Revised PG Syllabus introduced from 2009

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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<tbody>
<tr>
<td></td>
<td></td>
<td><strong>1st Semester</strong></td>
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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>
<td>2+1</td>
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<td>3</td>
<td>DM-613</td>
<td>Microbiology of Fluid Milk and Dairy Products</td>
<td>2+1</td>
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<td>4</td>
<td>DM 614</td>
<td>Environmental Microbiology &amp; Pollution Control</td>
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<tr>
<td>5</td>
<td>DM 615</td>
<td>Microbiology of Processed Dairy Foods</td>
<td>3+1</td>
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<td>6</td>
<td>DM 616</td>
<td>Analytical Techniques in Microbiology</td>
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<td><strong>2nd semester</strong></td>
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<td>7</td>
<td>DM 621</td>
<td>Starter Cultures and genetic improvement</td>
<td>2+1</td>
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<td>8</td>
<td>DM 622</td>
<td>Microbial Genetics</td>
<td>2+1</td>
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<td>9</td>
<td>DM 623</td>
<td>Microbial Quality Assurance</td>
<td>2+1</td>
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<td>10</td>
<td>DM-624</td>
<td>Probiotics for Health Foods</td>
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<td>11.</td>
<td>DM-625</td>
<td>Research Techniques in Dairy Microbiology</td>
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<td>DM 629</td>
<td>Masters’ Credit Seminar</td>
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<td>1</td>
<td>DM 711</td>
<td>Microbial Diversity and Physiology</td>
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<td>DM 712</td>
<td>Advances in Microbial Genetics</td>
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<td>4</td>
<td>DM 721</td>
<td>Advances in Dairy and Food Microbiology</td>
<td>3+0</td>
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<tr>
<td>5</td>
<td>DM 722</td>
<td>Mechanisms of Microbial Pathogenesis</td>
<td>3+0</td>
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<td>6</td>
<td>DM 729</td>
<td>Doctoral Credit Seminar II</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)
DM-624
DM-611 Microbial Morphology and Taxonomy (2+1)

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

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.
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, mesophillic, 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

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

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

Suggested Readings:

TEXT BOOKS:


LIST OF JOURNALS
1. International Dairy Federation Bulletin
2. International Dairy Journal
3. Journal of Dairy Research
4. Indian Journal of Dairy Science
5. Indian Dairyman
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); Microbiially 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
2. Estimation of micro-flora (i.e. total bacteria, coliforms, yeasts and moulds etc) of selected environmental samples from water 2
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
DM-615 Microbiology of Processed Dairy Foods

2+1

Objective

To understand microbiology of processed foods, significance of different food microorganisms, their control and other related aspects.

Theory:

Unit I

Developments in food microbiology, microbial ecology of processed food; factors that influence microbes in foods.

Unit II

Thermal processes for shelf stable-products, low temperature food preservation, current concepts in irradiation technology; Biopreservation.

Unit III

Stress induced injury to microorganisms, enumerations of stressed cells, predictive modeling for food spoilage; industrial strategies for ensuring safe foods.

Unit IV

New methods for controlling spoilage of foods; active packaging and antimicrobial packaging (AMP), modified atmosphere packaging (MAP) and shelf life of processed foods, Intermediate moisture foods and Hurdle concept.

Unit V

New prospects and problem in fermented foods, Nutraceuticals and Bioactive foods, Genetically Modified (GM) foods and their acceptance.

Practical:

- Productions of antimicrobial substances.
- Application of bacteriocins, Biopreservation of foods
- Application of hurdle concepts for enhanced shelf stability of processed foods
- Induction of bacterial cell injury and recovery of injured cells
- Effect of MAP on quality and shelf life of processed foods.

Suggested Readings

- 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
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-621 Starter Cultures, Probiotics and Fermented Dairy Products  (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 character1stics of phages associated with starters, phage control during starter handling and growth, mechanisms of phage res1stance 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**

• Wood, B.J.; Warner, Philip J. (Eds.). 2003. Genetics of Lactic Acid Bacteria. Springer

**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:
• Internet resources
DM 623  Microbiological Quality Assurance in Dairy Industry  (2+1)
(Revised in 29th AC)

Objectives:

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

Theory

Unit I

**Importance of Microbiological Quality and Safety Assurance System in Dairy Industry:** Principles of Quality and Safety Management Systems; Process approach based QMS (ISO-9001) and applications of HACCP system in dairy industry; TQM tools and techniques including Six sigma, 5S principle, kaizen; Plant hygiene and sanitation in dairy industry.

Unit II

**General principles for the establishment and application of microbiological criteria for dairy foods:** Definition, purpose and components of Microbiological criteria; Mandatory and advisory criteria; Sampling methods; Two and three class attributes for sampling plan (ICMSF); Establishment of microbiological standards, guidelines and specifications for different milk and milk products recommended by ICMSF, Codex, PFA, BIS.

Unit III

**Enumeration and detection of indicator organisms and dairy pathogens:** Indicator Organisms; Selection criteria for their use as quality and safety indicators; Conventional and rapid detection methods including commercial detection kits for indicator organisms and pathogenic bacteria in milk and milk products.

Unit IV

**Microbial bio-sensor for monitoring pathogens and non-microbial contaminants in dairy foods:** Definition, history, basic characteristics, classification and components of microbial bio-sensors; Detector system i.e. Electrochemical; Optical; Mechanical devices; Application of microbial bio-sensor in monitoring pathogenic bacteria, antibiotic residues and aflatoxin M1 in milk and milk products.

Unit V

**Establishment and accreditation of QA Lab in dairy processing unit:** Introductory information on Quality assurance lab in dairy processing unit; Bio-safety definition, principles and safety levels; Standard microbiological practices, safety equipment (primary barrier), facility design (secondary barrier), medical surveillance criteria and biological waste disposal; FDA requirements for establishing biosafety laboratory in dairy industry and its accreditation as per ISO.

**PRACTICAL**
2. Bacteriological analysis of dairy water for Aerobic plate counts and Coliform counts (MPN).
4. Detection of antibiotic residues, aflatoxin M1 in milk using biosensor based micro-techniques.
7. Evaluation of common sanitizing agents in dairy plant by capacity and suspension test.
8. Microbiological tests for assessing equipments and personnel hygiene by rinse and swab techniques.

**SUGGESTED READINGS**

1. Adams MR and Moss MO 2008 Food Microbiology. 3rd Ed. RSC Publisher, Cambridge, UK.
3. JM Jay, Martin JL and David AG 2005 Modern Food Microbiology. 7th Ed. Food Sciences Text Series, New York, USA
11. Yadav JS, Batish VK and Grover S 1993 Comprehensive Dairy Microbiology. Metropolitan Publisher, Delhi, India.

**LIST OF JOURNALS**

1. International Journal of Food Microbiology
2. Food Microbiology and Food Safety Journals
3. Journal of Food safety
4. Journal of rapid methods and automation in Microbiology
5. Journal – Microbial food safety standards.
**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 health 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, Oligosachharides, 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 (2+1)

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

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 I

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
Old syllabus from 2009

DM-614: Environmental Microbiology and Pollution Control (2+1)

Objective
To understand the fundamentals of environmental microbiology for overall effects of microorganisms in combating the pollution in the environment.

Theory
Unit I
Microorganisms as components of the environment and their role in nutrient cycling; extreme environments and microbial ecology.

Unit II
Microbes in aquatic and terrestrial environment; aero-microbiology; microorganisms as indicators of environment pollution; bio-organic pollution.

Unit III
Microbial toxicants and pollutants and their biodegradation; organic pollutants and their degradation; biodegradation of plastics and polymers.

Unit IV
Biofouling and biofilms; bioremediation and metabolic engineering; water pollution and control.

Unit V
Biological treatments of food industry wastes; Issues concerning release of genetically engineered microorganisms in environment; environment laws.

Practical
Determination of BOD in industrial wastes; Determination of composite micro-flora of selected environmental samples; Detection of low levels of xenobiotics, microbial toxins and residual antibiotics in environmental samples; Isolation of bacteria capable of degrading organic and microbial pollutants from environmental samples; Isolation and characterization of bio-indicators from environmental samples; Visit to a sewage and sludge treatment plant.

Suggested Readings
- Maier RM, Pepper IL and Gerba CP 2000 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
Ecotoxicology and Environmental Safety
Environmental Microbiology
Environment International
Environmental Monitoring and Assessment
Environmental Research
Environmental Science and Pollution Research
International Journal of Environment and Pollution
Science of the Total Environment

Broad Topics for Master's and Doctoral Research
- Role of extremophiles in microbial ecology and industry.
- Air micro-flora as spoilage and infectious agents in dairy industry.
- Microorganisms as indicators of environment pollution.
- Bio-organic pollution and its control measures.
- Biodegradation of pollutants and packaging of food materials in the environment.
- Biofilms in dairy industry.
- Bioremediation of food industry wastes and metabolic engineering.
Objective
To understand the fundamentals of structure, functions and synthesis of macromolecules and their genetic manipulation.

Theory
Unit I
Macromolecules: DNA, RNA, their structure, types, organization, function and their properties, DNA replication, damage and repair.

Unit II
Gene Expression and its regulation in Prokaryotes and Eukaryotes: Transcription; Genetic Code Translation and post translational modifications; Negative and positive regulation of gene expression; Operon Models (lac and trp operon)

Unit III
Mutagenesis, mutation and mutants; Lamda phage and its gene organization

Unit IV
Plasmids and their properties, transposable elements; Bacterial Recombination-Transformation, Conjugation and Transduction

Unit V
Fundamental aspects of genetic engineering - Vectors, Resriction enzymes, gene cloning, gene banks, expression of cloned genes. Applications of Genetic Engineering-Restricition Mapping, site directed mutagenesis, polymerase chain reaction and application of genetic engineering in dairy and food industry

Practical
- Isolation and quantitative estimation of chromosomal DNA from E.coli and Lactobacillus by mini prep method.
- Isolation of plasmid DNA from E.coli and Lactobacillus by miniprep method.
- Isolation of Eukaryotic (yeast) chromosomal DNA
- Calcium chloride induced transformation of E.coli hosts with plasmids
- Induction of random mutation in E.coli and Lactobacillus by UV radiations and chemical mutagens
- Curing of plasmids with chemical mutagens (Ethidium Bromide) and elevated temperature
- Preparation of chloroplast and their regeneration and uptake in bacteria
- Use of restriction enzymes cleavage and ligation of DNA fragments
- P.C.R. amplification demonstration

Suggested Readings:
- Molecular Biology of Genes, J.D. Watson (2003), Publisher- W.A. Benjamin Inc. California
- Gene Expression Volume I and II,B. Lewin (1980), Publisher- John Wiley and Sons New York
• Molecular Genetics of Bacteria 2003, Synder, Lassy and Champness W., ASM Pub. Washington D.C
• DNA Repair and Mutagenesis (1995), Friedberg E.C and Walker G.C., Jones and Bartlett Pub. Massachusetts U.S.A.
• Microbial Genetics (1987) Friefelder D., Jones and Bartlett Pub. Massachusetts U.S.A
• Modern Microbial Genetics (2004), Uldis N. Streips, Ronald E. Yasbin (Editor); John Wiley and Sons.

List of Journals
• Molecular and Cellular Biology
• Applied Microbiology and Biotechnology
• International Journal of General and Molecular Microbiology
• Microbiological Research
• Nature
• Science
• Microbiology and Molecular Biology Reviews
• Current Genetics
• Journal in Genetics and Genomics
• Molecular Genetics, Microbiology , virology
• Molecular Biology

Broad Topics for Master’s and Doctoral Research
• Study of Plasmid linked properties of dairy cultures.
• Transformation of gene of interest in the bacterial hosts
• PCR based identification of pathogens.
• PCR based identification of dairy cultures and probiotic cultures
• Genetic modification of dairy cultures by rDNA technology.
DM – 623 Microbial Quality Assurance

Objective

To impart current knowledge pertaining to quality and safety functions in dairy processing unit

Theory

Unit I

Principles of Quality and safety systems including QMS, HACCP, SAFE, GMP, SSOP, personnel hygiene and food handling in dairy industry

Unit II

Establishment of Microbiological standards, guidelines and specification for foods; microbiological criteria; two and three class attributes plan for sampling

Unit III

Rapid detection methods including commercial detection kits; automatic detection techniques for hygiene indicators, pathogenic organisms, antibiotic/pesticide residues and aflatoxin M1 in dairy foods

Unit IV

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

Unit V

Trends in food borne diseases and implications; method of diseases transmission; principles of safety in a food microbiological laboratory

Practical

Conventional and rapid techniques for Microbiological quality evaluation of raw and pasteurized milk and other dairy products for hygiene indicators i.e. aerobic plate count, Staph aureus, coliform, enterococci, enterobacteriaceae counts, yeast and molds count; detection of common dairy pathogens and other contaminants from milk and milk products i.e E. coli, B. cereus, salmonella, Listeria, antibiotic residues and aflatoxin M1; shelf life studies of dairy products; effect of storage condition and packaging material on microflora of dairy foods.

Suggested Readings

• Rapid Analysis Techniques In Food Microbiology. Blackie Academic And Professional, London, UK.


List of Journals

• International Journal of Food Microbiology
• Food Microbiology and food safety journals
• Journal of Food safety
• Journal of rapid methods and automation in Microbiology
• Journal – Microbial food safety standards.
• Symposium on Microbiological food safety management 2007

Broad Topics for Master's and Doctoral Research

• Principles of food safety control programme on HACCP, standard sanitary operating procedures (SSOP) and GMP for dairy industry
• A process approach to quality management system
• Definitions, purpose and need for microbiological criteria. General principles for the establishment and application of microbiological criteria for foods. Consideration of sampling associated with a criterion
• Detection and enumeration of indicator organisms in dairy foods
• Detection and enumeration of conventional and emerging pathogenic organisms and other contaminants in dairy foods
• Principles Of Bio-Safety In Establishment Of Pathogen Testing Laboratory In Food Industry
• Trends in food borne diseases and implications; method of diseases transmission; principles of safety in a food microbiological laboratory
DM-722 Mechanisms of Microbial Pathogenesis (3 +0)

Objective

Upon satisfactory completion of this course, students should have developed knowledge, understanding and application of Foodborne pathogens at an advanced level.

Theory:

Unit I

Foodborne Pathogens: Host Invasion; Pathogenesis; Molecular approaches for detection, identification, typing and analysis of foodborne pathogens; Biosensor –based detection of foodborne pathogens.

Unit II

Staphylococcal Gastroenteritis: Incidence in Foods, Staphylococcal Enterotoxins: Types and Incidence, The Gastroenteritis Syndrome, Prevention of Staphylococcal and Other Food-Poisoning Syndromes

Unit III

Botulism: Analysis of Dairy Products for C. botulinum and Botulinal Toxin, Clinical Manifestations, Outbreaks, Prevention; Bacillus Cereus food poisoning: Analysis of Dairy Products for B. cereus and Toxin, clinical manifestation, outbreaks, prevention.

Unit IV


Unit V


Suggested Reading:


• Foodborne Microorganisms of Public Health Significance, 6th Ed, A.D. Hocking et al. eds), AIFST (NSW Branch) Food Microbiology Group, Sydney, 2003
• Guide to Foodborne Pathogens, Edited by Ronald G. labbe and Santos Garcia, John Wiley and Sons (2001)

List of Journals
• International Journal of Food Microbiology
• FEMS Microbiology Reviews
• Food Microbiology
• FEMS Microbiology Letters
• Microbial Pathogenesis
• Microbial Ecology in Health and Disease
• Foodborne Pathogens and Disease

Broad Topics for Master’s and Doctoral Research
• Emerging Foodborne pathogens
• Rapid methods for detection and identification of pathogens in milk and milk products.
• Resistance of Foodborne pathogens to emerging food processing technologies.

Molecular techniques for detection of Foodborne pathogens and their toxin