermal balance, heat production and heat loss. Physiological responses of farm animals to heat or cold. Defence against heat or cold.

UNIT III
Critical environmental temperature, lethal body temperature, zone of thermoneutrality, zone of survival, regulation of body temperature and its neural control set point, fever.

UNIT IV

Practical
Principle and methods of measuring climatic elements.
Determination of heat tolerance, thermal index in farm animals.
Climograph
Surface area measurement,
Measurement of sweating and O₂ consumption.
Recording of physiological responses in dairy animals.

Suggested Readings
Adaptation of domestic animals ESE Hafez (1968), Publisher Lea & Filiger, USA.

AP 711 Biotechniques in Animal Production (3+0)

Objective
To impact knowledge in animal biotechniques used for augmenting reproduction & production.

Theory
Unit I

Unit II
Endocrine therapeutic and regulatory techniques – induction of parturition, early growth and maturity, ovulation and lactation. Estrus synchronization, superovulation.

Unit III

Unit IV

Suggested Readings
Reproduction in Mammals-5
Physiology and Technology of Reproduction in Female Domestic
Animals, R.H.F. Hunter (1980), Publisher – Academic Press
Ova Transport in Fertility Regulation
Edited by M.J.K. Harper et al (1972), Proceeding of WHO Symposium
Egg Transfer in Cattle
Edited by L.E.A. Rowson, Proceeding of Seminar held at ARC Cambridge
Immunological Approaches to Fertility Control Karolinska Symposium, Proceeding No.7
Genes by Lewin. Ed. VIII, Oxford University Press 2000
Reproduction in Farm animals by E.S.E. Hafez/VIII ed

**AP 712**

**Comparative Physiology of Ruminant Digestion**

*3+0*

**Theory**

**Unit I**

Functional development of ruminant system and rumen environment, ruminant microbial digestion, rumen motility and its control.

**Unit II**

Salivary secretion and its regulation, buffering system. Intra ruminal environment, rumen metabolites and their assimilation. NPN feeding, nitrogen recycling in ruminants.

**Unit III**

Synthesis of microbial protein and vitamins. Comparative aspects of digestion and absorption in dairy animals, rumen dysfunctions.

**Unit IV**

Manipulation of rumen fermentation, protected nutrients feeding, probiotics supplementation. Rumen flow rate and ruminal content.

**Suggested Readings**

Dukes Physiology of domestic animals Edited by M.J.Swensen, Publisher – Panima Publishing Corporation, New Delhi.

Animal Nutrition by P.Mc Donald.

**AP 713**

**ADVANCES IN NEURO-ENDOCRINOLOGY**

*3 + 0*

**Objective**

To acquaint the students about neuro-endocrine integrating mechanism in animals.

**Theory**

**UNIT I**

Neuroendocrine integrating mechanism. Structure of hypothalamus, pituitary gland, limbic and other neural pathways and endocrine functions.
UNIT II
Neural control of oxytocin, adrenocorticotropic hormone, aldosterone, thyrotropic hormone, growth hormone, gonadotrophins etc. Hypothalamic releasing factors and the neuro-vascular link between brain and anterior pituitary.

UNIT III
Role of afferent impulses from genitals and other regions in reproductive system. Influence of hormones on brain activity.

UNIT IV
Interaction of nervous, endocrine and immune system in animal production and reproduction.

Suggested Readings

Selected articles from journals.

AP 714 Advances in Biosynthesis and Secretion of Milk (3+0)

Objectives To acquaint students about the advances in physiology and mechanism of lactation

Theory
Unit I
Hormonal and non-hormonal factors influencing the mammary gland development in domestic animals. Recent developments in hormonal requirement of mammary gland during pregnancy and lactation.

Unit II
Role of hypothalamus and pineal on galactopoietic hormones. Growth hormone, GH-releasing factor and other biotechniques to enhance milk production in dairy animals. Neural factors influencing milk let-down, milk ejection, milk yield and composition, feedback inhibitor of lactation.

Unit III
Environmental factors influencing galactopoetics hormones in lactating animals. Endocrine Responses to Photoperiod and Melatonin in Lactating Cows, Partioning of nutrients in high and low producing animals, Tissue culture techniques for evaluating mammary gland metabolism.

Suggested readings
Biology of Lactation
G.H. Schmidt (1971), Publisher-W.H. Freeman & Co.San Franscisco
Comparative Aspects of Lactation
Edited by M.Peaker (1977), Publisher-Academic Press, London.
Lactation
Edited by B.L. Larson (1985), Publisher-Iowa Uni. Press. Iowa.
AP-715  
**Physiology of stress**  
(3+0)  

**Theory**  

Unit 1  
Definition of stress, various types of stresses their effect on animal production and reproduction.  

Unit II  
Adaptation of domestic animals to tropics, deserts, cold and high altitude. Physiological and nutritional adaptation.  

Unit III  
Animal shelters and management in tropical zones and amelioration of climatic stress.  

Unit IV  
Effect of various stresses on endocrine status of animals. Physico chemical changes of blood composition due to exercise and work. Energy utilization and requirement of muscles during work and exercise.  

**Suggested Readings**  

- Adaptation of domestic animals ESE Hafez (1968) Publisher Lea & Febiger, USA.  

AP-721  
**PHYSIOLOGY OF ANIMAL BEHAVIOUR**  
(3+0)  

**Objective**  
To impart knowledge on various aspects of animal behaviour viz. communication in animals, sexual behaviour, feeding behaviour etc.  

**Theory**  

UNIT I  
Introduction to animal ethology. Neurophysiological basis of animal behaviour. Components of animal behaviour  

UNIT II  
Behaviour in relation to changes in the environment. Feeding behaviour, herding behaviour, grazing, stall feeding and rumination.  

UNIT III  

UNIT IV  
Social behaviour, communication in animals, animal temperament. Response of dairy animals to training and Mechanization.  

**Suggested Readings**  

- Selected articles from journals.

AP 722  
**Advances in Reproductive Physiology**  
(3+0)  

**Objective:** To acquaint the students of latest developments in animal reproduction.  

**Theory**
Unit I
Advances in hypothalamo-hypophysial gonadal relationship. Circulating hormones and receptor affinity. Involvement of hormone agonists and antagonists in reproductive rhythm. Nitric oxide and reproductive functions.

Unit II

Unit III
Immunological concepts in male and female reproduction. Immuno neutralization approaches to augment reproduction. Current concepts in bovine infertility Prostaglandins and reproduction.

Unit IV

Suggested Readings:

Selected articles from journals

AP 723 ADVANCES IN BIOENERGETICS AND GROWTH (3+0)

Objective
To acquaint the students about energetics of productive processes and growth in relation to performance of animals.

Theory
UNIT I
Current concepts and developments in bioenergetics of growth, milk and work production, factors limiting growth and work efficiency, efficiency complex, influence of biological and seasonal rhythms, metabolic catalysts in efficiency complex.
UNIT II
Current concepts in heat flux and thermo dynamical control; cardiovascular adjustments to work heat and combined thermal and metabolic stress, circulatory and body fluid adjustments.
UNIT III
Competition between thermoregulation and other homeostatic systems, peripheral and deep receptor interactions, microcirculation in relation to thermal stress.
UNIT IV
Brain body temperature – role of carotid rete, respiratory and blood gas adjustments, muscle fatigue and its assessment, Adaptation to pressure and electrical gradients.

UNIT V

Neuro Endocrine strategies during adaptation to stress. Aging – Physiological interpretation, control mechanisms and exercise, gerontology and adaptation to stressors.

Suggested Readings
Bioenergetics and Growth
S.Brody(1945), Publisher- Reinhold Publ.Co., USA
Bioenergetics, A.L. Lehninger (1965) Publisher WA Benjamin, New York
The fire of life , Max Kliber Publ. John Willy and sons Inc.

Selected articles from journals

AP 724 ADVANCES IN IMMUNOPHYSIOLOGY (3+ 0)

Objective
To study cellular basis of immunity, organs of immune system, its development and role in physiological functions and immunomodulation.

Theory
UNIT I
Cellular basis of immunity, organs of immune system, ontogeny and phylogeny of immune system, vertical transmission of immunity and difference between vertebrates and invertebrates.

UNIT II
Structure, class, subclass of immunoglobulins, functions of antibody molecules, hematopoiesis, T-cell and B-cell-evolution, development and their functions, species specific immunity, cytokines-sources and actions, MHS, genetic organization of immunoglobulin, MHC and complement system.

UNIT III
Immune-endocrine interactions, immune system in reproduction, lactation, ageing, stress and other physiological functions, immunomodulation.

UNIT IV
Hypersensitivity, diseases related to immune system, dysfunction, autoimmune disorders and their genesis, immunodeficiency. Immunological techniques.

Suggested Readings
Tizzard IR. 2004. Veterinary Immunology. 5th Ed. WB. Saunders.
Veterinary Immunology and Immunopathology (An International Journal of Comparative Immunology), Elsevier.
VETERINARY PHYSIOLOGY
List of Journals

* Acta Endocrinologica
* Advances in Clinical Chemistry
* Advances in Reproductive Physiology
* Advances in Veterinary Sciences
* American Journal of Clinical Nutrition
* American Journal of Physiology
* American Journal of Veterinary Research
* Animal Nutrition and Feed Technology
* Animal Reproduction Science
* Animal Sciences
* Annual Review of Physiology
* Buffalo Journal
* Domestic Animal Endocrinology
* Indian Journal of Animal Reproduction
* Indian Journal of Animal Nutrition
* Indian Journal of Animal Physiology
* Indian Journal of Animal Research
* Indian Journal of Animal Science
* Indian Veterinary Journal
* Journal of Endocrinology
* Journal of Physiology
* Journal of Reproduction and Fertility
* Neuroendocrinology

e-Resources
* http://intl-joe, endocrinology-journals.org (Journal of Endocrinology)
* http://arjournals.annualreviewes.org (Annual Review of Physiology)
* www.jneurosci.org (Journal of Neuroscience)
* www3.interscience.wiley.com (Journal of Physiology & Animal Nutrition)

Suggested Broad Topics for Master's and Doctoral Research
* Physiological manipulation to enhance growth and productivity in ruminants
* Physiological adaptation to environmental stress and its amelioration in domestic animals
* To study the mechanism of regulation of various hormones involved in production and reproduction in domestic animals
* Dietary effects on growth and production in livestock
SEMESTER-WISE DISTRIBUTION OF COURSES OF ANIMAL REPRODUCTION, Gynaecology & Obstetrics

Ist Semester
ARO 611 General Gynaecology (3+1)
ARO 612 Veterinary Obstetrics (3+1)
ARO 613 Semen Preservation and Artificial Insemination (3+1)

ARO 614 Clinical Practice – I (0+3)

ARO 619 Master’s Credit Seminar (1+0)

Ilnd Semester

ARO 621 Female Infertility (3+1)
ARO 622 Andrology and Male Infertility (3+1)
ARO 623 Reproductive Biotechnology (2+1)
ARO 624 Clinical Practice – II (0+3)
ARO 629 Master’s Credit Seminar (1+0)

Ph.D. courses
ARO 711 Advances in Gynaecology (2+1)
ARO 712 Advances in Andrology (2+1)
ARO 713 Advances in Semen Preservation (1+1)
ARO 714 Clinical Practice – I (0+3)
ARO 719 Doctoral Credit Seminar (1+0)
ARO 721 Advances in Obstetrics (2+1)
ARO 722 Advances in Reproductive Biotechnology (2+1)
ARO 724 Clinical Practice – II (0+3)
ARO 729 Doctoral Credit Seminar (1+0)

ARO 730 Special Problem (0+2) SEM - I, II
Masters courses (M.V.Sc degree in Veterinary GynaecoloAROy & Obstetrics)

ARO 611 GENERAL GYNAECOAROY (3+1) SEM - I
Objective: To understand hormonal regulation of female reproduction and therapeutic management of infertility.

Theory
UNIT-I: Puberty and sexual maturity, role of hypothalamic-pituitary-gonadal axis in attainment of puberty and sexual maturity, onset of postpartum ovarian activity, Endocrine regulation of estrous cycle.
UNIT-II: FolliculAROgenesis, oAROgenesis and ovulation and associated endocrine pattern, manipulation of follicular waves, synchronization of estrus and ovulation and induction of ovarian activity.
UNIT-III: Gamete transport, fertilization, implantation and maternal recAROOnition of pregnancy.
UNIT-IV: Embryonic and fetal development, placentation, fetal circulation and gestation, position of fetus in the uterus, age characteristics of fetus.
UNIT-VI: Factors affecting reproduction – seasonality, nutrition, stress, environment, management, suckling and diseases.
UNIT-VII Lactation and artificial induction of lactation.

Practical

ARO 612 VETERINARY OBSTETRICS (3+1) SEM - I
Objective: To impart knowledge and training on problems of pregnancy and parturition and their management in domestic animals.

Theory
UNIT-II: Principles of handling of dystocia, obstetrical procedures: mutations, fetotomy, caesarean section. Obstetrical anesthesia and analgesia, epidural anesthesia.
UNIT-III: Fetal and maternal dystocia: causes, diagnosis and management.
UNIT-IV: Uterine torsion: causes, diagnosis and its correction.
UNIT-V: Diseases and accidents during gestation and around parturition.
UNIT-VI: EtioloAROy, diagnosis and treatment of ante-partum and post-partum uterine and
vaginal prolapse.
UNIT-VII: Induction of parturition and elective termination of pregnancy.
UNIT-VIII: Involution of uterus following normal and abnormal parturition.
UNIT-IX: Care of dam and the newborn.

**Practical**
Pelvimetry of different species of farm animals. Diagnosis and correction of abnormal fetal presentation, position and posture in phantom box. Epidural anesthesia, ovariohysterectomy and caesarean operation. Fetotomy exercises. Detorsion of uterus.
Management of prolapse. Handling of clinical cases of dystocia.

**ARO 613 SEMEN PRESERVATION AND ARTIFICIAL INSEMINATION (3+1) SEM - I**
Objective: To impart knowledge and training about collection, evaluation and preservation of semen and artificial insemination (AI) in domestic animals.

**Theory**
UNIT-I: History of artificial insemination.
UNIT-II: Methods of semen collection.
UNIT-III: Semen evaluation: macroscopic, microscopic, biochemical and microbiological tests, Computer assisted semen analysis (CASA).
UNIT-IV: Semen preservation. Extenders for preservation of semen at different temperatures. Semen additives for enhancement of motility and fertilizing capacity of spermatozoa.
UNIT-V: Cryopreservation of semen. Effects of cryopreservation on spermatozoa, semen quality and fertility.
UNIT-VII: Ideal protocol for AI in different species of animals. Factors affecting success of AI.

**Practical**

**ARO 614 CLINICAL PRACTICE – I (0+3) SEM - I**
Objective: Hands-on training on diagnosis and treatment of reproductive disorders in animals.

**Practical**
Clinical examination of animals affected with reproductive disorders, use of diagnostic techniques for diagnosis and institution of required therapy. Maintenance of case records. Presentation on selected /assigned cases.

**ARO 619 MASTER’S CREDIT SEMINAR (1+0)**

**ARO 621 FEMALE INFERTILITY (3+1)**

Objective: To impart knowledge and training in diagnosis and treatment of infertility in female domestic animals.

**Theory**
UNIT-I: Introduction to infertility, classification, economic impact. Anatomical causes of infertility, congenital and hereditary causes and acquired defects.
UNIT-II: Nutritional causes of infertility. Importance of body condition score.
UNIT-IV: Infectious causes of female infertility, specific and non-specific infections.
UNIT-V: Ovarian dysfunction: anoestrus, cystic ovarian degeneration, anovulation, delayed ovulation and luteal insufficiency.
UNIT-VI: Repeat breeding: its causes, diagnosis and treatment.
UNIT-VII: Early embryonic death (EED): causes, diagnosis and therapeutic management.
UNIT-IX: Interactions in ImmunoAROical mechanisms and infertility.

**Practical**

**ARO 622 ANDROLAROY AND MALE INFERTILITY (3+1)**

Objective: To impart knowledge and training about male reproduction and treatment of male infertility in domestic animals.

**Theory**
UNIT-I: Structure and function of reproductive tract of male.
UNIT-II: Sexual behavior and examination of bulls for breeding soundness.
UNIT-III: SpermatAROenesis, (formation, migration, maturation and ejaculation of semen), fine structure of spermatozoa, semen and its composition.
UNIT-IV: Diseases transmitted through semen.
UNIT-V: Factors affecting semen quality, semen culture, tests for assessment of sperm motility, sperm survival and fertilizing capacity of spermatozoa.
UNIT-VII: Impotentia coundi and impotentia generandi. Testicular hypoplasia and degeneration: causes and affect on semen and fertility.
UNIT-VIII: Coital injuries and vices of male animals.

Practical

ARO 623 REPRODUCTIVE BIOTECHNOLAROY (2+1)
SEM - II
Objective: To impart knowledge and training on biotechniques in animal reproduction.

Theory
UNIT-I: Embryo transfer technolAROy: selection of donors and recipients.
UNIT-II: Synchronization, super-ovulation, surgical and non-surgical collection of embryos and evaluation of embryos.
UNIT-III: Cryopreservation of embryos, transfer of embryos to donors.
UNIT-IV: In vitro fertilization, in vitro maturation, micromanipulation of embryos.
UNIT-V: Sexing of sperm and embryos.
UNIT-VI: Transgenic animals. Chimeras
UNIT-VII: Stem cell biotechnolAROy
UNIT-VIII: Immuno-neutralization of hormones. Immunomodulation of fertility

Practical
Sexing of embryos.

ARO 624 CLINICAL PRACTICE – II (0+3)
SEM - II
Objective: Hands-on training on diagnosis and treatment of reproductive disorders in animals

Practical
Clinical examination of animals affected with reproductive disorders, use of diagnostic techniques for diagnosis and institution of required therapy. Maintenance of case records. Presentation on selected /assigned cases.

ARO 629 MASTER’S CREDIT SEMINAR (1+0) SEM - II
Objective: To learn about advances in endocrine, ovarian and uterine functions and effect of nutrition, season and immunological factors on female fertility.

**Theory**

UNIT-I: Neuro-endocrine control of reproduction, follicular development, ovulation fertilization and implantation. Embryonic and fetal development.

UNIT-II: Maternal recognition of pregnancy, Advances in early diagnosis of pregnancy.


UNIT-IV: Seasonal breeders, synchronization and induction of estrus and ovulation in seasonal breeders, Assisted reproductive technology (ART) to increase reproductive efficiency in farm animals.

UNIT-V: Effect of stress, nutrition and immunological factors on fertility.

UNIT-VI: Onset of postpartum ovarian activity and factors affecting it.


**Practical**

Clinical examination of female animals. Use of ultrasonography in ovarian function (follicular image pattern, follicular dynamics) and in early pregnancy diagnosis and infertility. Utility of uterine culture, uterine cytology and uterine biopsy (histopathological examination) in infertility investigation. Laparoscopy in diagnosis of ovarian and uterine dysfunction. ELISA/RIA of hormones and interpretation of results. Use of Assisted reproductive technology (ART) to enhance reproductive efficiency in farm animals.

Objective: To learn advances in male reproduction and treatment of male infertility in domestic animals

**Theory**

UNIT-I: Spermatogenesis, spermatogenic waves, sperm passage in male genitalia, biochemical milieu of male genitalia. Correlation between motility and fertilizing capacity of spermatozoa.

UNIT-II: Separation of motile and immotile spermatozoa. Sexing and separation of male and female determining spermatozoa.


UNIT-IV: Biochemistry of seminal plasma and accessory sex gland secretions.
Electrolytes, proteins, enzymes and amino acids in seminal plasma. Fructose and other sugars, lipids, cholesterol, steroid hormones and prostaglandins in seminal plasma.

UNIT-V: Fructolysis index. Aerobic and anaerobic metabolism of spermatozoa.
UNIT-VI: Biochemical markers of fertility in males, sperm chromatin structure assay, Anti-sperm antibodies.

Practical
Breeding soundness evaluation of bulls, biochemical tests of semen for evaluation of fertility, semen culture for diagnosis of venereal diseases, diagnosis and treatment of genital pathological conditions. Computer assisted semen analysis (CASA), Semen evaluation for assessment of fertilizing capacity of spermatozoa: cervical mucus penetration test, sperm capacitation test, hypo osmotic swelling test and zona free hamster egg penetration test. Anti-sperm antibody assay.

ARO 713 ADVANCES IN SEMEN PRESERVATION (1+1) SEM - I
Objective: To learn advances in processing and cryopreservation of semen and insemination techniques to obtain high fertility.

Theory
UNIT-I: Transmission of venereal diseases through semen and their prevention.
UNIT-II: Factors affecting motility and fertilizing capacity of spermatozoa. Semen collection, extension and cryopreservation of semen, damages to spermatozoa caused by cryopreservation.
UNIT-III: Use of semen additives for promotion of sperm motility and fertilizing capacity.
UNIT-IV: Thawing protocols for frozen semen. Post-thaw evaluation of motility and fertilizing capacity of spermatozoa.

Practical

ARO 714 CLINICAL PRACTICE – I (0+3) SEM - I
Objective: Hands-on training on diagnosis and treatment of reproductive disorders in animals.

Practical
Clinical examination of animals affected with reproductive disorders, use of diagnostic techniques for diagnosis and institution of required therapy, maintenance of case records, presentation on selected/assigned cases.

ARO 719 DOCTORAL CREDIT SEMINAR (1+0) SEM - I
ARO 721 ADVANCES IN OBSTETRICS (2+1) SEM - II

Objective: To learn current developments in diagnosis and management of dystocia, accidents of gestation and peri-parturient disorders in domestic animals.

Theory
UNIT-I: Conceptus and its development. Factors influencing gestation period and birth weight.
UNIT-II: Anomalies of conceptus, teratAROens and effect of stress on conceptus development.
UNIT-IV: Induction of parturition and termination of abnormal pregnancies. Obstetrical analgesia and anaesthesia.
UNIT-V: Pre-treatment evaluation of the dam suffering from dystocia. Management of maternal and fetal dystocia, hydrallantois, hydramnion, fetal mummification, fetal maceration, uterine inertia and uterine torsion.
UNIT-VI: Fetotomy, caesarean section and ovairo-hysterectomy.
UNIT-VII: Neo-natal physiolAROy and post-natal adaptations.
UNIT-VIII: Involution of uterus, post-partum ovarian dysfunction and their manipulation.

Practical
Obstetrical operations in fetal dystocia: Mutations, fetotomy, caesarean section, ovariohysterectomy; induction of parturition, use of tocolytic drugs in dystocia, obstetrical analgesia and anaesthesia.

ARO 722 ADVANCES IN REPRODUCTIVE BIOTECHNOLOGY (2+1) SEM - II

Objective: To learn advances in recent developments in biotechnology in reproduction for the production of desired elite animals.

Theory
UNIT-I: Embryo transfer technolAROy and its application in farm animals.
UNIT-II: Selection and management of donor and recipient animals. Superovulation, surgical and non-surgical collection, evaluation of embryos and transfer of embryos.
UNIT-III: In vitro fertilization and maturation of oocytes.
UNIT-IV: Micromanipulation, sexing and cryopreservation of embryos.
UNIT-V: Sexing of sperm and embryos.
UNIT-VI: Transgenic animals. Chimeras.
UNIT-VII: Stem cell biotechnolAROy

Practical
ARO 724 CLINICAL PRACTICE – II (0+3) SEM - II
Objective: Hands-on training on diagnosis and treatment of reproductive disorders in animals.

Practical
Clinical examination of animals affected with reproductive disorders, use of diagnostic techniques for diagnosis and institution of required therapy.

ARO 729 DOCTORAL CREDIT SEMINAR (1+0) SEM - II

ARO 730 SPECIAL PROBLEM (0+2) SEM - I, II
Objective: To expose students to research techniques related to sub discipline of the subject and submission of written project with references.

Practical
Student will carry out research on allotted project and submit the project along with research papers for publication in scientific journals.
M.SC. (FOOD SCIENCE & NUTRITION)

As per rules, a student should take the following credits.

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<tr>
<th>Category</th>
<th>Credits</th>
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<tr>
<td>Major Courses</td>
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<td>Research</td>
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Total Credits: 60 Min.

Eligibility (existing)
- B.Sc./B.Sc. (H) Biochemistry/Biotechnology
- B.V.Sc./B.V.Sc & A.H./B.Sc. (Ag)
- B.Tech (Dairy Technol)/B.Tech. (Biotechnol), B.Tech/B.E. (Food Technol)/B.Sc. (Food Sci.)
- B.Sc. with Chemistry and any two of the following: Zoology, Botany, Biochemistry, Microbiology, Biotechnology
- B. Sc. Home Science

Major Subject: Food Science & Nutrition

Minor & Make up courses from: Animal Biochemistry & Dairy Technology

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Major course credits 25

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Minor course credit 17

Supporting Courses (3 min)
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**FN-611 (Principles of Food Processing)**

**Credit:** 3+1

**Objective:** To familiarize the basic principles involved in food processing and preservation, Application of advanced processing technologies in food industry, quality issues related to processed foods and concept of food packaging.

**Unit I**
Basics of Food Science: Food material composition, physical properties of food materials of plant and animal origin, Factors affecting the shelf-life of fresh produce including physical, chemical, physiological and microbiological agents

**Unit II**
Food Preservation Principles: Concept of Water activity (aw), Preservation of foods by heat (Drying & Dehydration, Thermal processing), Introduction to unit operations such as evaporation, concentration of foods, Equipments for heat preservation of foods (concentrators, evaporators, dryers and retorts)

**Unit III**
Food Preservation Principles: Low temperature preservation of foods (chilling, cold/refrigerated storage, advanced low temperature storage methods), Freezing of foods (concept & principles of freezing, changes during freezing, Processing equipments for freezing of foods), Thawing and methods of thawing

**Unit IV**
Advanced methods of food processing, Microwave: Principle, Equipment design and Applications in food industry; Ohmic heating: Working principle, design of Ohmic heater and salient applications; Infra-red heating

**Unit V**
Concept of Hurdle technology, Alternative processed for foods (Non-thermal processes) Principles and applications of HHP, Pulsed electric field (PEF), Irradiation in food processing & preservation

**Unit VI**
Food Additives: Definition, Food preservatives, antioxidants, hydrocolloids, emulsifiers, nutritive ingredients (vitamins & minerals), food colours and flavours. Regulatory standards for various types of Food additives
Unit VII
Food Packaging: Role of packaging, Types of packaging materials, their properties, utilization of packaging materials for various food products, advance packaging techniques

Unit VIII
Emerging concepts in food processing: Genetically modified foods, Organic foods, Nutrigenomics; Food quality management systems

PRACTICALS

| Determination of water activity (a_w) of foods |
| Calculation of F_0 Value of selected foods |
| Canning of fruits & vegetables |
| Drying of fruits & vegetables, efficacy of blanching treatment |
| Determination of additives in selected foods |
| Manufacture of extruded products |
| Effect of selected additives on quality attributes of processed foods |
| Determination of power of microwave oven |
| Testing of packaging materials |
| MAP Storage of selected foods |
| Experiments with Ohmic heater |
| Experiment with food evaporators |

SUGGESTED READINGS


FN-621 (Technology of Processed Foods-I)
Credit: 2+1
Objective: To impart theoretical and practical knowledge of foods of animal origin i.e. milk, meat, egg and fish to students.
Course Content
Unit I
Market Milk: Composition of milk, factors affecting the composition of milk, Collection, handling & distribution of raw milk, chilling, Milk reception, platform tests, Unit operations in milk processing (filtration, clarification, cream separation, standardization, bactofugation, homogenization) Heat processing of milk (Thermization, Pasteurization, UHT processing, Sterilization of Milk), Recombined milk, Filled Milk

Unit II
Technology of condensed, evaporated and dried milk (Definition, standards, types, methods for the manufacture of condensed, evaporated and dried milks), Working principles of evaporators and dryers, Properties of dairy powders, defects in condensed, evaporated and dried milks and remedial measures

Unit III
Technology of fermented milks: Types and classification of fermented milks, Starter cultures and methods for their propagation, Methods for the manufacturing of dahi, yoghurt, lassi, acidophilus milk, kefr, kumis and introduction to the concept of probiotic

Unit IV
Technology of cheeses: Classification of cheeses, definition of important varieties of cheeses, Basic principles involved in cheese manufacturing, Manufacturing process for the production of cheddar cheese, cottage cheese (other fresh variety of cheeses), Processed cheese, Defects in cheeses

Unit V
Technology of Indigenous dairy products: Classification of traditional dairy products, manufacturing technology of khoa & khoa based sweets; Heat-acid coagulated TDPs (paneer, channa & channa based sweets)

Unit VI
Technology of Fat-rich Dairy Products: Definition and classification of cream & Butter, Preservation of cream; Manufacturing process for plain and salted butter, defects in cream and butter; Manufacturing technologies for ghee & butter oil, Ice cream and Frozen desserts (Definition, processing technology, role of ingredients and defects in ice cream)

Unit VII
Technology of Meat and meat products: Meat animals, composition of meat, factors affecting the composition and quality of meat, slaughtering of animals for meat, ante-mortem and post-mortem inspection of animals, meat cuts, Conversion of muscle into meat (rigor mortis and other changes), Preservation of raw meat (chilling, freezing, curing), Role of curing
ingredients, colour fixation of cured meat, smoking preservation of meat, fermentation preservation of meat, technological aspects of sausages etc.

**Unit VIII**
Processing of Poultry and Egg: Composition of egg, structure of egg, composition of poultry meat, Slaughtering and dressing of poultry meat, Quality of poultry meat in relation of post-mortem handling, processed poultry meat products (nuggets, comminuted poultry meat products)

**Unit IX**
Technology of Fish and Fish products: Composition of fishes and other sea-foods, nutrition characterises of fishes, mechanisms and manifestations of spoilage in fish & seafood, Post-harvest treatments and preservation of fish & seafood, processed fish products

**Practical**
1. Determination of Platform tests (Fat, SNF, Total solids, MBRT, Common adulterants)
2. Familiarization with the unit operations in milk processing including cream separation, Standardization, homogenization and milk pasteurization and working of equipments involved (2 practical classes)
3. Preparation of khoa and khoa based sweets
4. Manufacturing of Paneer and chhana
5. Processing of milk for dahi & yoghurt & quality evaluation of products
6. Preparation of ice cream
7. Familiarization with cheese manufacturing principles
8. Preparation of cheddar cheese
9. Preparation of Mozzarella cheese
10. Preparation of cottage cheese
11. Preparation of Processed cheese
12. Preparation of kulfi
13. Manufacturing of sausages
14. Preparation of comminuted meat products
15. Preservation of egg (pickling, application of mineral oil in shell egg preservation)

**Suggested Readings:**
FN-622 (2+1)  Impact of Food Processing on Nutrition

Theory

Unit-I
Basic definitions related to nutritional assessment of foods, digestibility, absorption, bioavailability, Protein quality assessment parameters, An overview of nutritional changes in food during processing

Unit-II
Processing induced changes in carbohydrates in foods, Basic understanding of concepts such as gelatinization, retrogradation and associated phenomenon and its impact on nutritional characteristics, Browning reactions in foods, Enzymatic and non-enzymatic browning reactions, mechanisms and its effect of nutritional and sensory characteristics of foods

Unit-III
Processing related changes in fats and oils, Oxidation of lipids (Auto-oxidation, thermal and radiolytic decomposition); rancidity in foods and associated Nutritional changes associated with frying process in fried foods e.g. fried potatoes and quality changes in frying oil. Criteria for the selection of oils

Unit-IV
Nutritional changes associated with food proteins during processing and storage, Chemical reactions of proteins, protein losses during browning reactions (Maillard reaction), protein associated flavour changes in food products during processing and storage

Unit-V
Nutritional changes related with fermentation of foods – fermented milks (dahi, yoghurt, cheese), fermented cereals & legume based products (dosa, idli, sufu, tempeh, gari etc.) and fermented meat products (sausages)

Unit-VI
Changes in minerals and vitamins during processing, stability of vitamins, degradation reactions and interventions to minimize them, Role of minerals in food processing and food product stability,

Unit-VII
Food pigments, their role in product quality and nutritional value, Classification of pigments structure, occurrence, stability and impact of processing treatment on pigments
Unit-VIII
Introduction to the concept of Reaction kinetics and order of reactions; Kinetics of changes in macro and micro-nutrients during processing and other food manufacturing operations

Unit-IX
Food and nutritional toxicology: toxicants in food and their effect on nutrition; general principles of toxicology – phases of toxicological effects, dose-response relationships; factors influencing toxicity; Toxicity of nutrients.

Unit-X
Food and package interactions: Migration of package constituents into food products. Effect of moisture, air and light on nutrients in packaged foods.

Unit XI
Food toxicants and naturally occurring toxic components in foods and the inactivation of anti-nutritional substances – trypsin inhibitors, hemagglutinins, phytates, flatulence producing agents, inactivation of allergens; etc.; Processing induced formation of toxic components

Practical

<table>
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<tr>
<td>Determination of the extent of non-enzymatic (Maillard) browning in processed foods.</td>
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<td>Determination of available lysine in processed foods.</td>
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<td>Determination of amylase activity in malted flours.</td>
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<tr>
<td>Determination of the effect of thermal processing on trypsin-inhibitor</td>
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<td>Determination of the effect of thermal processing on vitamins.</td>
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<tr>
<td>Determination of the effect of thermal processing on pigments.</td>
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<tr>
<td>Determination of resistant starch formation in baked products.</td>
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<tr>
<td>Evaluating the effect of extrusion cooking on the nutritional quality of foods.</td>
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<td>Evaluating the changes in antioxidants of foods due to processing.</td>
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<tr>
<td>Monitoring glycolysis, proteolysis and lipolysis during fermentation of foods.</td>
</tr>
<tr>
<td>Kinetics of changes in vitamins and pigments of foods.</td>
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</tbody>
</table>

Suggested Books:

3. Omaye ST (2004). Food and Nutritional Toxicology. CRC Press, Boca Raton, FL, USA.

FN-623 Dietetics (3+0)

Unit I: Basic principles of meal planning, nutritional considerations for planning meals for adults (male and female), different levels of physical activity, pregnancy and lactation. Feeding of young children 0-3 years, old age and athletes. Nutritional considerations during emergencies such as drought, famine, floods etc.

Unit II: Concept and scope of community nutrition, assessment of nutritional status - use of clinical signs, anthropometry, biochemical tests, and biophysical methods. Nutritional problems of communities and implications for public health (PEM, Micronutrient Deficiencies, Fluorosis).


Note: At least one visit to Dietetics section of a reputed Medical Institute

Suggested Books:
Robinson. Basic Nutrition and Diet Therapy (8th edition)
Unit-1 (DM) Quality Assurance and Food Safety:
Basic Definition and Terminology; Concepts of Quality Control, Quality Assurance and Food Safety; HACCP concept, principle and application in food industry; QMS Concepts, principle and Standard Requirements; Bio-safety concepts in food laboratory

Unit-2 (DM) Microbiological analysis and regulatory standards:
General Principles for Establishment of ICMSF Microbiological Criteria ; 2 and 3 class sampling plan ; Enumeration and detection of quality and safety organisms; concept of Bio-sensors and rapid monitoring of foods; integrated food law ; microbiological standards for foods

Unit-3 (DC) Chemical quality control and analytical laboratory
Setting up of quality control labs with a special reference to analytical laboratory, Accreditation of Quality control laboratory under NABL and Role of national & International organization viz. IDF; CAC; AOAC; WTO, BIS; CCFS; FSSAI and Agmark

Unit-4 (DC) Chemical analysis
Sampling techniques for chemical analysis of food with respect to Macro & micro food nutrient analysis by colorimetric, spectrophotometric, fluorimetric & chromatographic techniques

Unit-5 (DT) Sensory Evaluation
Introduction, definition and importance of sensory evaluation; Requirements of sensory evaluation; Design and requirements of a sensory evaluation laboratory; General rules of sensory evaluation; Techniques of sensory evaluation: types of tests – difference tests, ranking, scoring techniques, hedonic and descriptive tests.

Unit-6 (DESM) Statistical quality analysis
Basic concepts of statistical quality control, Control charts for variables and attributes; Fundamental concepts of acceptance sampling plan; Sampling inspection plans for attributes, OC and AOQ curves

Practical
8. Microbiological analysis of food :- Dye reduction tests , antibiotic residues , aflatoxin M1, SPC, coliform, E. coli, YMC; Spore counts, Enterobacteriaceae count, faecal streptococci count; S. aureus; B. cereus; pathogenic E. coli; Salmonella; Shigella; L. monocytogenes (DM)
9. Preparation of standard solutions and buffers, Testing of available chlorine content in hypochlorites/ bleaching powder, Determination of purity of common salt for food use, Checking the calibration of Pipette, burette, lactometers, hydrometers, butyrometers and thermometers, Qualitative color test to distinguish between azo dyes and natural dyes (DC)
10. Studying the layout of a sensory evaluation laboratory. Paired comparison test (simple difference), duo trio test, triangle test, preference ranking test, nine point hedonic rating test, scoring technique. Sensory evaluation and detection of common sensorial defects in milk (DT)
11. Control chart for variables, Control chart for attributes (DESM)
Suggested reading

10. ISI Handbook of Food Analysis S.P. 18 (Part II) Dairy Products. 1981 ISI Specifications (concerned) (ISI)
M.Tech /M.Sc. (FOOD SAFETY AND QUALITY ASSURANCE)

As per rules, a student should take the following credits.

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<td>Research</td>
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<td><strong>Total Credits:</strong></td>
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**Eligibility Qualification**
- B.Tech. Dairy Technology / Food Technology /Food Technology & Management
- B.Sc. Food Science/ Home Science /Food Microbiology /Industrial Microbiology/Medical Microbiology
- B.Sc. Bio-Science or biological science with Physics, Chemistry, Mathematics / Biology subjects

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**Major Courses Credits** 27

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- Minor courses for Food Safety and Quality Assurance will be either from DM or DC.
- Since the syllabus pertaining to Course Nos. DM-613, DM-623 and DC-622, DC-623, DC-624 and FN-624 suits to the M. Tech programme in Food Safety and Quality Assurance, these have been included as major courses. Accordingly, in the transcript to be given to students, the courses offered in DM and DC as Major courses will be written as FS-613 (DM-613), FS-621 (DM-623), FS-622(DC-622), FS-623(DC-623), FS-624(DC-624) and FS-625(FN-624).
### Semester-wise break up of courses

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FS-611 (2+1)

Basic Concepts of Quality Assurance and Food Safety System

Theory

Unit-1 Concepts of Quality Control, Quality Assurance and Food Safety

Basic Definition and Terminology; new quality and food safety approaches: The Changing Scenario; Global Considerations - Codex Alimentarius Commission (CAC); Sanitary and phytosanitary standards (SPS) and Technical to Barrier and Trade (TBT) Agreements; Quality control Vs. Quality assurance; Concepts of Hygiene and Sanitation : Good Agriculture Practices (GAP)/Good Hygiene Practices (GHP) / Good Manufacturing Practices (GMP)/Good Distribution Practices (GDP) concept etc.

Unit-2 HACCP concept and principle

History and steps involved in application of HACCP in dairy unit; Establishment of a multi-disciplinary HACCP team; Product description; Identify intended use; Construct a process flow diagram; On-site verification of process flow diagram; Principles of Hazard Analysis and Critical Control point (HACCP) Concepts; HACCP plans and implementation of Operation Risk control; CCPs’, Traceability; Example of HACCP application in liquid milk; ice cream, pasteurised butter; dried products, cheese, cereals, fruits and vegetables, meat and meat products etc.

Unit-3 Introduction to Quality Management Systems (QMS)

Basic Definition and Terminology; Structure and General Principles; Benefits of applying QMS in food unit; ISO: 9000:2000–QMS Fundamentals and Standards; Guidelines for performance.

Unit-4 Concepts, principle and Standard Requirements of QMS–ISO 9000:2000

Process-based QMS concept and Principles; Key benefits of its Application into process, product and system; Standard requirements for QMS – ISO 9001:2000; Food Safety Management System (FSMS) – ISO 22000: Requirements; Goal of ISO 22000 and Methodology; Prerequisite programs (PRPs); Operational prerequisite programs (OPRPs); application of QMS in food processing unit with practical examples.

Unit-5 TQM tools and techniques

Six Sigma methodology (DMAIC and DMADV); Lean Manufacturing; Lean Six Sigma; Kaizen; Total Productive Maintenance (TPM); 5S principle; PDCA Cycles; Quality circles.
Unit-6 Environmental and Laboratory Management System

Evolution, concept, policies and Elements of EMS, Requirements of ISO 14001 and its methodology development and implementation; Laboratory Management System (LMS) as per ISO 17025; History, Fundamental of Laboratory Organization/Management, Quality Assurance and Designing; NABL Accreditation of Food Laboratory.

Unit-7 Management Systems Auditing

Audit as per ISO 19011; Audit Types and process, Key stages during Auditing: Initiating the Audit, Pre-assessment visits, Document Review, Preparing for On-site Audit activities, Reporting on Audit, Non-conformity Report, Audit Completion, Corrective Action, Follow-up and Surveillance visits.

Unit-8 Statistical Quality Control (SQC)

Principle and concept of SQC; Definition of SQC program standards, Precision; Accuracy; Variability Displaying Data; Control Charts; Pareto analysis; Rating Scales etc.

Practicals

1. Microbiological tests/ rapid assessment of equipment’s, personnel and environmental hygiene in a food processing unit (2)

2. Hazard analysis and CCPs determination for milk and food products: liquid milk; ice cream, pasteurized butter; dried products, cheese, cereals, fruits and vegetables etc. (3)

3. Development of HACCP plan for CCPs monitoring, correction and preventive action schedule preparation and documentation (3)

4. Identification of clauses; planning pre requisite programme (PRPs); and OPRPs for ISO 22000: 2005 implementation in dairy unit (1)

5. Preparation of audit schedule and to conduct an internal audit on QMS, HACCP and laboratory management system (3)

6. Development of quality Plan for Kaizen; 5S principle and their implementation in food processing unit (2).

7. Control charts and Pareto analysis of standard plate count and E. coli in indigenous dairy products (2)

8. Visit to any food processing plant for QMS/HACCP demonstration under field condition

Suggested readings


11. ISO/IEC 17025: 2005; General requirements for the competence of testing and calibration laboratories.


FS-612 (2+1)
Risk Analysis Concept and Regulatory Food Standards

Theory

Unit-1 Risk Analysis Concept in food chain
Definition and Terminology– Concept of Risk Analysis; Risk assessment -Hazard identification; Exposure assessment; Hazard characterization; Risk characterization; Risk management; Risk communication; Qualitative and Quantitative Risk assessment for pathogenic bacteria and their toxins; Microbiological risk profile: Concepts; Scope and Purpose; ICMSF ranking scheme of categorization of Hazards; Risk Ranking of Dairy Products; Risk Management Issues and Control Strategies for dairy and other food products.

Unit-2 Risk Assessment of Food Pathogens
Growth and survival characteristics of pathogens - E. coli, Enterobacter sakazaki, Salmonella, Shigella, Yersinia enterocolitica, Streptococcus sp., Listeria monocytogenes, Mycobacterium avium subsp. paratuberculosis, Brucella sp., Campylobacter jejuni, Staphylococcus aureus, Bacillus cereus, Clostridium perfringens in dairy foods, their pathology of illness, mode of transmission, incidence of illness, virulence and infectivity; Risk assessment models for dose response and exposer assessment; Antimicrobial resistant in bacteria.

Unit-3: Microbial Pathogenesis associated with foods
Current trends, incidence and surveillance of food borne diseases; Changing patterns in epidemiology, agricultural and food manufacturing practices, transmission and susceptibility; Food poisoning, food infections by colonization and adhesion factors, food intoxication and toxi-infections; structure and function of exotoxins, endotoxins as well as mycotoxins; Food borne pathogens implicated with human diseases, their sources, mechanism of pathogenesis and public health significance.

Unit-4 General Principles of food law/ Legislation
Definition of Food Legislation; General Food Law’; General Principles of Food Law; Integrated Food Law, Its Main Features and Functions; scope, provision, guidelines, rules, regulation and implementation; Duties and functions of the authority; Key Challenges for Speedy and Effective Implementation of Food Safety and Standard Act; Concept of
appropriate level of protection (ALOP); food safety objectives (FSO); Understanding Codex Alimentarius Commission (CAC) and its working; codex standards for Food / food additives; Food and Drug Administration (FDA) and European Food Safety Authority (EFSA)

Unit-5: Food Quality and Safety Standards

Definition of Food Standards, Specification and guidelines; Microbiological quality and safety standards for foods with special reference to milk and milk products; need for shifting to risk based assessment of foods for microbiological quality & safety; sampling and test methods and aspects related to sampling and testing of packaged foods, freshly cooked foods, and foods that require refrigeration during storage and transport.

Practical

1. Testing of food products for Hygiene Standards – SPC, coliform, faecal Streptococci; MBRT, Yeast and mold counts as per FSS regulation and 3-class sampling plan (3)
2. Testing of food products for Safety Standards – E. coli, Salmonella, L. monocytogenes, B. cereus, S. aureus, Enterobacter sakazakii as per FSS regulation and 2-class sampling plan (3)
3. Checking the compliance of Dairy Foods – pasteurized milk, cream, butter, ice cream, dried products, indigenous dairy products, fermented milks as per FSS regulation (4)
4. Experiments on Exposer Assessment of different pathogens in food products at various stages in supply chain (3)
5. To establish food safety objectives (FSO) for different pathogens based on Dose Response Studies/ Analysis (3)

Suggested Readings


**List of Journals**

1. Epidemiology and Infection
2. Food control
3. Food Microbiology
4. Food Microbiology and Food Safety Journals
5. Indian Journal of Public Health
6. International Journal of Food Microbiology
8. Journal of Food Protection
9. Journal of Food Safety
10. Journal of Infectious Disease
11. Journal of Veterinary Public Health
12. Microbial Pathogenesis

**FS-614 (2+1) Food Microbiology**

**Unit-I: Food Borne Micro-Organisms**

Morphology of food related bacteria, yeast and moulds, viruses and their classification; Factors affecting growth of microorganisms in food: intrinsic factors- water activity, pH and
buffering capacity, redox potential, nutrient content, antimicrobial constituents; extrinsic factors- relative humidity, temperature, gaseous atmosphere.

Unit-2 General Principles Underlying Food Spoilage and Diseases
Source of contamination, types of food spoilage-proteolysis, lipolysis, hydrolytic rancidity etc.; Food Poisoning, food infection, intoxication and toxi-infection; Food borne bacterial diseases; causative agents and sources, symptoms and prevention of Staphylococcal food poisoning, botulism, salmonellosis, Bacillus infection, E. coli etc. Food borne fungal diseases-ergotism, Aflatoxins; Food borne viral diseases - Hepatitis, Polio; Food borne protozoal diseases-Amoebiasis.

Unit-3 Microbiology of Processed Fruits, Vegetables, Cereals, Egg, Meat and Fish Products -Sources of contamination; types of spoilage of raw and processed fruits and vegetables; micro-flora in cereal grains, flour, bread cake and pasta; spoilage of bread, cake and cereal products; micro-flora of egg, fish and meat, spoilage of egg, fish raw and canned meat; factors affecting growth and preservative principle of different products; microbial defects and their control measures.

Unit-4 Microbiology of Milk and Milk Products
Microorganisms associated with milk; sources of contamination; micro-environment of raw, pasteurized, sterilized milk, cream, butter, khoa, cheese, sweetmeats, canned foods and dried products; factors affecting growth and preservative principle of dairy products; Microbial defects and their control measure.

Unit-5 Beneficial Microorganisms in Food Fermentation
Role of Lactic Acid Bacteria (LAB), Acetic acid bacteria, Propionic acid bacteria, Bifidobacteria in food fermentation; Dairy starter, preservation techniques, DVS preparation; role of starters in fermented food preparation-Dahi, Yoghurt,Bread, Wine, Cheese, sauerkraut etc.

Unit-6 Food preservation
Bio-preservation using microbial metabolites - Organic acid, Bacteriocins and enzymes, active packaging and antimicrobial packaging (AMP), modified atmosphere packaging (MAP), Hurdle concept; Alternate methods for controlling spoilage of foods (Non-thermal): High Pressure Processing, Pulsed electric field (PEF) processing, Ultrasonic Food Processing, Ohmic Heating of Foods, Intense Pulse Light, Plasma Light, Oscillating Magnetic Fields (OMF)

Practicals
1. Identification of microorganism –Bacteria, Yeast and moulds  
2. Simple staining, grams staining and hanging drop preparation.  
3. Microbiological examination of Pasteurised Butter; Ice cream and Dried products.  
4. Microbiological examination of fruits and vegetables  
5. Microbiological examination of bread and cake  
6. Microbiological examination of egg  
7. Microbiological examination of canned foods.  
8. Production of fermented foods – Dahi, yoghurt, bread, sauerkraut  
9. Activity and purity tests for dairy starters
10. Production of bacteriocin and their role in bio-preservation of foods – paneer, khoa etc.
11. Freeze drying of dairy starters /DVS culture

**Suggested reading**


**List of Journals**

1. Food Microbiology
2. Food Microbiology and Food Safety Journals
3. International Journal of Food Microbiology
4. Journal of Food Protection
5. Journal of Food safety
6. Journal of rapid methods and automation in Microbiology
FN-611 (Principles of Food Processing)

Credit: 3+1

Objective: To familiarize the basic principles involved in food processing and preservation, technological aspects for the manufacture of selected foods, quality issues related to processed foods and concept of food packaging.

Course Content

Unit I
Basics of Food Science: Food material composition, physical properties of food materials of plant and animal origin, Factors affecting the shelf-life of fresh produce including physical, chemical, physiological and microbiological agents, Post harvest Management of fresh fruits & vegetables, food grains, foods of animal origin (milk, meat, fish etc.)

Unit II
Food Preservation Principles: Concept of Water activity (aw), Preservation of foods by heat/thermal energy (Drying & Dehydration, Thermal Processing of Foods), Unit operations such as evaporation, concentration of foods, Equipments for heat preservation of foods (concentrators, evaporators, dryers and retorts)

Unit III
Food Preservation Principles: Low temperature preservation of foods (chilling, cold/refrigerated storage, advanced low temperature storage methods), Freezing of foods (concept & principles of freezing, changes during freezing, Processing equipments for freezing of foods), Thawing and methods of thawing

Unit IV
Principles of Fermentation and its role in food preservation, Technology of fermented foods (Fermented beverages, Cereal products, Pickles/fermented vegetables, Fermented dairy products and Sausages)

Unit V
Introduction to non-thermal processing technologies (High Hydrostatic Pressure (HHP), Pulsed Electric Field (PEF), Irradiation, Ultrasound preservation) Concept of Hurdle technology

Unit VI
Food Additives: Definition, Food preservatives, antioxidants, hydrocolloids, emulsifiers, nutritive ingredients (vitamins & minerals), food colours and flavours. Regulatory standards for various types of Food additives

Unit VII
Processing of Fruits and vegetables: Unit operations involved in sorting, grading, peeling, juice extraction, fruit juice clarification, fruit beverages: Types, manufacturing and their preservation, Jam & Jellies, Preserves, Candies, Crystallized fruits

Unit VIII
Processing of cereals: Milling of cereals grains (Rice, wheat & corn), Quality criteria of flours for product manufacturing, Technology of bread, biscuits and cake (role of ingredients, unit operations involved, quality of bakery products and common defects & remedial measures)

Unit IX
Food Packaging: Role of packaging, Types of packaging materials, their properties, utilization of packaging materials for various food products, advanced packaging techniques
PRACTICALS

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<td>Chemical analyses of processed fruits and vegetable products</td>
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<td>Determination of water activity ($a_w$) of foods</td>
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<td>Preparation of squash, cordial, nectar and syrup</td>
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<td>Manufacture of bread &amp; pizza base</td>
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<td>Manufacture of biscuits</td>
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<td>Canning of fruits &amp; vegetables</td>
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SUGGESTED READINGS


FN-621 (Technology of Processed Foods-I)

Credit: 2+1

Objective: To impart theoretical and practical knowledge of foods of animal origin i.e. milk, meat, egg and fish to students.

Course Content

Unit I
Market Milk: Composition of milk, factors affecting the composition of milk, Collection, handling & distribution of raw milk, chilling, Milk reception, platform tests. Unit operations in milk processing (filtration, clarification, cream separation, standardization, bactofugation, homogenization) Heat processing of milk (Thermization, Pasteurization, UHT processing, Sterilization of Milk), Recombined milk, Filled Milk

Unit II
Technology of condensed, evaporated and dried milk (Definition, standards, types, methods for the manufacture of condensed, evaporated and dried milks), Working principles of evaporators and dryers, Properties of dairy powders, defects in condensed, evaporated and dried milks and remedial measures

Unit III
Technology of fermented milks: Types and classification of fermented milks, Starter cultures and methods for their propagation, Methods for the manufacturing of dahi, yoghurt, lassi, acidophilus milk, kefr, kumis and introduction to the concept of probiotic

Unit IV
Technology of cheeses: Classification of cheeses, definition of important varieties of cheeses, Basic principles involved in cheese manufacturing, Manufacturing process for the production of cheddar cheese, cottage cheese (other fresh variety of cheeses), Processed cheese, Defects in cheeses

Unit V
Technology of Indigenous dairy products: Classification of traditional dairy products, manufacturing technology of khoa & khoa based sweets; Heat-acid coagulated TDPs (paneer, channa & channa based sweets)

Unit VI
Technology of Fat-rich Dairy Products: Definition and classification of cream & Butter, Preservation of cream; Manufacturing process for plain and salted butter, defects in cream and butter; Manufacturing technologies for ghee & butter oil, Ice cream and Frozen desserts (Definition, processing technology, role of ingredients and defects in ice cream)

Unit VII
Technology of Meat and meat products: Meat animals, composition of meat, factors affecting the composition and quality of meat, slaughtering of animals for meat, ante-mortem and post-mortem inspection of animals, meat cuts, Conversion of muscle into meat (rigor mortis and other changes), Preservation of raw meat (chilling, freezing, curing), Role of curing ingredients, colour fixation of cured meat, smoking preservation of meat, fermentation preservation of meat, technological aspects of sausages etc.

Unit VIII
Processing of Poultry and Egg: Composition of egg, structure of egg, composition of poultry meat, Slaughtering and dressing of poultry meat, Quality of poultry meat in relation of post-mortem handling, processed poultry meat products (nuggets, comminuted poultry meat products)
Unit IX
Technology of Fish and Fish products: Composition of fishes and other sea-foods, nutrition characterises of fishes, mechanisms and manifestations of spoilage in fish & seafood, Post-harvest treatments and preservation of fish & seafood, processed fish products

Practical
16. Determination of Platform tests (Fat, SNF, Total solids, MBRT, Common adulterants)
17. Familiarization with the unit operations in milk processing including cream separation, Standardization, homogenization and milk pasteurization and working of equipments involved (2 practical classes)
18. Preparation of khoa and khoa based sweets
19. Manufacturing of Paneer and chhana
20. Processing of milk for dahi & yoghurt & quality evaluation of products
21. Preparation of ice cream
22. Familiarization with cheese manufacturing principles
23. Preparation of cheddar cheese
24. Preparation of Mozzarella cheese
25. Preparation of cottage cheese
26. Preparation of Processed cheese
27. Preparation of kulfi
28. Manufacturing of sausages
29. Preparation of comminuted meat products
30. Preservation of egg (pickling, application of mineral oil in shell egg preservation)

Suggested Readings:
Unit-I
An overview of nutritional changes in food during processing: changes in nutritive value – carbohydrates, proteins, vitamins and pigments; changes in bioactive compounds; development of toxic or potentially toxic compounds during processing.

Unit-II
Nutritional changes associated with thermal processes such as blanching, pasteurization, sterilization, canning, UHT, evaporation and drying of foods. Nutritional changes associated with extrusion cooking.

Unit-III
Nutritional changes associated with frying in fried foods e.g. fried potatoes and quality changes in frying oil. Nutritional changes associated with commercial food processing operations including baking – bread, cake, biscuits, cookies, crackers, etc.; barbequing, roasting, puffing.

Unit-IV
Nutritional changes associated with preliminary unit operations such as milling and germination of food grains – rice, wheat, corn, barley, millets, pulses, etc., cooking and storage, Processing induced changes during refining and other processing operations related to production of oils & fats (degumming, bleaching, deodorization, hydrogenation etc.)

Unit-V
Nutritional changes related with fermentation of foods – fermented milks (dahi, yoghurt, cheese), fermented cereals & legume based products (dosa, idli, sufu, tempeh, gari etc.) and fermented meat products (sausages)

Unit-VI
Nutritional changes associated with freezing, thawing and reheating of foods – frozen fruits, vegetables, meat, etc.

Unit-VII
Nutrient transformation associated with emerging food processing techniques such as high pressure processing, microwave heating, ohmic heating, pulsed electric field, irradiation, etc.

Unit-VIII
Introduction to the concept of Reaction kinetics and order of reactions; Kinetics of changes in macro and micro-nutrients during processing and other food manufacturing operations

**Unit-IX**
Food and nutritional toxicology: toxicants in food and their effect on nutrition; general principles of toxicology – phases of toxicological effects, dose-response relationships; factors influencing toxicity; Toxicity of nutrients.

**Unit-X**
Food and package interactions: Migration of package constituents into food products. Effect of moisture, air and light on nutrients in packaged foods.

**Unit XI**
Food toxicants and naturally occurring toxic components in foods and the inactivation of anti-nutritional substances – trypsin inhibitors, hemagglutinins, phytates, flatulence producing agents, inactivation of allergens; etc.;

**Practicals**
1. Determination of the extent of non-enzymatic (Maillard) browning in processed foods.
2. Determination of available lysine in processed foods.
4. Determination of the effect of thermal processing on trypsin-inhibitor
5. Determination of the effect of thermal processing on vitamins.
6. Determination of the effect of thermal processing on pigments.
7. Determination of resistant starch formation in baked products.
8. Evaluating the effect of extrusion cooking on the nutritional quality of foods.
9. Evaluating the changes in antioxidants of foods due to processing.
10. Monitoring glycolysis, proteolysis and lipolysis during fermentation of foods.
11. Kinetics of changes in vitamins and pigments of foods.

**Suggested Books:**
3. Omaye ST (2004). Food and Nutritional Toxicology. CRC Press, Boca Raton, FL, USA.

Ph. D. (FOOD SAFETY AND QUALITY ASSURANCE)

As per rules, a student should take the following credits.
Major Courses: 15 Min
Minor Courses: 6 Min
Supporting Courses: 3 Min
Seminar: 2 Min
Research: 45 Min.
Total Credits: 75 Min.

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Major Courses Credits 15

Minor Courses (Min. 6)
26. DT-721 | Product Monitoring and | 3+0 | 3 | DT

Eligibility Qualification
- M.Sc. Food Science / Food Science and Nutrition
- M. Sc. Honours (Microbiology)/industrial Microbiology / Microbial Technology / Applied Microbiology
- M.V.Sc.(Bacteriology/Microbiology)/Public Health/LPT
- M. Sc. (Ag) Microbiology
- M.V.Sc.
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**Supporting Courses credit**

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**Total credits**

82

* The Doctoral students will have to register these courses if not studied at Master’s level.

**Note:** The syllabus pertaining to Course Nos. DC 713, DC- 721, DC-722 and DM- 722 suits to the Ph. D. programme in Food Safety and Quality Assurance and therefore, have been included as major courses. Accordingly, in the transcript these courses may be written as FS-711 (DC 713), FS-721 (DC-721), FS 722 (DC-722) and FS-723 (DM-722).
## Semester-wise break up of courses

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COURSE CONTENTS FOR Ph. D. Food Safety and Quality Assurance (FSQA)

FS-711/DC-713 : Advances in Chemistry of Functional Dairy Foods and Nutraceuticals (3+0)

Objectives:
To impart knowledge to the students about the chemical aspects of functional dairy foods and nutraceuticals

Unit I

Unit II
Bio-functional milk proteins and their therapeutic potential, recent advances in their bio-separation, Generation of bioactive peptides from casein and whey proteins, their isolation and characterization, technological and health aspects, colostrums as source of nutraceuticals

Unit III
Technological and nutritional aspects of milk lipids, conjugated linoleic acids (CLA) in milk, their variation, physiological effects and their importance in dairy foods, Omega fatty acid and their health attributes, strategies to reduce the cholesterol in dairy products

Unit IV
Mineral fortification in milk and milk products, vitamins fortification as dietary supplements in dairy products, Artificial sweeteners: classification, properties, analysis and applications in dairy products

Unit V
Milk oligosaccharides, structural and technological aspects, health promoting aspects of milk oligosaccharides

FS-712 : Biotechnological Interventions in Food Safety & Quality Assurance (3+0)

Objectives:
To impart current knowledge / advances in biotechnology field for achieving food safety and Quality assurance during production, processing and distribution of food products

Unit- I Biotechnological concepts and their application
History and benefits of biotechnological interventions in production of safe food; Biotechnology as diagnostics for food safety and prevention of food borne illness; Transgenic crop or animals to produce foods and safety evaluation; Allergen free
foods; Genetically engineered microbes or enzymes for enhanced bio-preservation of food products; Biotechnology to reduce carbon footprint in agriculture; Insecticide resistant food plants; Ethical and clinical issues associated with biotechnology based food.

Unit -II Nucleic acid based concepts and their application in food safety
Molecular biology tools (PCR, Real Time PCR, DNA aptamers, RAPD, gene cloning, sequencing, and gene polymorphism) for microbial culture strain differentiation; Nucleic acid based assays for detection of food borne pathogens (Northern Blot, Southern Blot, PCR, Microarray, Next gen sequencing, RNAseq etc); Nucleic acid expression based assays for detection of adulteration in milk from heterogeneous sources (e.g. cow vs buffalo milk etc.); Gene expression analysis of important milk proteins (Beta casein polymorphism A1 vs A2 milk, lysozyme, Lactoferrin etc.); Genome sequencing of dairy cultures and its importance; DNA Barcodes.

Unit -III Proteomics based techniques for food safety
Introduction to proteomics, metabolomics and their application in food safety applications; Introduction to Mass Spectrometry (LC-ESI-qTof, MALDI-Tof, Triple Quadrupole ToF); Application of proteomics and metabolomics for biomarker discovery in milk and milk products (mastitis, proteomics of milk borne pathogens etc.); HPLC, Biotyping of milk borne pathogenic organisms (MALDI biotyping); Mass spectrometry based analysis of adulterants in milk and milk products (antibiotics, pesticides, heavy metals, Melamine contamination aflatoxins, neutralizers, plant proteins, hide proteins, hormones etc.) using LC-MS-MS; ELISA based detection of pathogens in food items.

Unit-IV Advanced techniques in biotechnology and their demonstration:
Isolation of DNA from bacteria/somatic cells /milk and milk products; Agarose gel electrophoresis; Protein extraction from milk; SDS PAGE; 2-D gel electrophoresis; PCR and Real-Time PCR for detection of food pathogens; Analysis of beta casein polymorphism in milk (A1 vs A2 milk); Sample preparation for identification of proteins in food products using LC-MS-MS; Screening and quantitation of adulterants in foods especially milk; Practical aspects of MALDI biotyping for detection of milk borne pathogens.

FS-721/ DC-721: Advances in Chemistry of Milk Processing (3+0)

Objectives
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.

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, Milk fat replacers

Unit II
Physical changes in the fat globules in un-homogenized and homogenized milk; cold agglutination – its mechanisms and role

Unit III
Specific and non – specific enzymatic coagulation of milk

Unit IV
Status and formation of bioactive peptides in fermented milk products

Unit V
Chemistry involved in high pressure processing of milk

Unit VI
Heavy metals, drugs, pesticides, and polybiphenyls in milk (9).

11. Journal of Food safety
12. Journal of Food Science and Technology
13. Indian journal of Dairy Science
14. Bulletin of environmental contamination and toxicology
15. Indian Dairyman
16. Food additives and contaminants

**FS-722 /DC-722: Advances in Analytical Techniques in Dairy Chemistry (3+0)**

**Objectives**

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

**Unit I**
Isoelectric focusing and 2-D polyacrylamide gel electrophoresis (PAGE), Capillary zone electrophoresis, Enzyme linked immunosorbent assay (ELISA)

**Unit II**
Blotting techniques, High performance liquid chromatography (HPLC), Protein sequencing, X-ray crystallography, Circular dichroism (CD)

**Unit III**
Atomic-, Mass-, Infrared-, Fluorescence- Spectroscopy, Differential scanning calorimetry

**FS-723/ DM-722: Advances in Microbial Safety of Dairy Foods (3+0)**

**Objectives**

To impart current knowledge pertaining to risk assessment of emerging dairy pathogens and their safety issues in dairy foods.

**Unit 1**
Current trends, incidence and surveillance of Emerging milk borne disease; Changing patterns in epidemiology, agricultural and food manufacturing practices, transmission and susceptibility.

**Unit II**
Microbiological risk profile of dairy products; Historical aspects of safe food production; Evolution of food safety system; Identification and description of the micro-organisms that may be associated with dairy products and public health impact; Description of the dairy production, processing, distribution and consumption chain and what is currently known of the impact of these factors on public health and safety risks; Examination of epidemiological data (domestic and international) related to the consumption of dairy products; Examination of prevalence and concentration data on potential hazards from products along the entire dairy food chain.

**Unit III**

**Unit IV**
Food borne infection by colonization and adhesion factors like pilli or fimbriae, adhesion proteins, biofilm formation; invasion and intracellular residence; phagocytosis, invasion mediated induced phagocytosis; iron acquisition; motility and chemotaxis, invasion of immune system; intoxication; toxi-infection, structure and function of exotoxins & endotoxin; genetic regulation & secretory system for virulence factors.
Details of the Courses to be offered for Master’s Degree in Dairy Economics during

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Details of the Courses to be offered for Doctoral Degree in Dairy Economics during 2014-15

<table>
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<th>Category</th>
<th>Course No.</th>
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<td>ES-711 (2+1)</td>
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<td></td>
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Division of Dairy Economics, Statistics & Management
# National Dairy Research Institute, Karnal -132001

**Distribution of M.Sc. / Ph. D. Courses for the Session 2009-10**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Class/Year</th>
<th>Course No./Credit</th>
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<td>Micro Economic Theory and Applications</td>
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<td>Seminar</td>
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**AGRICULTURAL ECONOMICS**
Course Contents

ES 611: MICRO ECONOMIC THEORY AND APPLICATIONS (2+0)

Objective
This course is intended to provide an overview of microeconomic theory and its applications. The course starts with the theory of consumer behavior consisting of consumer’s utility maximization problem and demand theory. It intends to provide fundamental concepts and models in the theory of production and costs and sets out to provide a basic understanding of price and / or output determination under different types of market structures including factor markets. This course will also expose the students to the theory of general equilibrium and welfare economics.

Theory
UNIT I

UNIT II

UNIT III

UNIT IV

Suggested Readings

ES-612: EVOLUTION OF ECONOMIC THOUGHT (1+0)

Objective
To introduce the students to the evolution of economic thought over a period of time, the background of emanation of thoughts and approaches, as acts of balancing and counter balancing events and criticisms. The course will also in a comprehensive way help the students to know and appreciate the contributions of the Galaxy of Economists.

Theory
UNIT I

UNIT II

UNIT III

UNIT IV
The Era of globalization – Experiences of developing world - Rigidity of the past vs. emerging realism – The changing path of international Institutions to economic growth and development approaches.

UNIT V
Economic Thought in India – Naoroji and Gokhale – Gandhian Economics - Economic thought of independent India – Nehru’s economic philosophy - Experiences of the Structural adjustment programmes of the post liberalization era.

Suggested Readings

ES-613 LINEAR PROGRAMMING 1+1
Objective
The Course Objective of the course is to impart knowledge of Linear programming techniques.

Theory

UNIT I
Decision Making- Concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.

UNIT II
Simplex Method: Concept of simplex Method, solving profit maximization and cost minimizations problems. Formulation of farms and nonfarm problems as linear programming models and solutions.

UNIT III
Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.
UNIT IV
Game Theory - Concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies, the rectangular game as Linear Programme.

Practical
Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the simplex matrices for typical farm situations.

Suggested Readings
Vaserstein. 2006. Introduction to Linear Programming. Pearson Education Publication

ES-614  AGRICULTURAL MARKETING AND PRICE ANALYSIS  (2+1)
Objective
To impart adequate knowledge and analytical skills in the field of agricultural marketing issues, and enhance expertise in improving the performance of the marketing institutions and the players in marketing of agricultural commodities.

Theory
UNIT I

UNIT II

UNIT III
Role of Information Technology and telecommunication in marketing of agricultural commodities - Market research-Market information service - electronic auctions (e-bay), e-Choupals, Agmarket and Domestic and Export market Intelligence Cell (DEMIC) – Market extension.

UNIT IV

UNIT V

Practical
Supply and demand elasticities in relation to problems in agricultural marketing. Price spread and marketing efficiency analysis. Marketing structure analysis through concentration ratios.
Performance analysis of Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products. Chain Analysis - quantitative estimation of supply chain efficiency - Market Intelligence – Characters, Accessibility, and Availability Price forecasting. Online searches for market information sources and interpretation of market intelligence reports – commodity outlook - Technical Analysis for important agricultural commodities - Fundamental Analysis for important agricultural commodities - Presentation of the survey results and wrap-up discussion.

Suggested Readings

ES-615 agricultural development and policy analysis (2+0)

Objectives
- To provide orientation to the students regarding the concepts and measures of economic development
- To provide orientation on theories of economic growth and relevance of theories in developing countries.
- To make them to understand the agricultural policies and its effect on sustainable agricultural development
- To make them to understand the globalization and its impact on agricultural development.

Theory
UNIT I
UNIT II
UNIT III
Role of agriculture in economic / rural development – theories of agricultural development – Population and food supply - need for sound agricultural policies – resource policies – credit policies – input and product marketing policies – price policies.
UNIT IV
Development issues, poverty, inequality, unemployment and environmental degradation – Models of Agricultural Development – Induced Innovation Model - policy options for sustainable agricultural development.

UNIT V
Globalization and the relevance of development policy analysis – The dilemma of free trade?
— Free trade versus Protectionism- Arguments for protection. Arguments against protection.
Role of protection in Developing Countries. WTO – Agreement on Agriculture - Contradictions of free trade - proponents and opponents policies in vulnerable sectors like agriculture – Lessons for developing countries.

Suggested Readings

ES – 616: **Mathematics for Agricultural Economics** (2+0)

- Variables and functions; limit and continuity. Specific functions is economic theory. Differentiation, theorems of differentiation, differentiation of logarithmic trigonometric, exponential and inverse functions, function of a function, derivative of higher order, partial derivatives. Application of derivatives to determine average and marginal values in economic analysis; determination of elasticities; points of inflexion; linear homogenous production functions; derivation of average and marginal curves.

- Maxima and minima and their economic applications for optimization problems of cost, production, demand and supply.

- Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral, use of integration to determine relation between average and marginal value. Capitalization over time, estimation of returns from capital goods over time. Pareto distribution.

- Set theory-set operations, finite and infinite sets, operations of set, function defined in terms of sets.

- Solution of linear and quadratic equations involving one variable, simultaneous equations determinants evaluation and properties of determinants, Vectors and vector spaces, Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; application of determinants and matrices in solution of equation for economic analysis.

Suggested Readings

2. Yamane, Taro; Mathematics for Economics
   Prentice Hall of India, New Delhi

3. Mehta, B.C., & Madnani G.M.K., Mathematics for Economists
   Sultan Chand & Sons, New Delhi.

4. Searle, Shayle R.; Matrix Algebra Useful for Statistics
   John Wiley & Sons

5. Berry, Tanuj , Mathematical Methods for Economists
   Archetypal Publications New Delhi

   Modern Publishers


**ES-617 : STATISTICAL METHODS FOR SOCIAL SCIENCES (2+1)**


Scoring and scaling techniques, reliability and validity of test scores, rating scales. Factor analysis. Discriminant function and $D^2$-statistics, multivariate analysis.

Introduction to time series, components of time series – secular trend, linear and non-linear, periodic movements, cyclical fluctuations and irregular variations, Adjusting time series for trend, seasonal, cyclical-irregular variations. Forecasting methods, index numbers and their uses-method of their construction, problems in construction of index numbers.

**Practical**

Test of significance based on Z-test, t-test, F-test & $t$-test (2)
Correlation and regression (1)
Multiple regression and standard partial regression coefficient (1)
Ranking techniques (1)
Non-Parametric tests (1)
Factor analysis and Discriminant function analysis (1)
Analysis of time series data–secular trend, seasonal variation and cyclical–irregular variations (4)
Methods of construction of index numbers (2)
Suggested Reading

1. Snedecor, G.W., Cochran, W.C.; Statistical methods
   Oxford and IBH Publishing Co. New Delhi

2. Golden, C.H.; Methods of Statistical analysis
   Asia Publishing House Bombay.

3. Gupta, S.P.; Statistical Methods
   Sultan Chand & Sons, New Delhi.

   Prentice Hall of India Private Ltd., New Delhi


6. Panse V.G. and Sukhatme, P.V.; Statistical Methods for Agril. Workers
   Indian Council of Agricultural Research, New Delhi


ES 621: MACRO ECONOMICS AND POLICY (2+0)

Objective
Macro economics and Policy course is intended to expose the students to macroeconomic concepts and theory, the application of the macro economic theory, and implication of the macroeconomic policies.

Theory
UNIT I

UNIT II
Consumption function- Investment and savings - Concept of Multiplier and Accelerator - Output and Employment - Rate of interest - Classical, Neo classical and Keynesian version- Classical theory Vs Keynesian theory – Unemployment and Full employment.

UNIT III

UNIT IV
IS & LM frame work - General Equilibrium of product and money markets - Monetary policy - Fiscal policy- Effectiveness of Monetary and Fiscal policy - Central banking.

UNIT V
Objective
To expose the students to research methodology used in social sciences. The focus will be on providing knowledge related to research process, data collection and data analysis etc.

Theory
UNIT I
Importance and scope of research in agricultural economics. Types of research - Fundamental vs. Applied. Concept of researchable problem – research prioritization – selection of research problem. Approach to research – research process.

UNIT II
Hypothesis – meaning - characteristics - types of hypothesis – review of literature – setting of Course Objective and hypotheses - testing of hypothesis.

UNIT III
Sampling theory and sampling design – sampling error - methods of sampling – probability and non-probability sampling methods - criteria to choose. Project proposals – contents and scope – different types of projects to meet different needs – trade-off between scope and cost of the study. Research design and techniques – Types of research design.

UNIT IV

UNIT V

Practical

Suggested Readings


**ES-623 ECONOMETRICS (2+1)**

**Objective**

The Course Objective of the course is to impart knowledge on econometric tools to the students of agricultural economics. Training in econometrics will help the student to analyze the economic problem by applying quantitative techniques.

**Theory**

**UNIT I**

Introduction – relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics-regression analysis.

**UNIT II**

Basic two variable regression - assumptions estimation and interpretation approaches to estimation - OLS, MLE and their properties - extensions to multi variable models-multiple regression estimation and interpretation.

**UNIT III**

Violation of assumptions – identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches - model misspecification.

**UNIT IV**

Use of dummy variables-limited dependent variables – specification, estimation and interpretation.

**UNIT V**

Simultaneous equation models – structural equations - reduced form equations - identification and approaches to estimation.

**Practical**

Single equation two variable model specification and estimation – hypothesis testing-transformations of functional forms and OLS application-estimation of multiple regression model - hypothesis testing - testing and correcting specification errors - testing and managing Multicollinearity - testing and managing heteroscedasticity - testing and managing autocorrelation - estimation of regressions with dummy variables - estimation of regression with limited dependent variable - identification of equations in simultaneous equation systems.

**Suggested Readings**


Objective
The Course Objective of the course is to impart knowledge on issues related to lending to priority sector credit management and financial risk management. The course would bring in the various appraisal techniques in project - investment of agricultural projects.

Theory
UNIT I
Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing - Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI’s - NGO’s, and SHG’s.

UNIT II
Lending to farmers – The concept of 3 C’s, 7 P’s and 3 R’s of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening.

UNIT III

UNIT IV

UNIT V

Practical

Suggested Readings

ES-625 DAIRY BUSINESS MANAGEMENT (2 + 1)


Practical
Delineation of milk shed area.
Case studies for solving problem situations.
Demand forecasting
Estimation of cost of milk procurement and processing.
Break-even analysis and break-even charts.
Use of PERT in dairy industry.
Optimisation of product-mix.
Estimation of cost of inventory.
Economic lot size and other quantity standards.

Suggested Readings

**Es-626 AGRICULTURAL PRODUCTION ECONOMICS (2+1)**

**Objective**
To expose the students to the concept, significance and uses of agricultural production economics.

**Theory**

UNIT I

UNIT II
Factors of production, classification, interdependence, and factor substitution - Determination of optimal levels of production and factor application –Optimal factor combination and least cost combination of production - Theory of product choice; selection of optimal product combination.

UNIT III
Cost functions and cost curves, components, and cost minimization –Duality theory – cost and production functions and its applications -Derivation of firm’s input demand and output supply functions -Economies and diseconomies of scale.

UNIT IV
Technology in agricultural production, nature and effects and measurement - Measuring efficiency in agricultural production; technical, allocative and economic efficiencies - Yield gap analysis-concepts-types and measurement - Nature and sources of risk, modeling and coping strategies.

**Practical**
Different forms of production functions - specification, estimation and interpretation of production functions – returns to scale, factor shares, elasticity of production - physical optima-economic optima-least cost combination- optimal product choice- cost function estimation, interpretation-estimation of yield gap - incorporation of technology in production functions- measuring returns to scalarisk analysis through linear programming.

**Suggested Readings**
Heady EO. *Economics of Agricultural Production and Resource Use*. Prentice- Hall.
The Course Objective of this course is to introduce the theoretical models and applications of microeconomic theory. In particular, the basic comparative statistical techniques and the more modern duality theory will be developed and applied to the models of maximization, unconstrained and constrained utility maximization, expenditure minimization, constrained profit maximization, and cost and expenditure minimization. These mathematical structures form the basic building blocks of neoclassical economics; this course will stress the development and application of these important models. We follow a calculus rather than a graphical approach to the theory. In the subsequent sections of the course, we provide a fairly rigorous exposure to price determination under different market situations, general equilibrium theory, causes and consequences of market failure and welfare economics including the theory of public choice.

Theory

UNIT I

UNIT II
Perfect competition – Monopoly, monopolistic competition and oligopoly. Oligopoly models – collusive and non-collusive models of oligopoly – Cournot model, Chamberlin model, Stackleberg solution.

UNIT III

UNIT IV

UNIT V

Practical
ES-712 ADVANCED ECONOMETRICS (2+1)

Objective
The Course Objective of the course is to impart knowledge on advanced econometric tools to the Research Scholars of agricultural economics. Training in advanced econometrics will help the Research Scholars to analyze the economic problem by applying quantitative techniques.

Theory
UNIT I

UNIT II

UNIT III
Dummy variables - Qualitative and truncated dependent variables – limited dependent variables –LPM, probit and logit models, their multinomial extensions.

UNIT IV
Autoregressive distributed lag models – panel data fixed and random effects models and their extensions.

UNIT V
Simultaneous equation methods –identification – estimation by indirect least squares 2SLS, PIML, SURE, 3SLS.

Practical

Suggested Readings
Objective
The main Course Objective of this course is to critically analyze the important marketing concepts, models, properties of agricultural commodity prices and forecasting, data collection and analysis using current software etc., in order to make them policy decisions in the field of agricultural marketing.

Theory
UNIT I
Importance of market analysis in the agricultural system - types of marketing advantages and disadvantages - quantitative estimation - the distinguishing characteristics and role of agricultural prices - data sources for agricultural products and prices - softwares used in market analysis.

UNIT II
Role of various formal institutions in agricultural marketing - and functions - measuring their efficiency - public - private partnership – institutional arrangements. Successful case studies.

UNIT III

UNIT IV
Agricultural commodity marketing - spot and futures- marketing of derivatives-speculation, hedging, swap, arbitrage etc. commodity exchanges - price discovery and risk management in commodity markets- Regulatory mechanism of futures trading.

UNIT V
Lag operators and difference equations; stationary and stochastic processes; UNIT roots and co integration; conditional heteroscedasticity: ARCH and GARCH models - forecast evaluation; methods of forecasting. price indices and econometric estimation and simulation.

Practical
Estimation of demand/ supply forecasting, supply chain / value chain analysis for different commodities - Commodity models- multi market estimation- time series analysis - market integration studies- price discovery price volatility estimation - commodity price forecasting using econometric softwares.

Suggested Readings
ES-714: Operations Research (3+0)

UNIT I
Linear Programming: Objective, Assumptions, Formulation of Linear Programming Problem, Graphic Method, Simplex method, Transportation and Assignment Problems.

UNIT II
Inventory control Models: Costs Involved in Inventory Management, Types of Inventory, Economic Order Quantity (EOQ) Model, Continuous Review (Q) System, Periodic Review (P) System, Hybrid System, Simulation.

UNIT III

UNIT IV
Decision making under Risk and uncertainties, Decision problem, Maximax Criterion, Maximin Criterion, Minimax Regret Criterion, Laplace Criterion, Pay off Tables, Decision Trees, Expected Value of perfect Information.

UNIT V
Game Theory - Two-Person Zero-Sum Game, Simulation, Network analysis – PERT & CPM.

Suggested Readings

ES-721 ADVANCED MACRO ECONOMICS ANALYSIS (2+0)

Objective
Advanced macroeconomics course will be offered to PhD students of Agricultural Economics with the following Course Objective.
• to understand the macroeconomic theory
• to examine the macroeconomic Policy issues
• to analyze the macroeconomic Policy implications

Theory
UNIT I
Review of Macro Economics concepts-Comparative statistics- Keynesian theory- Consumption Function and Theories of Consumption -Saving Function and Theories of Saving.

UNIT II

UNIT III
UNIT IV

UNIT V

Suggested Readings

ES-722 ADVANCED PRODUCTION ECONOMICS (3+0)
Objective
To expose the students to the concept, significance and uses of advance production economics.

Theory
UNIT I
Agricultural Production process – Relationship between farm planning and production economics-scope of agricultural production and planning methods/ procedures in agro-economic research and planning.

UNIT II

UNIT III
Decision making with multiple inputs and outputs – MRT and product relationship-cost of production and adjustment in output prices-single input and multiple product decisions- Multi input, and multi product production decisions - Decision making with no risk -Cost of wrong decisions - Cost curves – Principles and importance of duality theory - Correspondence of production, cost, and profit functions - Principles and derivation of demand and supply functions.

UNIT IV
UNIT V
Simulation and programming techniques in agricultural production-Multiple Course Objective Programming – Goal programming and Compromise programming – applications.

Practical
Estimation of different forms of production functions- Optimal input and product choice from estimated functions-Derivation of demand and supply functions and estimation-Estimation of cost function and interpretations-Optimal product and input choice under multi input and output system-Estimation of factor shares from empirical functions estimated-Estimating production functions incorporating technology changes: Decomposition analysis and incorporation of technology- Estimation of efficiency measures – Stochastic, probabilistic and deterministic frontier production functions-Risk programming – MOTAD-Quadratic programming-Simulation models for agricultural production decisions-Goal programming – Weighted, lexicographic and fuzzy goal programming- Compromise programming.

Suggested Readings
UNIT V
Social Accounting Matrices and multipliers — Computable General Equilibrium models to assess economy wide impact of policy changes.

Practical

Suggested Readings

ES-724 ADVANCED MICRO ECONOMIC ANALYSIS (2+0)

Objectives
The Course Objective of this course is to introduce the theoretical models and applications of microeconomic theory. In particular, the basic comparative statistical techniques and the more modern duality theory will be developed and applied to the models of maximization, unconstrained and constrained utility maximization, expenditure minimization, constrained profit maximization, and cost and expenditure minimization. These mathematical structures form the basic building blocks of neoclassical economics; this course will stress the development and application of these important models. We follow a calculus rather than a graphical approach to the theory. In the subsequent sections of the course, we provide a fairly rigorous exposure to price determination under different market situations, general equilibrium theory, causes and consequences of market failure and welfare economics including the theory of public choice.

Theory
UNIT I

UNIT II
Perfot competition – Monopoly, monopolistic competition and oligopoly. Oligopoly models – collusive and non-collusive models of oligopoly – Cournot model, Chamberlin model, Stackleberg solution.

UNIT III

UNIT IV

UNIT V

Practical

Suggested Readings

SUPPORTING COURSES FOR OTHER DISCIPLINES

ES-627: Statistics for Industrial Applications (3 +1)

Statistical Methods in Industrial Applications; Testing of Hypothesis. Tests of significance – Z, t, Chi-square and F tests; Analysis of variance, one way, two way classification, Transformations, Partial and Multiple Correlation and Regression; Non-linear Regression; Ranking techniques; Coefficient of concordance; Principles of experimental design-Industrial experimentation; Basic designs-CRD; RBD & LSD; Missing plot technique; Factorial experiments-main effects and interactions. 2^n series and mixed factorial experiments;
Experimental designs in Sensory Evaluation; Response Surface Design and their applications in Dairy Industry; Introduction to sampling techniques and their application to consumer preference studies.

**Practical**
Tests of significance – Z, t, Chi-square and F tests.
Analysis of variance-one way and two way classification
Partial and multiple correlation and regression
Rank correlation and coefficient of concordance
Analysis of Industrial experiments – CRD; RBD and LSD
Missing plot technique
Factorial experiments – $2^2$ and $2^3$, mixed factorial experiments
Response Surface Design
Different methods of selecting samples.

**Suggested Readings**

S. Chand & Co., New Delhi
S. Chand & Co., New Delhi
Penguin Books, U.K.
Oxford and IBH Publishing Co., New Delhi
Asia Publishing House, Bombay
Wiley Eastern Pvt Limited, New Delhi
Chapman & Hill, New York

**ES-628: DESIGN OF EXPERIMENTS (3+1)**

Statistical methods for animal experiments, analysis of variance, transformation, linear and non-linear regression and correlation, including two independent variables.

Principles of experimental design, completely randomized, randomised block and latin square design, designs suitable for animal experimentation, missing plot technique, cross over design, switch over trails.

Factorial experiments, main effects and interactions, $2^n$ and $3^r$ series, mixed factorial experiments, principles of confounding-total and partial confounding. Balanced incomplete block designs, split plot design. Use of concomitant variates and analysis of covariance.
Practical
Test of significance based on Z-test, t-test $\chi^2$ test and F-test. (2)
Correlation and regression, multiple regression (2)
Analysis of data in CRD, RBD and LSD (2)
Missing plot technique (2)
Cross-over design (1)
Factorial experiments in $2^n$ series (2)
Split plot design (1)
Analysis of covariance (1)

Suggested readings
1. Snedecor, G.W., Cochran, W.G.; Statistical methods
2. Panse V.G. and Sukhatme, P.V.; Statistical Methods for Agril. Workers
   Indian Council of Agricultural Research, New Delhi
   Wiley Eastern Pvt. Ltd., New York
4. Gupta, S.P., Statistical Methods
   Sultan Chand Publisher, New Delhi.
5. Amble, V.N., Statistical Methods for Animal Sciences
   Indian Council of Agril. Research, New Delhi
   Wiley Eastern Pvt. Ltd., New Delhi

CS-621: Software Packages for Statistical Computing (2 + 1)

Theory
General data analysis requirements in dairy research; introduction to statistical and other standard software packages (SYSTAT; SPSS; MATLAB; and MS-Excel); data preparation and job control commands for statistical analysis of data pertaining descriptive statistics; tests of significance - t-test, Chi-square test and F-test; analysis of variance (ANOVA); basic experimental designs - CRD; RBD and LSD; factorial experiments; Correlation; simple and multiple linear regression; curvilinear regression; stepwise regression; discriminant analysis; graphic features of the above listed software packages; linear programming using appropriate software packages; least-squares analysis; brief introduction to data mining techniques such as neural networks, genetic algorithms and fuzzy logic for predictive modeling.

Practical
Statistical software packages and their operations; data preparation and data generation; import and export of data from spreadsheet and database packages; application of software packages to the problems related to: descriptive statistics; tests of significance (t-test; Chi-
square test and F-test); ANOVA; correlation; simple and multiple linear regression; curvilinear regression; stepwise regression; discriminant analysis; graphic features of the above noted software packages; linear programming problem; least-squares analysis; neural network and fuzzy logic models for prediction/classification.

**Suggested Readings**


User reference guides/manuals for respective software packages
ORGANIZATION OF COURSE CONTENTS & CREDIT REQUIREMENTS

Code Numbers
- All courses are divided into two series: 600-series courses pertain to Master’s level, and 700-series to Doctoral level. A Ph. D. student must take a minimum of two 700-series courses, but may also take 600-series courses if not studied during Master’s programme.
- Credit seminar for Master’s level is designated by code no. 691, and the two seminars for Doctoral level are coded as 791 and 792, respectively.
- Similarly, 699 and 799 codes have been given for Master’s research and Doctoral research, respectively.

Course Contents
The contents of each course have been organized into:
- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the PG students.

Minimum Credit Requirements

<table>
<thead>
<tr>
<th>Subject</th>
<th>Master’s programme</th>
<th>Doctoral programme</th>
</tr>
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<tbody>
<tr>
<td>Major</td>
<td>28</td>
<td>17</td>
</tr>
<tr>
<td>Minor + Supporting</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>(minimum 6 for minor &amp; 3 for supporting)</td>
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<td></td>
</tr>
<tr>
<td>Seminar</td>
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<td>02</td>
</tr>
<tr>
<td>Research</td>
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<tr>
<td><strong>Total Credits</strong></td>
<td><strong>60</strong></td>
<td><strong>75</strong></td>
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</table>

Compulsory Non Credit Courses

Major subject: The subject (department) in which the students takes admission

Minor subject: The subject closely related to students major subject. A suggested list of specified minor subjects is given in Table 1.

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student’s research work.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six Courses (PGS 501-PGS 506) are of general nature and are compulsory for Master’s Programme. Ph. D. students may be exempted from these courses if already studied during Master’s degree.
### Course Structure – at a Glance

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td><strong>M.Sc. First year: First semester (Major Courses)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DX-611</td>
<td>Fundamentals of Dairy and Animal Husbandry Extension</td>
<td>2+1</td>
</tr>
<tr>
<td>DX-612</td>
<td>Communication for Dairy Development</td>
<td>2+1</td>
</tr>
<tr>
<td>DX-613</td>
<td>Training for Human Resource Development</td>
<td>2+1</td>
</tr>
<tr>
<td>DX-614</td>
<td>Social Psychology and Group Dynamics</td>
<td>2+1</td>
</tr>
<tr>
<td>DX-615</td>
<td>Programme Planning and Evaluation for Rural Development</td>
<td>2+1</td>
</tr>
<tr>
<td>DX-616</td>
<td>e-Extension for Rural Development</td>
<td>2+1</td>
</tr>
<tr>
<td><strong>Minor courses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES-614</td>
<td>Agricultural Marketing and Price Analysis</td>
<td>2+1</td>
</tr>
<tr>
<td><strong>M.Sc. First year: Second semester (Major Courses)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DX-621</td>
<td>Research Methodology in Social Sciences</td>
<td>2+1</td>
</tr>
<tr>
<td>DX-622</td>
<td>Extension Techniques and Audio Visual Aids</td>
<td>2+1</td>
</tr>
<tr>
<td>DX-623</td>
<td>Participatory Methods for Technology Development &amp; Transfer</td>
<td>1+1</td>
</tr>
<tr>
<td>DX-624</td>
<td>Management in Extension</td>
<td>2+1</td>
</tr>
<tr>
<td>DX-625</td>
<td>Diffusion and Adoption of Dairy and Animal Husbandry Innovations</td>
<td>2+1</td>
</tr>
<tr>
<td>DX-626</td>
<td>Gender Sensitization for Development</td>
<td>1+1</td>
</tr>
<tr>
<td>DX-627</td>
<td>Entrepreneurship Development</td>
<td>2+1</td>
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<tr>
<td><strong>Minor courses</strong></td>
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<tr>
<td>ES-625</td>
<td>Dairy Business Management</td>
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<td>LP-625</td>
<td>Integrated Livestock Farming System</td>
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<tr>
<td><strong>supporting</strong></td>
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<tr>
<td>ES-617</td>
<td>Statistical Methods for Social Sciences</td>
<td>2+1</td>
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<td><strong>Non-credit courses (Compulsory):</strong></td>
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<tr>
<td>PGS-631</td>
<td>Library and Information Services</td>
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<tr>
<td>PGS-632</td>
<td>Technical Writing &amp; Communication Skills</td>
<td>0+1</td>
</tr>
<tr>
<td>PGS-633</td>
<td>Intellectual Property &amp; Its Management in Agriculture</td>
<td>1+0</td>
</tr>
<tr>
<td>PGS-635</td>
<td>Disaster Management</td>
<td>1+0</td>
</tr>
<tr>
<td>DX-629</td>
<td>Master's Seminar</td>
<td>1+0+1</td>
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Semester-wise distribution of courses for Ph.D. students of Dairy Extension Division

<table>
<thead>
<tr>
<th>Ph.D. First year: First semester (Major Courses)</th>
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<tbody>
<tr>
<td>DX- 711 Organizational Management</td>
<td>3+0</td>
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<tr>
<td>DX- 712 Farm Journalism and Public Relations</td>
<td>2+1</td>
</tr>
<tr>
<td>DX- 713 Advances in Training Technology</td>
<td>2+1</td>
</tr>
<tr>
<td>DX- 714 Dynamics of Change</td>
<td>2+0</td>
</tr>
<tr>
<td>DX- 715 Policies and Regulations in Dairy and Livestock Sector</td>
<td>2+0</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Ph.D. First year: Second semester (Major Courses)</th>
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<tbody>
<tr>
<td>DX- 721 Advanced Research Techniques in Social Research</td>
<td>3+1</td>
</tr>
<tr>
<td>DX- 722 Organizational Communication</td>
<td>2+1</td>
</tr>
<tr>
<td>DX- 723 Educational Technology</td>
<td>2+1</td>
</tr>
<tr>
<td>DX-724 Advances in Extension</td>
<td>2+1</td>
</tr>
<tr>
<td>DX- 790 Special Problem</td>
<td>0+2</td>
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</table>

<table>
<thead>
<tr>
<th>Seminar (s) (Major Courses)</th>
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<tbody>
<tr>
<td>DX- 719 Doctoral Seminar (I)</td>
<td>1+0</td>
</tr>
<tr>
<td>DX- 729 Doctoral Seminar (II)</td>
<td>1+0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Courses from Minor Disciplines</th>
<th></th>
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<tbody>
<tr>
<td>LP 611 Cattle and Buffalo Production and Management</td>
<td>2+1</td>
</tr>
<tr>
<td>LP 723 Advances in Environmental Management</td>
<td>3+0</td>
</tr>
<tr>
<td>ES-624 Agricultural Finance and Project Management</td>
<td>2+1</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Supporting Course</th>
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<tbody>
<tr>
<td>CS--621 Software Packages for Statistical Computing</td>
<td>2+1</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Non-credit courses (Compulsory): Third Semester</th>
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</thead>
<tbody>
<tr>
<td>GS-631 Library and Information Services</td>
<td>0+1</td>
</tr>
<tr>
<td>GS-632 Technical Writing &amp; Communication Skills</td>
<td>0+1</td>
</tr>
<tr>
<td>GS-633 Intellectual Property &amp; Its Management in Agriculture</td>
<td>1+0</td>
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<tr>
<td>GS-635 Disaster Management</td>
<td>1+0</td>
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<tr>
<td>Code</td>
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</tr>
<tr>
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<td>M.Sc. First year: First semester</td>
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<tr>
<td>DX- 611</td>
<td>Fundamentals of dairy and animal husbandry extension</td>
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<tr>
<td>DX- 612</td>
<td>Communication for dairy development</td>
</tr>
<tr>
<td>DX- 613</td>
<td>Training for human resource development</td>
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<td>Programme Planning and Evaluation for Rural Development</td>
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<td>DX-616</td>
<td>e-Extension for Rural Development</td>
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<tr>
<td></td>
<td>M.Sc. First year: Second semester</td>
</tr>
<tr>
<td>DX- 621</td>
<td>Research methodology in social sciences</td>
</tr>
<tr>
<td>DX- 622</td>
<td>Extension techniques and audio visual aids</td>
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<td>DX- 623</td>
<td>Participatory methods for technology development &amp; transfer</td>
</tr>
<tr>
<td>DX- 624</td>
<td>Entrepreneurship development and Management in Extension</td>
</tr>
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<td>Diffusion and adoption of dairy and animal husbandry innovations</td>
</tr>
<tr>
<td>DX- 626</td>
<td>Gender Sensitization for Development</td>
</tr>
<tr>
<td>Code</td>
<td>Course title</td>
</tr>
<tr>
<td>--------</td>
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</tr>
<tr>
<td>DX- 711</td>
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<tr>
<td>DX- 712</td>
<td>Farm journalism and public relations</td>
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<td>DX- 713</td>
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<td>Advanced research techniques in social research</td>
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<td>Organizational communication</td>
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<tr>
<td>DX- 723</td>
<td>Educational technology</td>
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<tr>
<td>DX- 724</td>
<td>Advances in Extension</td>
</tr>
<tr>
<td>DX- 790</td>
<td>Special problem</td>
</tr>
</tbody>
</table>

**Seminar (s)**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course title</th>
<th>Credits</th>
<th>Teachers</th>
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<tbody>
<tr>
<td>DX- 619</td>
<td>Master's seminar</td>
<td>1+0</td>
<td>Khajan Singh</td>
</tr>
<tr>
<td>DX- 719</td>
<td>Doctoral seminar (I)</td>
<td>1+0</td>
<td>Jancy Gupta</td>
</tr>
<tr>
<td>DX- 729</td>
<td>Doctoral seminar (II)</td>
<td>1+0</td>
<td>Jancy Gupta</td>
</tr>
<tr>
<td>DX- 699</td>
<td>Master's research</td>
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<td>With Concerned Guide</td>
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<tr>
<td>DX- 799</td>
<td>Doctoral research</td>
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<td>With Concerned Guide</td>
</tr>
</tbody>
</table>
Discipline of Dairy Extension Education
COURSE CONTENTS

M.Sc. Courses
DX- 611 (2+1): Fundamentals of Dairy & Animal Husbandry

Objective
To acquaint the students with the genesis, development and present status of animal husbandry extension and linkages among departments and various institutions.

Theory
UNIT I: Concept, philosophy, principles, genesis, growth and scope of extension education.
UNIT II: Earlier extension efforts and their implications. Emerging issues, problems and challenges of dairy extension education.
UNIT III: Extension approaches of State and Central Governments, ICAR, SVUs/ SAUs, NGOs and other organizations in delivery of dairy and animal husbandry services.
UNIT IV: Linkages between researcher-extension agent - livestock farmer-industry in the generation, dissemination and utilization of dairy farming practices.

Practical
Study of the organizational set-up and functioning of State Animal Husbandry Department and dairy/rural development agencies. Study of indigenous technical know-how about animal husbandry practices in villages.

Suggested Readings
Mosher AT. 1978. An Introduction to Agricultural Extension. ADC.
DX- 612 (2+1): Communication for Dairy Development

Objective
To acquaint the students with concept and models of communication and to improve their communication skills

Theory
UNIT I: Communication- meaning, concept, purpose and process.
UNIT II: Models and theories of communication. Types of communicationintrapersonal, interpersonal, verbal and non-verbal. Criteria of effective communication, Determinants of communication- Empathy, credibility, fidelity, distortion, feedback and barriers to communication.
UNIT III: Group and mass communication. Modern communication technologies. Key communicators and their role in dairy and animal husbandry development.

Practical

Suggested Readings

DX- 613 (2+1): Training for Human Resource Development

Objective
To make the students aware of planning, implementation and evaluation of various training programmes.

Theory
UNIT I: Concept of training and education. Training infrastructure for extension personnel and farmers in India. Role of institution, organization and participants in success of training programme.
UNIT II: Assessment of training needs, curriculum design and development. Training strategies, models of training.
UNIT III: Planning, development and execution of training programmes.
UNIT IV: Training methods– Lecture, symposium, workshop, case studies, group discussion, conference, convention, panel discussion, buzz session, forum, debates, syndicate, simulation exercises, role playing, brain storming.
UNIT V: Evaluation and follow-up of training programmes.

Practical
Preparation of training programmes for extension personnel, dairy farmers, etc. Evaluation of on-going training programmes.

Suggested Readings
Selected articles from journals.
**DX- 614(2+1): Social Psychology and Group Dynamics**

**Objective**
To acquaint the students with the structure and functioning of social groups and socio-psychological aspects in interacting with livestock farmers.

**Theory**

UNIT I: Meaning, scope and importance of psychology in dairy and animal husbandry extension work. Orientation of psychology.

UNIT II: Perception - nature, laws and selectivity in perception, factors in perception, importance of perception in extension work. Attitude - nature, theories, measurement and change of attitude towards dairy farmers, formation of stereo types and prejudice, factors in attitude change.


UNIT IV: Intelligence - nature, theories and measurement. Personality - nature, traits, types, biological and socio-cultural determinants of personality. Group and individual behaviour.

UNIT V: Concept and types of groups; Typology and importance in rural development; Group structures - attraction, coalition, communication and power; Processes in group development and group identity; Factors affecting group performance; Conflicts in groups; Group belongingness.

**Practical**
Study of structure and functioning of selected Self Help Groups (SHGs), factors influencing the success/ failure of SHGs, Milk Cooperative Societies.

**Suggested Readings**

**DX- 615(2+1): Programme Planning and Evaluation for Rural Development**

**Objective**
To expose the students on planning, formulation, implementation and evaluation of various animal husbandry development programmes.

**Theory**

UNIT I: Importance of programme planning in Dairy and animal husbandry extension. Objectives, principles and steps in programme planning process. Role of Dairy and animal husbandry extension agencies, local leaders, livestock owners and institutions in planning and implementation of need-based Dairy and animal husbandry extension programmes.

UNIT II: Genesis, nature and principles of planning. Planning Commission and its role. Five Year Plans with reference to dairy and animal husbandry development. Organizational structure for planning at different levels.

UNIT III: Concept, principles, types and methods of evaluation. Importance of monitoring various dairy development programmes.

UNIT IV: Needs assessment—meaning, importance, classification and steps. Concept of FSR, Participatory Approaches- Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA)

Practical
Preparation of Dairy development plan for a village. Developing instruments for monitoring and evaluation of on-going development programme at village level (Logical Frame Work ). Exercises on Participatory approaches (RRA,PRA, Case study, Problem Based Learning).

Suggested Readings

DX- 616 (2+1): e- Extension for rural development

Objective
Students will gain knowledge and skills in understanding the concepts of Information and communication technologies and how these ICT tools can be used for Agricultural Extension. Besides, he studies various ICT projects which are successful in delivering the services to the clientele fulfilling the objective of Transfer of Technology i.e. Reaching the unreached.

Theory
UNIT I: ICTs- Concept, definition, tools and application in extension education. Reorganizing the extension efforts using ICTs, advantages, limitations and opportunities.
UNIT II: ICTs projects, case studies in India and developing world. Different approaches (models) to ICTs. ICT use in field of extension- Expert systems on selected crops and enterprises; Self learning CDs on package of practices, diseases and pest management, Agricultural web sites and portals related crop production and marketing etc.

Practical

Suggested Readings
DX- 621(2+1): Research Methodology in Social sciences

Objective
To apprise the students about the selection criteria of research problem, variables, research design, sampling techniques, data collection procedure and report writing in the field of dairy and animal husbandry extension.

Theory
UNIT I : Concept, nature and scope of research in social sciences. Types of research-fundamental, applied and action research, experimental and non-experimental research. Variables, types and their measurement. Selection and formulation of research problem. Hypothesis— importance, selection criteria (quality of workable hypothesis), formulation and testing of hypothesis.

UNIT II : Measurement and levels of measurement; Research designs- exploratory, experimental, and ex-post-facto research design. Action research. Sampling methods-probability and non-probability sampling. Sources of errors.


Practical
Selecting a research problem and working it out with all the steps; report writing and presentation of the report.

Suggested Readings

DX- 622 (2+1): Extension Techniques and Audio-Visual Aids

Objective : To train the students about various techniques/methods for transfer of dairy and animal husbandry technologies through suitable audio-visual aids.

Theory

UNIT II: Extension approaches in Dairy development– individual, group and mass approach (electronic and non electronic). Relative merits and demerits of different teaching methods in dairy and animal husbandry extension.
UNIT III: Audio-visual aids—classification, use and evaluation. Selection criteria of audio-visual aids.

UNIT IV: Multi-media projection and computer aided teaching aids for dairy and animal husbandry extension.

UNIT V: Selection of different extension methods for dissemination of dairy and animal husbandry technologies and media-mix.

Practical
Preparation and presentation of various audio-visual aids. Use of different teaching methods in field situations. Review of research studies in teaching methods and A.V. aids.

Suggested Readings


DX-623 (1+1) Participatory Methods for Technology Development and Transfer

Objective
This course is intended to orient the students with the key concepts, principles process of different participatory approaches for technology development and transfer and also to expose the students with various participatory tools and techniques like space related, time related, relation oriented methods. Besides the students will be learning the preparation of action plans participatory monitoring and evaluation.

Theory
UNIT I : Participatory extension – Importance, key features, principles and process of participatory approaches: Different participatory approaches (RRA, PRA, PLA, AEA, PALM, PAR, PAME, ESRE, FPR) and successful models.

UNIT II : Participatory tools and techniques. Space Related Methods : village map (social & resource), mobility services and opportunities map and transect; Time related methods : time line, trend analysis, seasonal diagram. Daily activity schedule, dream map; Relation oriented methods : cause and effect diagram (problem tree), impact – diagram, well being ranking method, Venn diagram, matrix ranking, livelihood analysis.

UNIT III : Preparation of action plans, concept and action plan preparation; Participatory technology development and dissemination; Participatory planning and management, phases and steps in planning and implementation aspects; Process monitoring, participatory evaluation.

Practical
Simulated exercises on space related methods, time related method and relation oriented methods; Documentation of PTD and dissemination; Preparation of action plan; Participatory monitoring and evaluation of developmental programmes.

Suggested Readings


Practical
Field visit to Successful enterprises-Study of Characteristics of Successful entrepreneurs Development of Project Proposal -Case Studies of Success / Failure enterprises-Exercise on Market Survey-Field visit to Financial institutions- Simulated exercise to understand management process-Field visit to extension organizations to understand the functions of management -Group exercise on development of short term and long term plan-Simulated exercise on techniques of decision making-Designing organizational structure -Group activity on leadership development skills.

Suggested Readings

DX- 625 (2+1): Diffusion & Adoption of Dairy & Animal Husbandry Innovations

Objective
To sensitize the students towards technology generation, dissemination and its adoption through effective communication.

Theory
UNIT III; Role of change agents in transfer of technology. Diffusion studies in Dairy and animal husbandry extension. Role of communication in diffusion and adoption process.

Practical
Study of selected dairy and animal husbandry innovations- the adoption and non-adoption of various practices. Reasons for adoption and non-adoption of innovations

Suggested Readings

DX- 626 (1+ 1): Gender Sensitization for Development

Objective
In this course the students will learn about an overview of the concept of gender and gender balance on development and develop skills of identifying gender roles, rights, responsibilities and relationships on development. Besides the students will also learn the attitudinal change to internalize gender equity concerns as fundamental human rights and also enhance the capability for identifying and analyzing gender issues in agriculture and allied sectors.

Theory
UNIT I: Gender concepts, issues and challenges in development; Gender roles, gender balance, status, need and scope; Gender analysis tools and techniques.
UNIT II: National policy for empowerment of women since independence; Developmental programmes for women; Gender mainstreaming in agriculture and allied sectors – need and relevance; Gender budgeting – A tool for empowering women.
UNIT III : Women empowerment –Dimensions; Women empowerment through SHG approach; Women entrepreneurship and its role in economic development; Public Private Partnership for the economic empowerment of women; Building rural institution for women empowerment; Women human rights; Action plans for gender mainstreaming.

Practical
Visits to rural institutions of women for studying in the rural institutions engaged in Women empowerment; Visits to entrepreneurial unit of women for studying the ways and means of establishing entrepreneurship units for Women and their development and also SWOT analysis of the Unit; Visit to Center for women development - NIRD to study the different activities related to projects and research on gender; Visit to gender cell, Office of the Commissioner and Director of Agriculture, Hyderabad, to study the mainstreaming of gender concerns and gender budget of the department.

Suggested Readings
DX-627 (2+1): Entrepreneurship Development

Objective
The first part of the course is intended to provide overall picture of planning and development of enterprises for extending sustainable livelihoods for rural people. The second part of the course is structured to help the students to gain knowledge and skills in different concepts and techniques of management in extension organizations.

Theory

UNIT II: Micro enterprises – Profitable Agri enterprises in India – Agro Processing, KVIC industries. Micro financing – meaning, Sources of Finance, Banks, Small scale industries development organizations. Marketing for enterprises – Concept, planning for marketing, target marketing, Competition, market survey and strategies, Product sales and promotion. Gender issues in entrepreneurship development – Understanding gender and subordination of women, Gender as a development tool, Policy approaches for women entrepreneurship development. Success and Failure stories for enterprises – Issues relating to success and failure of enterprises – Personal, Production, Finance, Social, Marketing.

Ph.D. Courses (First semester)

DX-711 (3+0): Organizational Management

Objective
To acquaint the students with the general administration, management and motivational techniques for organizational change and development.

Theory
UNIT I: Concept, approaches and functions of management. Principles and process of organization, hierarchy of organization, departmentalisation. Authority and responsibility. Components of individual behaviour in organization. Organizational climate, decision making by consensus and participation by subordinates.

UNIT II: Motivation– nature and significance, motivational process, theories of motivation with respect to dairy & animal husbandry work. Importance of human needs, priority of needs, Managing work motivation.


UNIT IV: Supervision– principles, techniques and functions of supervision. Qualities of supervisor, supervisor-subordinate relationship and interaction process. Changing organizational structure and system, changing organizational climate and interpersonal style, issues and choice involved in making organizational climate.

UNIT V: Organization development– history, nature, characteristics, assumptions and process. Organization development interventions.

Suggested Readings
Selected articles from journals.
DX-712 (2+1): Farm Journalism and Public Relations

Objective
To sensitize students about the role of mass media, newspapers, magazines, radio, T.V. and internet for promoting dairy & animal husbandry.

Theory
UNIT I: Concept of farm journalism and communication. Journalism as a means of mass-communication and its role in dairy development. Opportunities, strength and limitations. Ethics and principles of journalism for effective writing.

UNIT II: Art of writing, news items, news stories, feature articles, success stories, magazines, bulletins, folders etc. Fundamentals of lay-out in writing. Writing of research papers and popular articles in journals and farm magazines.

UNIT III: Methods and techniques of broadcasting of farm programmes. Writing scripts for radio and televisions. Importance of public relations in dairy and animal husbandry extension.

UNIT IV: Rapport building with different categories of clients involved in dairy and animal husbandry extension programmes. Art of speaking. Importance of listening and reading. Relations with press media.


Practical
Designing and preparation of news stories, feature articles, success stories related to dairy farming and/or animal husbandry. Designing and preparation of magazines, folders, popular research articles, radio and T.V. scripts. Visit to agricultural information and communication centre to record the activities of preparation, editing and publication of news articles and research publications. Exercise on the art of good speaking in class-room and field situations.

Suggested Readings
Selected articles from journals.

DX-713(2+1): Advances in Training Technology

Objective
• Plan and design a training programme
• Plan & Develop effective training sessions
• Manage difficult situations while organizing training programmes
• Use different advanced participatory training methods

Theory
UNIT I: Paradigm shift in training - learning scenario, Training Approaches – Experiential learning - laboratory - organization development (system) approaches; Training Design, Designing an effective training programme, Harmonizing training needs, Course Objective, content and methods.

UNIT II: Designing an effective training session - the semantics involved, Designing experiential training sessions, simulation exercises, and openness in training transaction - managing dilemmas, ambivalence and conflicts and confusion (for both trainers and trainees).

UNIT III: Recent Training Techniques for understanding and facilitation team building, group dynamics, motivation and empowerment, laboratory methods: micro-lab process work, and sensitivity training. Psychological instruments as training tools: TAT, Inventories, Cases, etc.
UNIT IV: Participatory Training Techniques - Lecture, Brainstorming, Group discussion and Training Games. Role Play, Psycho-drama, Coaching, Counselling, etc., Trainer's roles and dilemmas, Factors Effecting Training Effectiveness and Training Evaluation.

**Practical**
Techniques of participatory training need assessment. Formulation of Course Objective, design of training programmes. Simulation exercises. Participatory training methods - Role Play & Brainstorming, Group discussion and Counselling and Conducting experiential learning sessions. Training evaluation - Techniques of Knowledge, Skill & Attitude evaluation. Visit to training institutions and study of training technologies followed.

**Suggested Readings**

**DX- 714 (2+0): Dynamics of Change**

**Objective:** To make the students aware of dynamics of change, group dynamics and social change.

**Theory**
UNIT I: Definition of change, development, social and cultural change. Dimensions, characteristics, types, rate & directions of social change. General conditions of social change.
UNIT II: Process of change. Concept, importance and problems of planned change. Role of change agents. Approaches of change agents towards planned change. Acceptance and rejection to planned change in animal husbandry. Techniques for accelerating change.
UNIT III: Theories of change: Darwin, Kurt, Lewin, Ogburn & influence process of change, assessment of resources, fixation of change objective, evaluating change effect. Barrier to change- psychological, social & economical, stimulants to change: psychological, social & economical.
UNIT IV: Agrarian changes with reference to dairy development.

**Suggested Readings**: Selected articles from journals.

**DX- 715 (2+0): Policies and Regulations in Dairy & Livestock Sector**

**Objective**
To sensitize the students about policies and regulations in dairy & animal husbandry sector.

**Theory**
UNIT II: HACCP, Sanitary and phyto-sanitary measures to protect the animals' life and health, food safety uses in relation to animal husbandry sector. Introduction to Agreement on Technical Barriers to Trade (ATBT).
UNIT III: Animal welfare laws- legislations in dairy and animal sciences.
Suggested Readings: Selected articles from journals.

DX-721(3+1): Advanced Research Techniques in Social Research

Objective
To train the students about various research and management techniques/methods applicable to animal husbandry researches.

Theory
UNIT I: Measurement—meaning and levels, tests, and scales. Different types of Variables.
UNIT II: Techniques of attitude scale construction viz. paired comparison, equal appearing interval, successive interval, summated ratings, scalogram analysis.
UNIT IV: Experimental and quasi experimental research designs. Content analysis and projective techniques.
UNIT V: Multivariate analysis, systems analysis, principle component analysis, discriminate analysis and their application in extension education research.

Practical
Exercises on scaling techniques, attitude scale construction – Paired Comparison, Equal Appearing interval, Summated Rating Scale, Critical Incident Technique, Knowledge Test.

Suggested Readings: Selected articles from journals.

DX-722 (2+1): Organizational Communication

Objective
To sensitize the students towards communication and networking to increase the efficiency of an organization.

Theory
UNIT I: Organizational communication—its importance, function and characteristics. Understanding of organizational communication. Types of organizational communication—upward, downward, diagonal and grapevine. Communication network.
UNIT II: Effectiveness and efficiency of organizational communication.
UNIT III: Essentials of a sound organizational communication system. Social and Psychological barriers to effective organization communication. Causes of poor organization communication.

Practical
Studies on organizational communication patterns in dairy & animal husbandry

Suggested Readings: Selected articles from journals.

DX-723 (2+1): Educational Technology

Objective
To acquaint students with different concepts of education technology and preparation of teaching aids

Theory
UNIT II: Preparation of course outline for instructions, lesson planning. Designing instructions for theory and practical, Instructional methods and devices in class room instruction, computer aided learning. Understanding learners’ behaviour, learning styles, motivating learners.
UNIT III: Student counselling and guidance, Student evaluation – meaning and methods, construction of measuring instrument – question banking.


Practical
Preparation of course outline, Preparation of lesson plans, Planning and preparation of instructional aids, Individual classroom instructional exercises, Development of student evaluation instrument, Development of performance appraisal instrument for teachers.

Suggested Readings: Selected articles from journals.

DX-724 (2+1) : Advances in Extension

Objective
To acquaint the students with the recent development in extension.

Theory
UNIT I: Important concepts in extension science; various schools of thought; Systems concept in extension.
UNIT II: Changing approaches – Farmer participatory approaches; Global concepts of extension as applied to Indian Context.
UNIT IV: Various stakeholders in Dairy development; stakeholder analysis, problem tree

Suggested Readings

DX- 790 (0+2): SPECIAL PROBLEM

Objective
To provide expertise in handling practical research problem(s).

Practical
Short research problem(s) involving contemporary issues and research techniques
Major Subject: AGRONOMY (Forage Production)

Semester-I

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Course No.</th>
<th>Title of course</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>1.</td>
<td>FP-611</td>
<td>Modern concepts in Crop Production</td>
<td>3+0</td>
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<tr>
<td>2.</td>
<td>FP-612</td>
<td>Soil Fertility and Nutrient Management</td>
<td>2+1</td>
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<tr>
<td>3.</td>
<td>FP-613</td>
<td>Principles and Practices of Water Management</td>
<td>2+1</td>
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<td>4.</td>
<td>FP-614</td>
<td>Agronomy of Forage Crops</td>
<td>2+1</td>
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<tr>
<td>5.</td>
<td>SS 611:</td>
<td>Concepts of Soil Science</td>
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Semester-II

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<td>5.</td>
<td>FP-621</td>
<td>Principles and Practices of Weed Management</td>
<td>2+1</td>
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<tr>
<td>6.</td>
<td>FP-622</td>
<td>Seed Production Agronomy</td>
<td>2+1</td>
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<tr>
<td>7.</td>
<td>FP-623</td>
<td>Grassland and Pasture Management</td>
<td>2+1</td>
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<tr>
<td>8.</td>
<td>FP-624</td>
<td>Crop Ecology and Crop Physiology</td>
<td>3+0</td>
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Minor Subject: Animal Nutrition

Semester-I

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<tbody>
<tr>
<td>1.</td>
<td>AN-614</td>
<td>Non Conventional Feed stuffs and toxic Constituents/Antimetabolites in animal feed Stuffs.</td>
<td>2+2</td>
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Semester-II

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<tr>
<td>2.</td>
<td>AN-621</td>
<td>Animal Nutrition-Minerals, Vitamins and Feed Additives.</td>
<td>3+1</td>
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Supporting subject: Dairy Economics & Statistics.

Semester-I

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<tbody>
<tr>
<td>1.</td>
<td>ES-624</td>
<td>Agricultural Finance and Project Management</td>
<td>2+1</td>
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</table>

Semester-II
2. **ES-628** Design of Experiments 3+2

**FP-619** Seminar

**FP 611 MODERN CONCEPTS IN CROP PRODUCTION** 3+0

**Theory**

Crop growth analysis in relation to environment; agro-ecological zones of India.

Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

Effect of lodging in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.

Scientific principles of crop production; crop response production functions; concept of soil-plant relations; yield and environmental stress.

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming. Determining the nutrient needs for yield potentiality of crop plants, concept of balanced nutrition and integrated nutrient management; precision agriculture.

**FP 612** Soil Fertility and Nutrient Management 2+1

**Theory**

Soil fertility and productivity - factors affecting these; features of good soil management; problems of supply and availability of nutrients; relationship between nutrient supply and crop growth; organic farming-basic concepts and definitions.

Criteria of essentiality of nutrients. Essential plant nutrients - their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Preparation and use of farm yard manure, compost, green manure, vermi-compost, bio fertilizers and other organic concentrates, their composition, availability and crop responses; recycling of organic wastes and residue management.

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency, fertilizer mixtures and grades;
agronomic, chemical and physiological methods of increasing fertilizer use efficiency; nutrient interactions.

Time and methods of application of manures and fertilizers; foliar application and its concept; relative performance of manures and fertilizers; economics of fertilizer use; integrated nutrient management; use of vermi-compost and crop residue.

Practical

- Determination of total N, P, K and S in plants.
- Interpretation of interaction effects and computation of economic and yield optima.
- Identification of fertilizers and manures.

FP - 613  PRINCIPLES AND PRACTICES OF WATER MANAGEMENT  2+1

Theory

Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states.

Water movement in soil and plant, transpiration; soil-water-plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress conditions. Dry land farming and water management. Water harvesting and moisture conservation techniques.

Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation, micro irrigation system; fertigation; management of water in controlled environments and polyhouses.

Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; water use efficiency. Excess of soil water and plant growth; water management in problem soils; drainage requirement of crops and methods of field drainage, their layout and spacing.

Practical

- Measurement of soil water potential by using tensiometer, and pressure plate and membrane apparatus.
- Soil –moisture characteristics curves.
- Water flow measurements using different devices.
- Determination of irrigation requirements.
- Calculation of irrigation efficiency.
- Determination of infiltration rate.
FP-614 Agronomy of Forage Crops 2+1

Theory

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like maize, Sorghum +Teosinte, bajra, guar, cowpea, oats, barley, berseem, senji, lucerne, mustard, turnip, hybrid napier grass, Guinea grass, rye grass, red clover, white clover, Lasiuras, Cenchrus etc.

Suitable fodder rotations of fodder crops and their mixtures for different agroclimatic zones of the country.

Year-round fodder production. Principles and methods of hay and silage making, chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichment and biological methods for improving nutritive value of poor quality fodder. Economics of fodder cultivation.

Practical

- Identification of important fodder crops, grasses and weeds.
- Practical training of farm operations in raising of fodder crops.
- Canopy measurement and yield estimation.
- Estimation of pH and aminonical nitrogen of silage.
- Maintenance of herbarium.
- Estimation of crude protein, NDF, ADF, lignin, silica, cellulose.

Supporting Course: Soil Science- for M.Sc./Ph.D. Agronomy (Forage Production) students

Semester-I

SS 611: Concepts of Soil Science Credit hour: 3(2+1)

Theory:

Unit-I: Soil as a natural body and medium for plant growth; nature and origin of soil, soil formation, classification and survey. Soil physical, chemical and biological properties in relation to crop production and soil-water-plant relations.

Unit-II: Types, factors and causes of land degradation, Land capability classification, Problem Soils and their distribution in India. Nature and characteristics of acidic, salt-affected and waterlogged soils of India. Reclamation and management of problem soils, use of amendments and drainage.

Unit-III: Sources of soluble salts and other impurities in water; quality of different water resources in India; factors affecting use of poor quality irrigation water for crop production; management practices for using saline-sodic waters; sewage and industrial effluents for irrigation.
Unit-IV: Crop production techniques in problem soils- crops, varieties, cropping systems and agronomic practices, salt tolerant crops

Unit-V: Fertilizers, insecticides and their effects on soil.

Practical:
- Soil sampling for different purposes
- Soil profile & its characteristics
- Bulk density, particle density and aggregate size analysis of soil
- Identification of fertilizers & their application
- pH, EC and OC determination of soils
- Cation and anions analysis of irrigation water
- Determination of micronutrients
- Lime and Gypsum requirement of problem soils

FP 621 Principles and Practices of Weed Management  
2+1

Theory

Weed biology and ecology, crop-weed competition including allelopathy; principles and methods of weed control and classification.

Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides. Herbicide structure-activity relationship, factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, weed control through bio herbicides myco-herbicides and allelochemicals; Degradation of herbicides in soil and plants; herbicide resistance in weeds and crops and its management, herbicide rotation.

Weed management in major crops and cropping systems; parasitic weeds, weed shifts in cropping systems; aquatic and perennial weed control. Integrated weed management, cost benefit analysis of weed management.

Practical

- Identification of important weeds and weed seeds.
- Preparation of a weed herbarium.
- Weed survey in crops and cropping systems.
- Crop-weed competition studies.
- Preparation of spray solutions of herbicides for high and low-volume sprayers.
- Use of various types of spray pumps and nozzles and calculation of swath width.
- Economics of weed control.
- Herbicide residue analysis in plant and soil.
- Calculation of herbicidal requirement and diagnosis of herbicide injury.
General principles of seed production and certification. Problems of seed production in India with special reference to forage crops. Seed production techniques and agronomical practices of important cereals, pulses, and forage crops. Seed industry in the country and role of various agencies, seed morphology, seed multiplication chain, seed purity, seed health, dormancy, seed vigor, hybrid seed production, seed treatment, seed viability, seed quality, physiology of seed germination, seed testing for germination and seedling evaluation, seed certification, processing, grading and storage, distribution and marketing, storage grain pests.

Practical

Seed sampling and evaluation of seed quality on the basis of purity and germination rouging, detaseling, inspection.
Familiarization with seed processing equipments and materials
Precautions for seed storage
Comparison of farmer’s saved seed with certified seed.
Sowing and maintenance of seed production fields of important crops.
Visits to commercial seed production fields, seed processing plants and sale counters of seed agencies.
Theory

Importance of agrostalogy, principles of grassland ecology;
grassland ecology-community, climax, dominant species, succession, biotype,
etiological status of grasslands in India, grass cover of India, economic aspects of grasslands,
their problems and management. Improvement of grasslands.

Importance, classification, scope, status and research needs of pastures;
pasture establishment, management, improvement, renovation and utilization of natural pastures; cultivated pastures.

Development and management of range lands and grasslands, systems of grazing. Suitable grass legume mixtures. Cultivation of important grasses and legumes under irrigated, rainfed and hilly areas. Role of grasses in improvement of soil fertility; Silvi-pasture system and its scope in India. Grazing management. Nutrient management. Importance of agroforestry; agroforestry systems- agrisilviculture, silvipasture, agrisilvipasture, agrihorticulture; alley cropping.

Practical

- Preparation of charts and maps of India showing different types of pastures and agroforestry systems.
- Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to silvi-pasture system.
- Seed treatment for better germination.
- Methods of propagation/planting of grasses and trees in silvipastoral system.
- Fertilizer application in strip and silvipastroal systems.
- Estimation of protein content in loppings of important fodder trees.
- Visit to Indian Grassland and Fodder Research Institute, Jhansi and Palampur.

Basic concept and principles of crop ecology, agricultural systems, ecology of cropping systems, principles of plant distribution and adaptation, crop and world food supply; physiological limits of crop yield and variability in relation to the ecological optimum; Ecosystem characteristics, types and functions, terrestrial ecology, flow of energy in ecosystem, ecosystem productivity, biomass, succession and climax concept. Physiological response of crop plants to light, temperature, CO2, moisture and solar radiation; influence of climate on photosynthesis and productivity of crops; effect of global climate change on crop production.

Exploitation of solar energy in crops; vertical distribution of temperature; efficiency in crop production. Competition in crop plants; environmental pollution, ecological basis of environmental management and environment manipulation through agronomic practices.
**FORAGE RESEARCH AND MANAGEMENT CENTRE**
**NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL**
**Ph. D. AGRONOMY (FORAGE PRODUCTION)**

Major Field: Agronomy (19 Credits)
Minor Field: Animal nutrition (09 Credits)
Supporting Field: (03 Credits)
Seminar: (02 Credits)
Thesis: (45 Credits)
**Total (Minimum) (75 Credits)**

**Semester-wise Distribution of Courses**

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<tr>
<th>Course No.</th>
<th>Name of the Courses</th>
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<tbody>
<tr>
<td>FP 711</td>
<td>Modern Concepts in Agronomy *</td>
<td>3</td>
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<tr>
<td>FP 712</td>
<td>Advances in weed management</td>
<td>3</td>
<td>0</td>
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<tr>
<td>FP 713</td>
<td>Recent Trends in fodder and pasture crops production*</td>
<td>2</td>
<td>1</td>
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<td></td>
<td>Soil fertility and Nutrient management</td>
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<tr>
<td>FP 715</td>
<td>Experimental techniques in Agronomy*</td>
<td>2</td>
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<tr>
<td>FP 721</td>
<td>Principles and Practices of Organic Farming</td>
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<tr>
<td>FP 722</td>
<td>Recent Concept of water management</td>
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<tr>
<td>FP 723</td>
<td>Advances in Seed production and management</td>
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<tr>
<td>FP 724</td>
<td>Agrostology and Agroforestry</td>
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<tr>
<td>FP 725</td>
<td>Crop Ecology and Climate Change</td>
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<tr>
<td>FP 726</td>
<td>Farming Systems</td>
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**III-VI Semester**
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<tr>
<td>FP 731</td>
<td>Seminar</td>
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<tr>
<td>FP 732</td>
<td>Research</td>
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*Core courses for Ph.D.*
Objective:
To acquaint the students about the recent developments in agronomy and resource management.

Theory:

UNIT I
Environmental concerns related to intensive use of agricultural inputs. Sustainable agriculture - need, scope, practices and economic evaluation, holistic approach of farming systems. Agro-physiological basis of variation in yield, role of agro-biodiversity in sustainable food production, GM crops, crop diversification for improved food and nutritional security.

UNIT II
Conservation agriculture, modern approaches for improving resource-use efficiency, crop residue management in multiple cropping systems. Principles and practices of conservation tillage and watershed management, carbon sequestration.

UNIT III
Precision farming - current status and opportunities for adoption in India. GIS, GPS and remote sensing for crop management, global warming.

UNIT IV
Contract farming - concept, scope, partnerships, types, characteristics, management and administration, problems and advantages for farmers/ sponsors, WTO issues in agriculture.

UNIT V
Crop modeling, systems classification; flow charts, modeling techniques and methods of integration - state, rates and driving variables, feedbacks and relational diagrams information technology, elementary models for crop growth based on basic methods of classical growth analysis.

UNIT VI
Protected agriculture - concept, characteristics, types, scope and limitations in India. Plant nutrition - challenges and tasks ahead. Stress crop production.

Suggested Readings:
AGRON 712: ADVANCES IN WEED MANAGEMENT 3(3+0) SEM - I

Objective: To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Theory
UNIT-I: Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects.
UNIT-II: Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.
UNIT-III: Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, residue management of herbicides, adjuvants.
UNIT-IV: Advances in herbicide application techniques; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides.
UNIT-V: Development of transgenic herbicide resistant crops; herbicide development, registration procedures.
UNIT-VI: Relationship of herbicides with tillage, fertilizer and irrigation; bioherbicides, allelochemical herbicide bioassays.

Suggested Readings
FP 713: RECENT TRENDS IN FODDER AND PASTURE CROP PRODUCTION 3(2+1) SEM-I

Objective:
To teach the crop husbandry, conservation and utilization of different fodder crops, pastures and tree-forage crop-based systems

Theory:

UNIT I: Introduction, origin, history, distribution, adaptation, classification, climate, soil, varieties, water, weed management and nutrient requirement of important cultivated fodder crops like maize, pearl millet, teosinte, cluster bean, cowpea, oats, barley, berseem, senji, lucerne etc.

UNIT II: Introduction, origin, history, distribution, adaptation, classification, climate, soil, varieties, water, weed management and nutrient requirement of important forage crops/ grasses/ legumes, like, napier and hybrid napier grass, guinea grass, Lasiurus, buffel grass, stylo, suitable weed flora for fodder etc.

UNIT III: Anti-quality factors of important fodder crops, forage grasses and legumes. Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder.

UNIT IV: Natural grasslands of India. Establishment of pastures and their management with special reference to weed control and fertilization including micronutrients important to animals, defoliation and its effects, regeneration of infested pastures.

UNIT V: Wasteland development - selection of species, planting methods and problems of seed germination in agro-forestry systems. Lopping and coppicing in agro-forestry systems.

Practicals:
- Practical training of farm operations in raising fodder crops, canopy measurement.
- Yield and quality estimation, viz. crude protein, NDF, ADF, lignin, silica, cellulose etc. of various fodder and forage crops.
- Anti-quality components like HCN in sorghum and such factors in other crops.
- Hay and silage making
- Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry.
- Methods of propagation/planting of grasses, trees in silvipastoral system.
- Fertilizer application in strip and silvi-pastoral systems.
- Visit to IGFRI / NRCAF, Jhansi.

Suggested Readings:
FP 714: SOIL FERTILITY AND NUTRIENT MANAGEMENT 3(2+1) SEM - I

Objective: To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory
UNIT-I: Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.
UNIT-II: Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.
UNIT-III: Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management.
UNIT-IV: Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency, fertilizer mixtures and grades; agronomic, chemical and physiological methods of increasing fertilizer use efficiency; nutrient interactions.
UNIT-V: Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic manures; economics of fertilizer use; integrated nutrient management; use of vermin compost and residue wastes in crops.

Practicals
- Determination of total N, P, K and S in plants
- Interpretation of interaction effects and computation of economic and yield optima

Suggested Readings
Objective: To teaching methodology of planning, layout, data recording, analysis, interpretation and report writing of agronomic experiments

Theory:
UNIT I-Historical aspects of field experimentation, principles and practices of field experimentation
UNIT II-Identification of research problem and preparation of research project proposal. Presentation of data and report writing.
UNIT III-Planning of experiments, recording of data - before layout of experiment, during crop growth and after harvest. Selection of experimental design, layout of experiment, number of treatments / replications, plot size, border effect etc. Techniques for increasing the precision for an experiment.
UNIT III-Interpretation of data from weed control, irrigation, fertilizer and cropping system experiments. Interactions in factorial experiments.
UNIT IV-Contrast analysis, pooled analysis, data transformation. Evaluation of direct, residual and cumulative effects of treatments
UNIT V-Correlation and regression analysis, and their application. Energetics and economic analysis.
UNIT VI-Analysis of data of typical agronomic experiments. Nutrient and water balance sheets. Statistical softwares and their application.

Practicals:
- Practical considerations in field experimentation.
- Overview of softwares in agricultural research and analysis of data.
- Analysis of data of field experiments and Use of excel in data analysis.
- Statistical analysis of data using MSTATC.
- Calculation and interpretations of interactions of factorial experiments.
- Calculation of direct, residual and cumulative effects of treatments in cropping systems.
- Exercise on confounding designs.
- Exercise on data transformation.
- Exercise on missing plot analysis.
- Exercise on pooled analysis of data over years/locations.
- Exercise on linear regression equation.
- Exercise on quadratic regression equation.
- Economic analysis of field crop production.
- Exercise on determination of optimum economic dose of fertilizers.

Suggested Readings:
FP 721: PRINCIPLES AND PRACTICES OF ORGANIC FARMING 3(2+1)  SEM-II

Objective: To teach the principles and practices of organic farming for sustainable crop production.

Theory:

UNIT I: Definition, concepts, history and importance of organic farming; organic production scenario in the world, relevance and scope in India, principles, myths and constraints. Limitations of organic farming.


UNIT III: Package of practices for organic crop production – farm designing, crop planning, site selection, conversion period, conservation tillage, selection of seed / seedlings, availability and use of organic inputs, viz. vermicompost, biofertilizers, compost, green manures for crop nutrition, water and weed management, crop protection, harvesting and post harvesting processing / care.

UNIT IV: Production technology and availability of different organic inputs, viz. vermicompost, biofertilizers, improved compost, green manure, bio-pesticides and plant products, crop-specific package of practices for organic production of different food, vegetable and flower crops.

UNIT V: Changes in physical, microbiological and chemical properties of soil. Evaluation of soil and produce quality. Certification of organic produce and process, certification agencies, group certification, marketing, success stories, potential organic production areas/ crops of India.

Practicals:

- Technique of bio fertilizers application and their response in crops.
- Technique of bio-pesticide and pheromones application and their response in crops.
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms.
- Techniques of growing green manure crops.
- Visit to National Centre for Organic Farming (NCOF).
- Visit to blue-green algae centre of IARI, vermin-compost and bio-fertilizers production unit.
- Visit to bio-pesticide production units, Centre for Protected Crop Production, organic crop production farm.

Suggested Readings:


**FP 722: RECENT CONCEPTS OF WATER MANAGEMENT 3(2+1) SEM-II**

**Objective:** To teach the basic principles of water management and practices to enhance water productivity

**Theory:**

**UNIT I:** Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states. Soil-plant-atmosphere continuum, soil water movement in soil and plants, transpiration, soil-water-plant relationships, water absorption by plants, plant response to water stress, crop plant adaptation to moisture stress condition.

**UNIT II:** Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation; micro-irrigation system; fertigation; management of water in controlled environments and polyhouses

**UNIT III:** Water management of crops and cropping systems, management of soil moisture stress and plant growth, strategies of using limited water supply, quality of irrigation water and management of saline water for irrigation, water-use efficiency.

**UNIT IV:** Water stress – deficit and excess, its effect on growth and development, water stress injury and resistance, management of water stress through soil and crop manipulations, excess of soil water and plant growth; water management in problem soils

**UNIT V:** Drainage - concept and classification. Field drainage systems with special emphasis on crop production and soil salinity. Inter-relationship of drainage with cropping patterns and types of farming. Drainage requirement of crops and methods of field drainage, their layout and spacing

**UNIT VI:** Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer’s participation in command areas; irrigation legislation.

**Practicals:**

- Measurement of soil water potential by using tensiometer, and pressure plate and membrane apparatus.
- Preparation of soil-moisture characteristics curves.
- Water flow measurements using different devices.
- Determination of irrigation requirement and irrigation efficiency.
- Determination of infiltration rate, saturated/unsaturated hydraulic conductivity.
- Estimation of drain spacing under surface and sub-surface method.
- Soil moisture constants and measurement.
- Measurement of evapo-transpiration and water requirement of crops.
- Water management experiments – planning, conduct, recording of data and interpretation

**Suggested Readings:**


**FP 723: ADVANCES IN SEED PRODUCTION AND MANAGEMENT 3(2+1) SEM-II**

**Objective:** To teach the basic principles of seed production

**Theory**
- UNIT-I General principles of seed production.
- UNIT-II Problems of seed production in India with special reference to forage crops, grasses and fodder trees.
- UNIT-III Seed production techniques and agronomical practices of important forage crops, grasses and fodder trees including GM crops.
- UNIT-IV Seed industry in the country and role of various agencies, seed morphology, seed multiplication chain, seed purity, seed health, dormancy, seed vigor, hybrid seed production, seed treatment, seed viability, seed quality, physiology of seed germination, seed testing for germination and seedling evaluation,
- UNIT-V Seed certification, processing, grading and storage, distribution and marketing and management of storage grain, control of storage grain pests.

**Practicals**
- Seed sampling and evaluation of seed quality on the basis of purity and germination, rouging, detaseling, inspection.
- Familiarization with seed processing equipments and materials
- Precautions for seed storage
- Comparison of farmer’s saved seed with certified seed.
- Sowing and maintenance of seed production fields of important crops.
- Visits to commercial seed production fields, seed processing plants and sale counters of seed agencies.
Objective: To teach crop husbandry of different forage, fodder and agroforestry crops/trees along with their processing.

Theory
UNIT-I: Agrostology: definition and importance; principles of grassland ecology: grassland ecology – community, climax, dominant species, succession, biotype, ecological status of grasslands in India, grass cover of India; problems and management of grasslands.

UNIT-II: Importance, classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses.

UNIT-III: Agroforestry: definition and importance; agroforestory systems, agrisilviculture, silvipasture, agrisilvipasture, agrihorticulture, aquasilviculture, alley cropping and energy plantation.

UNIT-IV: Crop production technology in agro-forestory and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation and manuring in agro-forestry systems, lopping and coppicing in agro-forestry systems, nutritive value of trees; tender operation; desirable tree characteristics.

Practicals
- Preparation of charts and maps of India showing different types of pastures and agroforestry systems
- Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry
- Seed treatment for better germination
- Methods of propagation/planting of grasses and trees in silvipastoral system
- Fertilizer application in strip and silvipastroal systems
- After-care of plantation
- Estimation of protein content in loppings of important fodder trees
- Economics of agro-forestry
- Visit to important agro-forestry research stations

Suggested Readings


Objective: To acquaint the students about the agricultural systems, agro-ecological regions, and adaptation of crops to different agro-climatic conditions.

Theory
UNIT-I: Concept of crop ecology, agricultural systems, ecology of cropping systems, principles of plant distribution and adaptation, crop and world food supply.
UNIT-II: Ecosystem characteristics, types and functions, terrestrial ecology, flow of energy in ecosystem, ecosystem productivity, biomass, succession and climax concept.
UNIT-III: Physiological response of crop plants to light, temperature, CO2, moisture and solar radiation; influence of climate on photosynthesis and productivity of crops.
UNIT-IV: Exploitation of solar energy in crops; vertical distribution of temperature; efficiency in crop production.
UNIT-V: Competition in crop plants; environmental pollution, ecological basis of environmental management and environment manipulation through agronomic practices; improvement of unproductive lands through crop selection and management.
UNIT-VI: Effect of global climate change on crop production and climate resilient forage production.

Suggested Readings
Objective:
To appraise about cropping and farming systems, types of integrated farming systems under different agro-ecosystems, farming systems research and optimization methodologies.

Theory:
UNIT I - Cropping systems – definition, indices, production potential, resource management in cropping systems, production potential under monoculture, multiple cropping, alley cropping, intercropping, multi-storeyed cropping. Yield advantages in intercropping systems.
UNIT II - Farming systems - definition and importance; classification of farming systems, characteristics, objectives and principles. Concept of sustainability in farming systems; efficient farming systems; natural resources identification and management.
UNIT III - Production potential of different components of farming systems. Cropping systems: as an important component of FS, remunerative cropping systems, crop diversification.
UNIT IV - Integrated farming systems for different agro-ecosystems, interactions and resource recycling among different enterprises.
UNIT V - Farming system research methodologies: on-farm research, on-station research and system modeling. Preparation of different farming system models; evaluation of different farming systems. case studies on different farming systems. Multi-criteria decision making and optimization methodologies for designing integrated farming systems.

Practicals:
- Indices for assessing cropping system efficiency.
- Measurement of competition effects in intercropping systems.
- Farming system analysis: Participatory Rural Appraisal, Rapid Rural Appraisal, diagnostic survey.
- Farming system analysis: Interaction with farmers, problem identification, and prioritization and development projects/interventions for solutions to the identified problems.
- Use of optimization software for developing models, formation of matrix and drawing of different scenarios,
- Handling single objective LP model, Handling multi-objective LP model and analysis of data for risk analysis, resource allocation and enterprise selection decisions.
- Visit to apiary, vermin-compost, mushroom production and biogas production unit, integrated farming systems

Suggested Readings:
FORAGE RESEARCH AND MANAGEMENT CENTRE
NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL
Ph. D. AGRONOMY (FORAGE PRODUCTION)

Major Field: Agronomy (19 Credits)
Minor Field: Animal nutrition (09 Credits)
Supporting Field: (03 Credits)
Seminar: (02 Credits)
Thesis: (45 Credits)
Total (Minimum) (75 Credits)

Semester-wise Distribution of Courses

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*Core courses for Ph.D.