NEW AND RESTRUCTURED
POST-GRADUATE CURRICULA & SYLLABI

Dairy Science & Technology
- Dairy Technology
- Dairy Microbiology
- Dairy Chemistry
- Dairy Engineering

Education Division
Indian Council of Agricultural Research
New Delhi

April 2009
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EXECUTIVE SUMMARY

The salient features of these new syllabi of the four major Dairy Processing disciplines of Dairy Chemistry, Dairy Engineering, Dairy Microbiology and Dairy Technology developed by the Broad Subject Matter Area Committee on Dairy Science & Technology are summarized hereunder.

Dairy Technology

- A new course introduced on “Traditional and value-added dairy products” thereby elevating the traditional dairy products to the PG programs.


- The doctoral-level course “Product-Process Monitoring” has been revamped with respect to the title and contents. This “Product monitoring & process control” course gives an insight into the novel analytical and processing dimensions of the modern food industry.

- The new courses introduced at master’s level will require additional infrastructure in terms of equipment for conducting the practical classes, without which it will end up being the same as it was under the old syllabus.

- Also, HRD training in the areas of new technologies and new instrumental techniques will be indispensable in implementation of the new curricula.

Dairy Microbiology

- Biotechnological applications in dairy processing with special reference to molecular biology particularly focused in the revised courses.

- ‘Microbial diversity and physiology” and “Advanced microbial genetics” are the re-designed courses meant to address the recent development in the rapidly advancing field.

- Food-borne pathogens and Microbial quality & safety aspects are the re-structured courses to take care of the emerging needs of the dairy & food industries.

- New biotechnological tools being essential in implementing the new syllabi, substantial, additional funds will have to be made available.

Dairy Chemistry

- Recent advances in the area of chemistry of milk constituents have been incorporated in the revised syllabi.
• Bioactive role of milk constituents in relation to dairy ingredients in health foods has been the stressed in the new curricula.

• New analytical techniques, particularly rapid test kits and bio-sensors are among the salient novel topics introduced in the syllabus.

• In order to effectively put the new curricula in teaching practice both the increased HRD and financial/infrastructural support requirement will become unavoidable.

**Dairy Engineering**

• While all the courses have been extensively revised to include recent developments, “Bio-thermal process engineering” represents a re-look at the emerging processing needs of the dairy and food industries.

• Simulation in Dairy and Food Engineering addresses the fast developing areas in the wake of the progress being made in the Computing Science.

• Newer developments in the area of electronics as applied to industrial instrumentation are crucial to the all-important process control, and this has been appropriately covered in the revised course contents.

• The Instrumental experiments will necessitate enhanced funds made available for HRD training and procurement of new equipment.
BSMA Committee on Dairy Science & Technology
(Dairy Technology/Dairy Engineering/Dairy Microbiology/Dairy Chemistry)
(Constituted by ICAR vide Office order No. F. No. 13 (1)/2007- EQR
dated January 14, 2008)

<table>
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<tr>
<th>Name &amp; Designation</th>
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<th>Specialization</th>
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<tbody>
<tr>
<td>Dr. G. R. Patil</td>
<td>National Dairy Research Institute, Karnal</td>
<td>Dairy Sciences</td>
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<tr>
<td>Jt. Director (Acad.)</td>
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<tr>
<td>Convener</td>
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<tr>
<td>Dr. G. S. Bhat</td>
<td>Dairy Science College, Karnataka Veterinary, Animal &amp; Fishery Sciences University, Hebbal, Bangalore</td>
<td>Dairy Chemistry</td>
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<td>Dean</td>
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<tr>
<td>Dr. A. K. Misra</td>
<td>Faculty of Dairy Technology, West Bengal University of Animal &amp; Fishery Sciences, Mohanpur</td>
<td>Dairy Microbiology</td>
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<td>Dr. B. P. Shah</td>
<td>Faculty of Dairy Science SMC College of Dairy Science, Anand Agril. Univ., Anand</td>
<td>Dairy Engineering</td>
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<td>Dairy Microbiology</td>
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<td>Prof. &amp; Head</td>
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<tr>
<td>Dr. A.A. Patel</td>
<td>Dairy Technology Division National Dairy Research Institute, Karnal</td>
<td>Dairy Technology</td>
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Member Secretary
PREAMBLE

The concerted efforts made by different dairy development agencies in the country over the past four decades have led India to emerge as the largest milk producing nation in the world. About 14% of nearly 100 million tones of milk produced annually (i.e. approx. 38 million liters of milk everyday) is channelled through the organized dairy sector. Thus, the ever increasing amount of milk handled by the organized sector requires that the industry be continually provided with quality manpower to meet its growing needs. Further, the increasing R & D requirement of the sector places a particular responsibility on the academic institutions involved in manpower development at the post-graduate level.

More and more institutions at national or state levels are offering post-graduate programs on the four major disciplines of Dairy Processing viz., Dairy Technology, Dairy Engineering, Dairy Chemistry and Dairy Microbiology. Therefore, a uniform approach in various aspects of these programs including the syllabi would be highly desirable. Further, since there are continuing developments in the area of Dairy Processing research, it is necessary to update the PG curricula as frequently as necessary. The last revision of the Dairy Processing syllabi at the ICAR level took place about a decade ago. Hence, a relook at the existing syllabi had become due.

The Indian Council of Agricultural Research, therefore, felt it necessary to constitute a National Core Group (NCG) under the chairmanship of Dr. J.C. Katyal, Vice Chancellor, CCSHAU, Hisar with the following objectives:
1. To define names and curricula of Master’s and Ph.D. programmes in different disciplines, and
2. To re-write the syllabi of the PG courses offered in various disciplines.

On the recommendations of the NCG, the Council constituted 18 Broad Subject Matter Area (BSMA) Committees for assisting the Group in restructuring the PG course curricula. The BSMA Committee on Dairy Science & Technology (vide Appendix-I) was constituted to have the nation’s major academic institutions offering PG courses in Dairy Processing well represented.

This committee, like other BSMA committees, was required to fulfill its mandate of re-writing the course curricula in Dairy Chemistry, Dairy Engineering, Dairy Microbiology and Dairy Technology, through interactions at various levels and among different groups including stakeholders. The inputs thus provided by the Committee to the NCG would enable the Group to make appropriate recommendations to the ICAR for a uniform system of PG education in the area of Dairy Processing.

In the process of achieving the NCG’s objectives, a meeting of the Conveners and Member-Secretaries of various BSMA committees was held with Dr. J.C. Katyal in the Chair, on February 14, 2008 in New Delhi, wherein various aspects of restructuring the PG syllabi in different disciplines were discussed in depth and some broad guidelines were developed for all the Committees to follow.

The Committee on DS&T made intense efforts to develop the revised curricula in the four Dairy Processing disciplines. In order to fulfill its mandate the Committee followed the under-mentioned course of action.

A. The Committee members (Convener, a Member and Member-Secretary) at NDRI carried out the following preliminary exercise (January 7-11, 2008):
   1. A preliminary appraisal of the current PG curricula in Dairy Processing disciplines of the NDRI University.
2. Working out of a unified approach with regard to the course structure (broad framework for course classification) and minimum credit hours based on the deliberations that took place in the BSMA meeting held on 18th Nov, 2007.

3. Identified experts (Appendix-II) in the academics and industry who could be invited to give their comments on the subject.

B. The PG curricula were sent to experts in various Dairy processing disciplines for their comments (March, 2008).

C. The syllabi (individual course contents) were also sent to subject matter specialists in Dairy Technology, Dairy Engineering, Dairy Chemistry and Dairy Microbiology together with a copy of a specimen of the revised “Organization of Course contents” for suitable revision. Feedback was received from most respondents following which a 2-day workshop was organized on 21st & 22nd April 2008 which was attended by the Committee members and senior scientists (Appendix-III) in different dairy processing disciplines at NDRI, Karnal.

D. The finalized syllabi were received by the Member-Secretary from the four discipline-Heads and fine-tuned by the Committee members located at Karnal (May-June, 2008).

The recommendations thus emerging from this process were discussed in the meeting of the Member-Secretaries of various BSMA committees held on 12th June 2008 at HAU Hisar. Subsequently, the syllabi were given final shape in meeting of the NCG and the BSMA Conveners and Member-Secretaries held at NASC, New Delhi on June 23-24, 2008.

The restructured curricula have several new features in terms of the organization of course contents as well as the course contents itself. Emphasis has been laid on emerging technologies such as molecular biology applications in dairy processing, new processing technologies e.g., electric pulse treatment, microwave processing, etc. - a new course has been introduced on these topics. Role of milk constituents as ingredients for health and special foods has been focused in view of the recent developments in the fundamental and applied aspects in this area.

It is hoped, when implemented, the revised curricula will prove meaningful in meeting the requirement of the concerned institutions for a uniform pattern of post-graduate teaching and research so that the objective of providing quality manpower for industrial and institutional dairy establishments can be attained. It will certainly help the Dairy Processing academic programs keep abreast of the frontier areas of research the world over.
ORGANIZATION OF COURSE CONTENTS
&
CREDIT REQUIREMENTS

Code Numbers
- All courses are divided into two series: 500-series courses pertain to Master’s level, and 600-series to Doctoral level. A Ph. D. student must take a minimum of two 600-series courses, but may also take 500-series courses if not studied during Master’s programme.
- Credit seminar for Master’s level is designated by code no. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively.
- Similarly, 599 and 699 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>
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<tr>
<th>Subject</th>
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<td>Major</td>
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<tr>
<td>Minor</td>
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<td>08</td>
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<tr>
<td>Supporting</td>
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<td>Seminar</td>
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<td>Research</td>
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<td><strong>Total Credits</strong></td>
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Compulsory Non Credit Courses: See relevant section

**Major subject:** The subject (department) in which the students takes admission

**Minor subject:** The subject closely related to students major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology & Nematology).

**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 501-506) 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.
# DAIRY TECHNOLOGY

## Course Structure - at a Glance

<table>
<thead>
<tr>
<th>CODE</th>
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<tr>
<td><strong>MAJOR COURSES</strong></td>
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<tr>
<td>DT 511*</td>
<td>ADVANCED DAIRY PROCESSING</td>
<td>3+1</td>
</tr>
<tr>
<td>DT 512*</td>
<td>ADVANCED FOOD PROCESSING</td>
<td>3+1</td>
</tr>
<tr>
<td>DT 513</td>
<td>RHEOLOGY OF DAIRY AND FOOD PRODUCTS</td>
<td>2+1</td>
</tr>
<tr>
<td>DT 514*</td>
<td>DAIRY PROCESS BIOTECHNOLOGY</td>
<td>2+1</td>
</tr>
<tr>
<td>DT 515</td>
<td>TRADITIONAL AND VALUE-ADDED DAIRY PRODUCTS</td>
<td>2+1</td>
</tr>
<tr>
<td>DT 521</td>
<td>MEMBRANE TECHNOLOGY IN DAIRY PROCESSING</td>
<td>2+1</td>
</tr>
<tr>
<td>DT 522</td>
<td>ADVANCED DAIRY AND FOOD PACKAGING</td>
<td>2+1</td>
</tr>
<tr>
<td>DT 523</td>
<td>ALTERNATIVE PROCESSES FOR THE DAIRY &amp; FOOD INDUSTRIES</td>
<td>2+1</td>
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<tr>
<td>DT 524*</td>
<td>FUNCTIONAL FOODS AND NEW PRODUCT DEVELOPMENT</td>
<td>3+1</td>
</tr>
<tr>
<td>DT 525</td>
<td>TECHNOLOGY OF FOOD EMULSIONS, FOAMS &amp; GELS</td>
<td>2+1</td>
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<tr>
<td>DT 591</td>
<td>MASTER’S SEMINAR</td>
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<tr>
<td>DT 599</td>
<td>MASTER’S RESEARCH</td>
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<tr>
<td>DT 611</td>
<td>ADVANCES IN LIPID TECHNOLOGY</td>
<td>3+0</td>
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<tr>
<td>DT 612</td>
<td>ADVANCES IN PROTEIN TECHNOLOGY</td>
<td>3+0</td>
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<tr>
<td>DT 621</td>
<td>PRODUCT MONITORING AND PROCESS CONTROL</td>
<td>3+0</td>
</tr>
<tr>
<td>DT 622*</td>
<td>R &amp; D MANAGEMENT IN DAIRY INDUSTRY</td>
<td>3+0</td>
</tr>
<tr>
<td>DT 691</td>
<td>DOCTORAL SEMINAR I</td>
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<tr>
<td>DT 692</td>
<td>DOCTORAL SEMINAR II</td>
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<tr>
<td>DT 699</td>
<td>DOCTORAL RESEARCH</td>
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## SUGGESTED SUPPORTING COURSES

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<tr>
<td>ES 525</td>
<td>DAIRY BUSINESS MANAGEMENT</td>
<td>2+1</td>
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<tr>
<td>ES 529</td>
<td>STATISTICS IN INDUSTRIAL APPLICATIONS</td>
<td>3+1</td>
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<tr>
<td>CS 521</td>
<td>COMPUTER SOFTWARE</td>
<td>2+1</td>
</tr>
<tr>
<td>DCRT 524*</td>
<td>RESEARCH TECHNIQUES</td>
<td>2+1</td>
</tr>
<tr>
<td>DC 523</td>
<td>CHEMICAL QUALITY ASSURANCE</td>
<td>2+1</td>
</tr>
<tr>
<td>DM 523</td>
<td>MICROBIAL QUALITY &amp; SAFETY IN DAIRY INDUSTRY</td>
<td>2+2</td>
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<tr>
<td>DE 524</td>
<td>ENVIRONMENTAL ENGINEERING</td>
<td>2+0</td>
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* Compulsory for Master’s programme; # Cross-listed

**NOTE:** Doctoral students shall take a minimum of two 600-level courses
DAIRY TECHNOLOGY
Course Contents

DT 511 ADVANCED DAIRY PROCESSING 3+1

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

Theory

UNIT I
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 II
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 III
Principles and equipment for bactofugation and Bactotherm processes, Microfluidization of milk: Principle, equipment, effects and applications, Homogenization and their applications in dairy industry.

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

UNIT V
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 VI
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

DT 512 ADVANCED FOOD PROCESSING 3+1

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

Theory
UNIT I
Status of food processing industry in India and abroad; prospects and constraints in development of Indian food industry.

UNIT II
Post harvest management of fruits and vegetables, Harvesting indices, Biochemical and physical changes during ripening of fruits & vegetables, respiration and factors affecting it, role of ethylene in accelerated ripening, post harvest treatments for extension of shelf-life of fresh produce, Strategic interventions to minimize post harvest losses including vapour heat treatment, wax coating, chemicals, etc.

UNIT III
Principles of chilling & refrigeration storage of foods, quality changes in cold stored products, controlled and modified atmospheric storage. Freezing of foods, principle and equipments for freezing, defects in frozen foods, re-crystallization, freezing of fruits and vegetables, freeze concentration of fruit juices.

UNIT IV
Application of heat energy to foods for preservation and processing, concept of drying rate of foods, industrial drying processes of foods; changes during drying, advanced drying processes (Freeze drying, infra red drying and microwave drying), Canning of fruits & vegetables, unit processes involved in canning, types of cans for thermal processing of foods.

UNIT V
Basic principles involved in fermentation, Technological aspects of pickled vegetables like sauerkraut, cucumbers, Technology of wine, beer and distilled alcoholic beverages, defects in alcoholic beverages.
UNIT VI
Conversion of muscle into meat, rigor mortis, freezing and canning of meat, curing & smoking of meat, fermented sausages, cooking of poultry, utilization of milk ingredients in processed meat and poultry products.

UNIT VII
Advances in milling of rice (solvent extractive milling) and Turbo milling of wheat. Bakery products; role of ingredients, Developments in manufacturing processes for bakery products such as breads; biscuits; pizza bases, cake etc; changes during processing of bakery products. Utilization and importance of dairy ingredients in bakery products.

UNIT VIII
Definition, classification and technologies of fabricated and formulated foods and their nutritional aspects. Imitation dairy products and dairy analogues. Principle of extrusion processing, design and working of extruder, classification, application in food and dairy processing. Food additives, including stabilizers, emulsifiers, antioxidants, preservatives, etc. for formulated foods.

UNIT IX
Important group of enzymes involved in food processing; Application of enzymes in food processes like enzymes juice extraction, juice clarification, in bread manufacture, meat tenderization, ice cream manufacture, desugaring of egg, etc.

UNIT X
Newer concepts in food processing including organic foods, processing of organic raw material, genetically modified foods.

Practical
MAP and its effect on shelf-life of fresh fruits and vegetables, Preparation of squash, cordial, nectar and whey beverages, whey based soups, Manufacture of bread, pizza base, biscuits and cake, Application of milk ingredients in caramel, egg-less cake, mayonnaise, canning of fruits & vegetables, manufacture of chicken soup, comminuted meat products, enzymatic extraction and clarification of fruit juices, Preparation of soymilk and tofu, Drying of fruits & vegetables, efficacy of blanching treatment. Manufacture of sauerkraut/fermented vegetables.

Suggested Readings
DT 513 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 I
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 II
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 III
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 IV
Rheology of semi-solid and solid foods; 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 V
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 VI
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 514 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 I**

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

**UNIT II**

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 IV**

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 V**

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 VI
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 hydrolysates; visit to a bio-processing unit.

Suggested Readings

DT 515 TRADITIONAL AND VALUE ADDED PRODUCTS  2+1

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

Theory
UNIT I
Present status of traditional dairy products; globalization of traditional dairy products; plans and policies of the Government and developmental agencies.
UNIT II
Process schedule of heat-desiccated, coagulated and fermented traditional dairy products; process improvement in production of milk sweets.
UNIT III
New products based on fruits, vegetables and cereals; application of membrane technology; microwave heating for industrial production of traditional dairy products.
UNIT IV
Advances in industrial production of ghee, flavour and texture simulation.
UNIT V
Techno-economic aspects for establishing commercial units for traditional products.
UNIT VI
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

DT 521 MEMBRANE TECHNOLOGY IN DAIRY PROCESSING 2+1

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

Theory
UNIT I
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 II
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 III
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 IV
Demineralisation: Importance of demineralisation, different processes available for demineralization: their principle, plant and operation.

UNIT V
Practical
Study of the effect of types of milk, temperature of milk and transmembrane 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 522 ADVANCED DAIRY AND FOOD PACKAGING 2+1

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

Theory
UNIT I
Status of current packaging; types of packaging materials; criteria for selection of proper packaging; testing of packaging materials.
UNIT II
Adhesives; graphics; coding, and labeling used in food packaging.
UNIT III
Protective packaging of foods; packaging of food products sensitive to oxygen, light, moisture; active packaging; special problems in canned foods.
UNIT IV
Packaging of dairy products; packaging of convenience foods, packaging of fruits, vegetables, and fruit juices.
UNIT V
Packaging of fats and oils; packaging of spices; packaging of meat and poultry: packaging of fish and other seafoods.
UNIT VI
Modified atmosphere packaging, controlled atmosphere packaging, shrink and stretch packaging.
UNIT VII
Retort pouch technology, microwavable, biodegradable, and edible packages.
UNIT VIII
Industrial packaging: unitizing, palletizing, containerising, distribution systems for packaged foods including prevention of shock damage to articles during transportation.

UNIT IX
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

DT 523 ALTERNATIVE PROCESSES FOR DAIRY AND 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 I
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 II
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 III
Infra-red heating: Interaction of infra-red (IR) radiation with penetration properties, equipment; dairy and food application, advantages and disadvantages of IR heating.
UNIT IV
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 V
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 VI
High hydrostatic pressure processing: Principle of microbial inactivation, barotolerance of microorganisms, effect on food constituents, equipment, dairy and food application, merit and demerits.

UNIT VII
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
Theory

UNIT I
Definition, classes of functional foods, status of functional foods in world and India. Concept of new product development, classes 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 II
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 III
Food fortification, techniques for fortifying dairy foods with minerals and vitamins, High protein foods prospective nutraceuticals for fortification of dairy foods. Nutritional significance of dietary fibers, classes of dietary fibers, fortification techniques for fibers in dairy foods.

UNIT IV
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 V
Technological aspects of reduced calorie foods, alternatives for calorie reduction, low calorie sweeteners, bulking agents and their application, fat replacers and their utilization in low calorie dairy foods.

UNIT VI

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

UNIT VIII
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 IX
Prebiotic substances and their utilization in functional foods, symbiotic foods, technological aspects and recent development in probiotics, prebiotics and synbiotics.

UNIT X
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 XI
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**

DT 525  TECHNOLOGY OF FOOD EMULSIONS, FOAMS AND GELS  2+1

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

Theory
UNIT I
Food dispersions, their characteristics and factors affecting food dispersions.
UNIT II
Food emulsions; emulsifiers and their functions in foods; the HLB concept in food emulsifiers; emulsion formation and stability; polymers and surfactants.
UNIT III
Milk foams and their applications, structure of foams, egg foams and uses, foam formation and stability.
UNIT IV
Theory of gel formation; pectic substances and jellies; fruit pectin gels; milk jellies.
UNIT V
Structure of dairy foods representing emulsions, foams and gels; physical structure of fat rich, concentrated, fermented, coagulated and dried products.
UNIT VI
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 611  ADVANCED IN LIPID TECHNOLOGY  3+0

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

Theory
UNIT I
Current Trends in the fats & oil Industry in India and abroad: Sources and utilization of animal, vegetable and marine fats/oils - An overview.
UNIT II
Basic chemistry structure aspects of fats and oils in general, and milk-fat in particular, in relation to their processing, properties, utilization and significance in human diet.

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

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

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

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

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

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

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

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

Suggested Readings


Kamal BS & Kakuda Y.1994. Technological Advances in Improved and
DT 612 ADVANCES IN PROTEIN TECHNOLOGY 3+0

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 I
Characteristics of proteins from plant, animal and microbial origins.

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

UNIT III

UNIT IV

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

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

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

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

Theory

UNIT I

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

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

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

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

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

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

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

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

UNIT X

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

UNIT XII
Monitoring of Chemical Contaminants: Heavy metal quantification by Atomic Absorption Spectrophotometer; Quantification of Agrochemicals by HPLC; Spectrofluorimetric determination of mycotoxins; Detection and quantification of Drug Residues.

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

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

Suggested Readings
DT 622 RESEARCH AND DEVELOPMENT MANAGEMENT 3+0 IN DAIRY INDUSTRY

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

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

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

UNIT III

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

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

Suggested Readings
IPR Bulletins (TIFAC) (www.tifac.org.in)
• American Journal of Clinical Nutrition
• Australian Journal of Dairy Technology
• Bioprocess and Biosystems Engineering
• Comprehensive Reviews in Food Science and Food Safety
• CRC Critical Reviews in Food Science and Nutrition
• Food Engineering
• Food Research International
• Food Science & Technology (LWT)
• Food Science and Technology International.
• Food Technology
• Indian Dairymen
•Indian Food Packer
• Indian Journal of Dairy Science
• International Dairy Journal
• International Journal of Dairy Technology
• International Journal of Food Properties
• International Journal of Food Science and Technology
• Journal of American Oil Chemists’ Society
• Journal of Applied Microbiology.
• Journal of Biotechnology
• Journal of Chemical Technology and Biotechnology
• Journal of Dairy Research
• Journal of Dairy Science
• Journal of Food Biotechnology
• Journal of Food Engineering
• Journal of Food Processing and Preservation
• Journal of Food Protection
• Journal of Food Science
• Journal of Food Science and Biotechnology
• Journal of Food Science and Technology
• Journal of Food Technology
• Journal of Human Nutrition and Dietetics
• Journal of Lipid Research
• Journal of Texture Studies
• Packaging Abstracts
• Packaging India
• Trends in Food Science and Technology
Suggested Broad Topics for Master’s and Doctoral Research

• Application of UF retentates in value added products and health foods.
• Application of reverse osmosis in dairy industry.
• Application of microfiltration in dairy industry.
• Application of nanofiltration in dairy industry.
• Application of modified microorganisms in the manufacture of improved quality dairy products.
• Bio-processing of whey for production of alcoholic beverages.
• Characteristics of newly developed microbial rennet in relation to curd forming behavior of ripened and unripened cheeses.
• Crystallization behaviour of milk-fat and its impact on texture of butter and ghee.
• Development of kinetic data on physicochemical changes in different dairy/food products during processing and storage.
• Development of low-cost quality food formulations with protein supplementation.
• Development of newer fermented milk products with enhanced health attributes.
• Development of newer variety of cheeses from microbial/recombinant rennet using cow and buffalo milk systems.
• Development of pro-biotic cheese and fermented foods.
• Development of improved infant food formulations.
• Development of casein/whey protein hydrolysates with enhanced functionality for food application.
• Development of fortified foods meant for community nutrition.
• Development of indigenous detergents for cleaning and sanitization of membranes.
• Development of mechanized systems for the production of heat desiccated milk sweets/desserts, such as rabri, basundi, kheer/payasam, kalakand, milk cake, etc.
• Dielectric/microwave heating characteristics of milk and milk products – effect of composition and degree of concentration.
• Effects of processing variables on the textural properties of certain indigenous milk products.
• Enhancement of flavor development in cheeses.
• Enhancement of shelf life of food products through packaging.
• Effects of ultrasonic treatment of milk products on their properties and microbial inactivation.
• Effect of bactofugation keeping quality of milk under Indian conditions.
• Extension of shelf life of dairy products by applying Hurdle Technology.
• Effect of season on the compositional profile and physicochemical properties of milk-fat.
• Flavour characteristics of fats from cows, buffaloes, goats and sheep.
• Foaming properties of milk as influenced by its constituents.
• Foam formation in cream-- Factors affecting the extent and stability of foam.
• Investigation on quality improvement of dairy foods using novel ingredients.
• Incorporation of fruits for value addition and improvement of nutritional value of traditional milk products.
• Incorporation of cereals for value addition and improvement of nutritional value of traditional milk products.
• Infra-red heating behaviour of milk and milk products.
• Investigation of prebiotic potential of milk molecules and their utilization in development of synbiotic foods
• Isolation and purification of natural antibacterial substances of milk for preservation of milk products
• Low-temperature irradiation of dairy products.
• Process modification of manufacture and storage of ghee to improve granulation and flavour of ghee.
• Preservation of milk by LP system: study of safety aspects through clinical trials.
• Preservation of dairy foods by employing bio-preservatives.
• Process development for herbal dairy products
• Physicochemical properties of buffalo, goat and sheep milk-fats.
• Rheological and textural characterization of certain traditional dairy foods.
• Relationship between instrumental measurements of dairy/food product characteristics and their sensory assessment.
• Shelf life extension of traditional milk sweets through use of bio preservatives.
• Structure-texture relationships in selected dairy products.
• Studies on extrusion cooking of high protein foods.
• Studies on UHT processing of concentrated milk.
• Studies on the effectiveness of bio-detergents.
• Studies on process development for health foods utilizing milk/milk by-products
• Studies on development of low calorie dairy foods
• Study of moisture sorption isotherms of traditional dairy products and milk sweets
• Study of functional properties of UF retentates.
• Study of fouling behaviour during UHT processing of buffalo milk.
• Technology development for manufacture of specialty foods for aged/sports/diseased persons
• Technology for development of milk-cereal fermented foods
• Technology for production of bioactive milk components and their application in functional foods
• Use of antimicrobial packaging material for shelf life extension of traditional and value added dairy products
• Utilization of dairy by-products in formulated foods
• Utilization of dairy byproducts in production of value added products employing biotechnology.
• Viscoelastic behaviour of buffalo-milk cheeses and other semi-solid products
• Viscometric characterization of flowable buffalo-milk products
### DAIRY MICROBIOLOGY
Course Structure - at a Glance

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<td>MICROBIAL MORPHOLOGY AND TAXONOMY</td>
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<td>DM 512*</td>
<td>MICROBIAL PHYSIOLOGY</td>
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<td>DM 513</td>
<td>METHODS IN MICROBIOLOGY</td>
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<td>MICROBIOLOGY OF PROCESSED DAIRY FOODS</td>
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* Compulsory for Master’s programme.

**NOTE:** Doctoral students shall take a minimum of two 600-level courses
DAIRY MICROBIOLOGY
Course Contents

DM 511 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
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; Diauxic phenomenon; 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 such as 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
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
DM 514  ENVIRONMENTAL MICROBIOLOGY  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

DM 515  MICROBIOLOGY OF PROCESSED DAIRY FOODS  3+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

DM 516 APPLICATION OF BIOTECHNOLOGY IN DAIRY INDUSTRY 2+1

Objective
To impart knowledge in the application of Biotechnology in Dairy / Food Industry to the students of Dairying at Master’s level

Theory
UNIT I
History and Development of Biotechnology; Status of Biotechnology Industries in India to meet the demands of Dairy and Food Industry

UNIT II
Genetic improvement of lactic starters to enhance their technological functions for industrial applications e.g. acid, flavour, EPS, probiotic functions, Metabolic engineering of lactic acid bacteria, Production of recombinant dairy / food enzymes / proteins e.g. Chymosin, lactoferrin, lysozyme, lipases, proteases, immunoglobulins etc. Detection of GMOs and GM foods and their safety from public health point of view

UNIT III
Dairy based Functional foods/Health foods and Nutraceuticals. Value addition in dairy products through fortification/supplementation with bioactive components and probiotic cultures, Nutrigenomics
UNIT IV  
Application of molecular tools, biosensors, etc. for detection of food borne and spoilage pathogens

UNIT V  
Molecular tools for studying Biodiversity; Regulatory standards for GMOs and GM foods.

Practical
- Plasmid isolation from E. coli
- Agarose gel electrophoresis
- Transformation of E. coli with plasmid (Amp')
- Growth of Starter cultures on MRS for ‘lac’ marker
- Induction of ‘lac’ mutation using UV rays or ethidium bromide
- PCR assays for identification of LAB and food-pathogen detection

Suggested Readings

DM 521  DAIRY STARTER CULTURES  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 I
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 II
Adjunct starter organisms: The genus Bifidobacterium; The genus Enterococcus; The genus Propionibacterium; The genus Brevibacterium. Miscellaneous microorganisms: Molds and yeasts.

UNIT III
Metabolism of starter organisms: biochemical characterization of lactic acid bacteria; carbohydrate, citrate and protein metabolism of starter cultures.

UNIT IV
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 V
Starter types: single, mixed and multiple strain starter cultures; propagation and preservation of starter cultures; commercial starter preparations:
UNIT VI
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 VII
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

DM 522 MICROBIAL GENETICS 2+1

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

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. based detection of microorganisms.

Suggested Readings

DM 523
MICROBIAL QUALITY AND SAFETY
IN THE DAIRY INDUSTRY

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

DM 524 FEED AND RUMEN MICROBIOLOGY 2+1

Objective
To understand the basics of microbiology of feed and rumen ecosystem for its outcome on dairy production, processing and management.

Theory
UNIT I
Biofertilizers; microbial inoculants for fodder crops; legume-rhizobium symbiosis; production and application of biofertilizers.

UNIT II
Silage fermentation: microbial and chemical changes; use of additives and inoculants; losses during ensiling.
UNIT III
Bioconversion of crop-residues by solid state fermentation; single-cell protein production; advantages and disadvantages.

UNIT IV
Rumen microbial ecosystem; numbers, types, characteristics and functions of rumen bacteria, fungi and protozoa.

UNIT V
Methods for isolation, enumeration and cultivation of rumen microbes; their role in rumen metabolism and fiber degradation; exploitation of fibrolytic microorganisms as direct-fed microbials/ microbial feed additives.

Practical
Isolation of rhizobium bacteria from fodder legume plants; preparation of rhizobium inoculant for fodder leguminous crops; estimation of moisture, NH$_3$-N and pH in silage; enumeration of silage microorganisms; estimation of lactic, acetic and butyric acids in silage; sampling technique of rumen liquor and direct microscopic count of bacteria and protozoa; anaerobic cultivation techniques for bacterial and fungal counts in rumen liquor; use of anaerobic jar, roll-tube technique, estimation of hydrolytic enzyme activities of rumen liquor/ rumen microbes; SCP production from cellulose in submerged fermentation; bioconversion of straw by solid state fermentation.

Suggested Readings

DM 525  PROBIOTICS AND FERMENTED DAIRY PRODUCTS  2+1

Objective
To impart knowledge on basic and applied aspects of probiotics and fermented dairy products.

Theory
UNIT I
Introduction and history of probiotics and fermented dairy products.

UNIT II

UNIT III
Microbiology of yoghurt and related products. Microbiology of acidophilus products, dahi, misti dahi, bhapa dahi, lassi, cultured butter milk, shrikhand, kefir, koumiss, yakult, villi, bifidus milk products, kishk, and milk based products containing probiotic cultures.

UNIT IV
Factors influencing the quality and storage stability of fermented milks. Methods used in their manufacture, evaluation and quality control.
UNIT V
Nutritional and therapeutic value of these products in human diet. Use of fermented milks in diet and cancer control.

Practical
- Manufacture of different fermented milks and their microbiological and chemical analysis.
- Study of shelf life of fermented milks using different methods of preservation.
- Microbiological assay of vitamins or amino acids in fermented milk.

Suggested Readings

DM 526 MICROBIAL FERMENTATION TECHNOLOGY 2+1
Objective
To disseminate recent information on basic and applied aspects of fermentation technology and its industrial application to the students along with hands on training.

Theory
UNIT I
Introduction to fermentation. Historical perspective, Fermentation as a means for enhancing shelf life of foods and pickles.
UNIT II
Rate of microbial growth and death, Fermentation kinetics, mass transfer diffusion, membrane transport, dialysis, nutrient uptake.
UNIT III
Fermenter/ Bioreactor design, operation, measurement and control in fermentation. Aeration and Agitation in fermentation; Oxygen requirement, Adsorption coefficient bubble aeration, mechanical agitation, correlation between mass transfer coefficients and operating variables.
UNIT IV
Types of fermentation, submerged / solid state, Batch / continuous fermentation. In situ sterilization, Scale up in fermentation, Product recovery, Role of Immobilization, Downstream processing for Recombinant proteins and bio-assays
UNIT V
Industrial production of Lactic acid, Penicillin, Betagalactosidase, amino acids, vitamins, ethanol.

Practical
- Follow up of bacterial growth in batch culture.
- Different methods of microbial cultivation
- Fermenter operation and measurement.
- Production of starters, baker yeast culture, alcohol, alcoholic beverages.

**Suggested Readings**


**DM 611 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.

**Suggested Readings**


ADVANCES IN MICROBIAL GENETICS

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 Readings
DM 621  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

DM 622  MICROBIOLOGY OF FOOD-BORNE PATHOGENS  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

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 Readings
DAIRY MICROBIOLOGY
List of Journals

- Advances in Microbial Physiology
- Antimicrobial Agents and Chemotherapy
- Antonie van Leeuwenhoek
- Animal Feed Science and Technology
- Annals of Clinical Biochemistry
- Advances in Microbial Physiology
- Advances in Applied Microbiology
- Annals of Microbiology
- Annual Review of Microbiology
- Applied and Environmental Microbiology
- Applied and Environmental Microbiology
- Applied Biochemistry and Microbiology
- Applied Microbiology and Biotechnology
- Archives of Animal Nutrition
- Archives of Environmental Health
- Archives of Microbiology
- Asian-Australasian Journal of Animal Sciences
- Bioscience, Biotechnology and Biochemistry
- British Journal of Nutrition
- British Medical Journal
- Cellular Microbiology
- Clinica Chimica Acta
- Clinical Chemistry
- Clinical Chemistry and Laboratory Medicine
- Clinical Microbiology
- Critical Reviews in Environmental Science and Technology
- Critical Reviews in Microbiology
- Current Advances in Clinical Chemistry
- Current Contents
- Current Genetics
- Current Microbiology
- Dairy Science and Technology (Le Lait)
- Ecotoxicology and Environmental Safety
- Environment International
- Environmental Microbiology
- Environmental Monitoring and Assessment
- Environmental Research
- Environmental Science and Pollution Research
- Enzyme and Microbial Technology
- Eukaryotic Cell
- European Journal of Clinical Microbiology and Infectious Diseases
- FEMS Microbiology Ecology
- FEMS Microbiology Letters
- FEMS Microbiology Reviews
• Food Microbiology
• Food Microbiology and food safety journals
• Food Research International
• Foodborne Pathogens and Disease
• Fungal Genetics and Biology
• Gene
• Genome
• Indian Journal of Animal Nutrition
• Indian Journal of Animal Sciences
• Indian Journal of Microbiology
• Indian Journal of Veterinary Science
• Indian Journal of Dairy and Biosciences
• International Dairy Journal
• International Journal of Dairy Technology
• International Journal of Environment and Pollution
• International Journal of Food Microbiology
• International Journal of Food Science and Nutrition
• International Journal of General and Molecular Microbiology
• International Journal of Probiotics and Prebiotics
• International Journal of Systematic and Evolutionary Microbiology
• Investigation
• Journal of Animal Science
• Journal of Animal and Feed Sciences
• Journal of Applied Animal Research
• Journal of Applied Microbiology
• Journal of Bacteriology
• Journal of Basic Microbiology
• Journal of Biological Chemistry
• Journal of Biotechnology
• Journal of Chromatography A
• Journal of Dairy Science
• Journal of Dairy Research
• Journal of Experimental Animal Science
• Journal of Food Protection Letters in Applied Microbiology
• Journal of Food Science
• Journal of Food Science and Technology
• Journal of Food safety
• Journal of General and Applied Microbiology
• Journal in Genetics and Genomics
• Journal of Industrial Microbiology and Biotechnology
• Journal of Microbial Food Safety Standards.
• Journal of Microscopy
• Journal of Molecular Microbiology and Biotechnology
• Journal of Rapid Methods and Automation in Microbiology
• Journal of Virology
• Microbial Pathogenesis
• Microbial Ecology in Health and Disease
• Microbiological Research
• Microbiology: Bacteriology, Mycology, Parasitology and Virology
• Microbiology and Molecular Biology Reviews
• Molecular and Cellular Biology
• Molecular and Cell Biology
• Molecular Biology
• Molecular Genetics, Microbiology, Virology
• Nature
• Nature Biotechnology
• New England Journal of Medicine
• Plasmid
• PNAS
• Process Biochemistry
• Scandinavian Journal of Clinical and Laboratory Science
• Science of the Total Environment
• Symposium on Microbiological Food Safety Management 2007
• Systematic and Applied Microbiology
• The Journal of Biological chemistry
• The Lancet
• Trends in Food Science and Technology
• Trends in Microbiology
• Veterinary Microbiology
• Veterinary Research
• World Journal of Dairy and Food Sciences
• World Journal of Microbiology and Biotechnology
Suggested 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.
- Alternative methods of microbial quantification
- Development of indicators and biosensors from microbial metabolites
- Energy metabolism
- Formulation of novel pharmaceuticals and nutraceuticals
- 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
- 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.
- 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.
- 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
- Genetic manipulation of Lactic starter cultures
- Improving functionality of probiotics through metabolic engineering
- Recombinant proteins/enzymes for application in dairy industry
- Molecular diagnostics in dairy/food industry
- Biodiversity of LAB
- Bioactive peptides and Nutraceuticals
- GMO and GM foods and safety regulations.
- 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.
• 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.
• 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.
• Applications of bio-fertilizers in leguminous fodder crops.
• Preservation of leguminous/ non-leguminous fodder crops by ensiling.
• Enrichment of poor-quality roughages by solid-state fermentation.
• Manipulation of rumen microbial ecosystem.
• Development of direct-fed microbials for ruminants.
• Screening of prebiotics.
• Isolation and screening of potential dairy probiotics.
• Development of synbiotic products.
• Evaluation lactic acid bacteria for production of functional biomolecules.
• Nutritional and therapeutic value of probiotic products.
• Enhancing shelf life of foods through microbial fermentation.
• Industrial production of metabolites such as recombinant proteins/enzyme in a bioreactor and down stream processing.
• Production of microbial biomass as single cell protein.
• 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.
• 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.
• 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.
• 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 toxins.
# DAIRY CHEMISTRY

## Course Structure - at a Glance

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<td>2+1</td>
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<td>DC 512*</td>
<td>MILK CARBOHYDRATES, MINERALS AND WATER SOLUBLE VITAMINS</td>
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* Compulsory for Master’s programme;  
# Cross-listed with Dairy Technology  

**NOTE**: Doctoral students shall take a minimum of two 600-level courses
DAIRY CHEMISTRY
Course Contents

DC 511 PHYSICO-CHEMICAL ASPECTS OF MILK CONSTITUENTS AND MILK PRODUCTS 2+1

Objective
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
Kinetics: Order and molecularity of a reaction; reactions obeying the kinetics of zero, 1st, 2nd and 3rd order; kinetics of denaturation of whey proteins; the role of enzymes as a biological catalyst; factors affecting the rate of enzyme action- (i) concentration of substrate, (ii) concentration of enzyme, (iii) concentration of reaction products, (iv) pH, (v) temperature, (vi) time, (vii) activators, and (viii) inhibitors; concept of activation energy.

UNIT II
Electrochemistry: Electrolytic dissociation; activity, ionic strength; salt equilibria in milk; dissociation constant of acids and bases; effect of ionic strength on dissociation constant; buffers; limitation of buffers; Good's buffer; buffer capacity and buffer index of milk; electrode potential; concentration cells; ion-selective electrodes.

UNIT III
Surface chemistry: Adsorption at solid-vapour (gas) inter-phase; monolayer and multilayer adsorption; capillary condensation; adsorption isotherms; hysteresis; adsorption at solid-liquid and liquid-liquid interphase; Gibb's equations. water activity: sorption of water on milk constituents and milk products- its relation to stability of dairy products.

UNIT IV
Interfacial tension; micelles-- definition, critical micelle concentration - formation and stability; emulsions-, foams- and gels--their formation, structure and stability; importance of these phenomena in milk and milk products.

UNIT V
Properties of colloidal systems with special reference to electrical, optical, hydrodynamic (shape and hydration) and rheological aspects; colloidal stability of casein micelles; membrane phenomenon and Donnan membrane effect.

Practical
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; preparation of a Tris/phosphate/citrate buffer of a given molarity/ionic strength and pH; determination of pH of the buffer; estimation of calcium ions of milk using an ions selective electrode; determination of viscosity of condensed milk using falling ball viscometer; 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**


**DC 512**

**MILK CARBOHYDRATES, MINERALS AND WATER SOLUBLE VITAMINS**

**Objective**

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.

**UNIT II**

Physical properties: crystalline habits, hydrates, lactose glass, equilibrium of different isomers in solution, solubility, density, sweetness.

**UNIT III**

Chemical properties: Hydrolysis, pyrolysis, oxidation, reduction, degradation with strong bases, derivatives, dehydration and fragmentation, browning reactions and its mechanism.

**UNIT IV**

Minerals: Major and minor minerals, factors associated with variation in salt composition.

**UNIT V**

Physical equilibrium amongst milk salts, partitioning of salt constituents and factors affecting it. Effect of various treatments on salt equilibrium.

**UNIT VI**

Salt balance and its importance in the processing of milk, protein mineral interaction, distribution and importance of trace elements in milk.

**UNIT VII**

Water soluble vitamins: Thiamin, riboflavin, niacin, pantothenic acid, pyridoxine, biotin, folin and cyanocobalamin.

**UNIT VIII**

Molecular structures of these vitamins, levels in milk and milk products, biological significance, factors affecting their levels.
UNIT IX
Ascorbic acid: structure and its relation to Eh of milk and milk products.

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

Suggested Readings

DC 513 CHEMISTRY OF MILK LIPIDS 2+1

Objective
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 and physical properties; neutral and polar lipids and their role in milk and milk products.
UNIT II
Fatty acids profile: composition, properties and factors affecting them.
UNIT III
Unsaponifiable matter: composition with special reference to sterols and fat soluble vitamins and carotenoids, chemistry, physiological functions and levels of milk.
UNIT IV
Chemical properties: hydrolysis by alkali, water and enzymes; hydrogenation and halogenation; transesterification and interesterification; oxidation by chemical reagents.
UNIT V
Auto-oxidation: Definition, theories, induction period, secondary products of auto oxidation, factors affecting, prevention and measurement; antioxidants: Definition, types, reaction mechanism and estimation.

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


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**DC 514 FOOD CHEMISTRY 3+1**

**Objective**

To impart knowledge on different aspects of food components.

**Theory**

**UNIT I**
Forms of water in foods, water solute interactions and food stability, solute mobility and food stability; role of ice in the stability of food at sub-freezing temperatures.

**UNIT II**
Forms, swelling, gelatinization; food applications and role of starch in bread making; modification of starches for industrial applications, physico-chemical changes taking place during malting, mutual interactions of hydrocolloids and interactions with proteins and lipids; role of hydrocolloids in different food preparations.

**UNIT III**
Functional properties of food proteins; structure-function relationship and their modifications, denaturation of food proteins; effect of pressure on food proteins, enzymes & their application in food industry; physico-chemical properties of food lipids and their modifications.

**UNIT IV**
Indigenous and synthetic food pigments; legal requirements for food colourants; flavour compounds of different foods and flavour enhancers

**UNIT V**
Changes taking place during fermentation; drying and roasting of chocolate and cocoa; chemistry of tea manufacture; composition of coffee beans; physico-chemical changes during roasting of coffee beans.

**Practical**

Determination of level of artificial sweeteners and crude fiber in food products; starch in flour by polarization method; total amino acids and polyphenols in lemon juice; fat in grains; proteins in flour; tannins in coffee/tea, caffeine content in coffee; HMF in honey, and visit to a food industry.

**Suggested Readings**


DC 521  CHEMISTRY OF MILK PROTEINS  3+1

Objective
To impart knowledge on different aspects of milk proteins.

Theory
UNIT I
Distribution and fractionation of different nitrogen fractions, non-protein nitrogen constituents, 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 - distribution and methods of isolation; whey protein concentrates and their functional properties.

UNIT IV
Denaturation of caseins and whey proteins as affected by change of temperature, pH and additives; casein-whey protein interactions; genetic polymorphism and biosynthesis of milk proteins.

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

UNIT VI
Milk enzymes: properties and their significance with particular reference to lipases, phosphatases, catalase, peroxidase, xanthine oxidase, lysozyme, lactoperoxidase and galactosyl transferase.

Practical
Estimation of different nitrogen fractions of milk by Kjeldahl method. Milk protein estimation by Folin method. Isolation of acid and micellar casein; urea fractionation of acid casein; separation of amino acids using thin layer/paper chromatography; isolation of alpha-lactalbumin and beta-lactoglobulin by ammonium sulphate precipitation; polyacrylamide gel electrophoresis of milk proteins; estimation of milk enzymes like lipase, alkaline phosphatase and lactoperoxidase; fractionation of milk proteins by molecular sieving; estimation of hexoses and sialic acid in casein.

Suggested Readings
Objective
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; structure and physico-chemical properties of dried milk as affected by different process treatments; stability of milk powder; physical properties of instant milk powder.

UNIT II
Role and mechanism of action of stabilizers and emulsifiers in ice cream. Physiological and biochemical response of infants to human milk and formulated foods.

UNIT III
Heat stability of concentrated milk as affected by different process variables; milk constituents and additives; milk clotting enzymes from different sources (animal and plant); their isolation; purification and action.

UNIT IV
Changes taking place during manufacturing and ripening of cheese; chemical defects in cheese. Theory and metabolic pathways of fermentation.

UNIT V
Size distribution of fat globules and factors affecting it; creaming phenomena; mechanism of churning; physico-chemical characteristics; grading and standards of butter.

UNIT VI
Genesis of flavour; aroma and texture in ghee; adulteration of ghee and its detection.

Practical
Determination of lactose and sucrose in condensed milk and ice-cream; determination of heat stability of milk and its concentrate; determination of moisture in skim milk powder/infant food by vacuum oven; determination of fat in cream by Gerber and Rose-Gottlieb methods; determination of moisture, fat (Gerber method), curd and salt in butter; determination of diacetyl and acetyl methyl carbinol in butter/cultured products; determination of RM, Polenske value, iodine value, saponification value of ghee; determination of nitrite, nitrate, free amino acids and free fatty acids in cheese; determination of rennet clotting time of milk.

Suggested Readings
Objective
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; quality management systems - ISO 9000; total quality management (TQM); hazard analysis of critical control points (HACCP); good manufacturing practices (GMP); role of international organisations such as ISO; IDF; CAC; AOAC; WTO and national organisations like BIS; CCFS.

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

UNIT III
Instrumentation in analysis of milk and milk products; detection of adulterants in milk and milk products; packaging materials in relation to quality assurance of dairy products.

UNIT IV
Chemical residues: pesticides; antibiotics; heavy metals; radionuclides etc; in dairy products.

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

Suggested Readings
DCRT 524  RESEARCH TECHNIQUES  2+1

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

Theory

UNIT I
Electrophoresis: principle and types, isoelectric focussing.

UNIT II
Chromatography: column, TLC, GLC, HPLC, gel-permeation, ion-exchange, affinity.

UNIT III
Spectrophotometry: UV, visible, IR and flame photometry; potentiometry: principle, various electrodes; electrometric measurements of pH, buffers.

UNIT IV
Radiotracer technique: nuclear transformation, nuclear decay, measurement of radioactivity and safety precautions for radioactive materials.

UNIT V
Membrane processes; ultracentrifugation.

Practical
Preparation of methyl esters of fatty acids of milk fat followed by their GLC separation and estimation; TLC separation of amino acids; gel-filtration of biomolecules; preparation of a buffer and measurement of its pH electro-metrically and using indicators; SDS gel electrophoresis and molecular weight determination; determination of absorption spectra of BSA and demonstration of Beer's law; determination of sodium and potassium by flame photometry; ultracentrifugal preparation of micellar casein, separation of milk proteins using ion-exchange chromatography.

Suggested Readings
DC 611 ADVANCES IN CHEMISTRY OF MILK PROTEINS  3+0
Objective
To impart knowledge on different aspects of milk proteins
Theory
UNIT I
Biosynthesis of milk proteins, proteins and lipoproteins of milk fat globule
membrane (MFGM).
UNIT II
Amino acid sequence of caseins, structure - function relationship of casein
and whey protein; association - dissociation equilibria.
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 derived bioactive peptides - their properties; significance and
application; bitter peptides in cheese; growth factors in milk; transgenic
milk proteins and their significance.
UNIT VI
Therapeutic and allergy aspects of milk proteins; protein films and
coatings; their properties and applications.
Suggested Readings
Marcel Dekker.
Fields Cregg B. 1997. Solid Phase Peptide Synthesis: Methods in
Science Publ.
IDF. 1993. Proceedings of Seminar on Indigenous Antimicrobial Agents of
Milk - Recent Developments. Uppasala, Sweden.
Popay AI & Prosser CG. 1997. Biotech in Agric. Series No. 18, CABI.
Welch RAS, Burns DJW & Davis SR. 1997. Milk Composition, Production
and Biotechnology. CABI.

DC 612 ADVANCES IN CHEMISTRY OF MILK LIPIDS  3+0
Objective
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.

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.

UNIT III
Essential fatty acids, prostaglandins and flavor compounds. Conjugated linoleic acids – different isomers, factors affecting their levels in dairy products and their significance.

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.

UNIT V

Suggested Readings

DC 621

ADVANCES IN CHEMISTRY OF MILK PROCESSING  3+0

Objective
- To highlight the impact of processing parameters on the milk constituents with special reference to chemical changes involved.
- To impart the knowledge on the status and chemistry of contaminants in milk and milk products.
- To impart the basic knowledge on the chemistry and significance of additives.

Theory

UNIT I

UNIT II
Milk fat replacers, chemistry of artificial sweeteners and fortified milk.
UNIT III
Physical changes in the fat globules in unhomogenized and homogenized milk; cold agglutination – its mechanisms and role.

UNIT IV
Specific and non – specific enzymatic coagulation of milk.

UNIT V
Status and formation of bioactive peptides in fermented milk products.

UNIT VI
Chemistry involved in high pressure processing of milk.

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

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

DC 622 ADVANCES IN ANALYTICAL TECHNIQUES IN DAIRY CHEMISTRY 3+0

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

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

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

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

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

Suggested Readings
DAIRY CHEMISTRY

List of Journals

- Analyst
- Analytical Biochemistry
- Australian Journal of Dairy Technology
- Bulletin of Environmental Contamination and Toxicology
- Dairy Science and Technology
- Environmental Science and Technology
- Food Additives and Contaminants
- Food Chemistry
- Indian Dairyman
- Indian Journal of Dairy Science
- International Dairy Federation Bulletin
- International Dairy Journal
- International Journal of Dairy Technology
- International Journal of Food Composition
- International Journal of Food Science and Technology
- Journal of Agricultural and Food Chemistry
- Journal of American Oil Chemist Society
- Journal of Association of Official Agricultural Chemists
- Journal of Biochemistry
- Journal of Chromatography
- Journal of Dairy Research
- Journal of Dairy Science
- Journal of Dairy Technology
- Journal of Food Quality
- Journal of Food Safety
- Journal of Food Science
- Journal of Food Science and Technology
- Journal of Lipid Research
- Lipids
- LWT-Food Science and Technology
- Milchwissenschaft-Milk Science International

Suggested Broad Topics for Master’s and Doctoral Research

- Product/process improvement and quality assessment
- Development of new dairy based products
- Formulation of value added dairy products
- Optimization of processes for enhancing quality of dairy products
- Status of lactose in traditional dairy products including milk sweets.
- Status and role of minerals in Indian dairy products with particular reference to buffalo milk products.
- Rapid methods for detection of animal body fats in ghee.
- Survey on the changes of physico - chemical parameters of milk fat.
- Structural aspects of milk lipids in relation to processing.
• Interactions of major milk constituents with different food ingredients during manufacture of value added products.
• Analysis of artificial sweeteners and their stability in dairy products.
• Characterization of bioactive proteins and peptides in milk.
• Structural and kinetic studies on milk proteins and peptides.
• Establishing antioxidative potential of milk and milk protein products for promoting them as health foods.
• Development of commercially viable separation technologies for fractionation of colostrum/milk proteins for value addition.
• Characterization and evaluation of milk protein products as neutraceutical.
• Milk protein products for value addition in foods.
• Biotechnological applications of milk proteins.
• Development of newer milk products by replacing partially or wholly some of the milk constituents.
• Projects to enhance the shelf life of milk products through process modification, packaging and antioxidants.
• Applications of instruments in the quality control of milk and milk products.
• Detection of adulterants in milk and milk products.
• Analysis of chemical residues: pesticides; antibiotics; heavy metals etc; in dairy products.
• Isolation and purification of growth factors and bioactive peptides from colostrum, milk and whey.
• Interaction of caseins and whey proteins during processing of milk.
• Enzymatic modification of milk proteins and their incorporation into food system.
• Structure and functional properties of milk proteins during processing.
• Use of antimicrobial factors of milk in formulation of value added products.
• Development of enzyme based new markers for assessing quality of thermally processed milk.
• Development of biosensors for rapid and on-line detection of chemical constituents including contaminants, adulterants and toxins in milk and milk products.
• Increasing CLA content in milk and milk products.
• Establishing authenticity of milk fat purity.
• Interaction between different components during processing.
• Fractionation of milk fat.
• Isolation, purification and characterization of bioactive peptides generated during fermentation of milk.
• Structural and functional stability of bioactive peptides.
• Chemistry of cheese made with recombinant chymosin.
• Analysis of artificial sweeteners and their stability in dairy products.
• Analysis of contaminants viz. pesticide residues, antibiotics residues, heavy metal, etc. in milk and milk products.
## DAIRY ENGINEERING  
### Course Structure - at a Glance

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* Compulsory for Master’s programme  
NOTE: Doctoral students shall take a minimum of two 600-level courses
DAIRY ENGINEERING  
Course Contents

DE 511  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
Engineering properties of dairy and food materials and their significance in equipment design; processing and handling of dairy and food products.
UNIT II
Concept of rheology: ideal elastic, plastic and viscous behaviour, viscoelasticity, rheological models and constitutive equations, Maxwell model, Kelvin model and Burgers model, viscoelastic characterisation of materials, stress-strain behaviour, creep, stress relaxation, non-Newtonian fluids and viscometry.
UNIT III
Rheology and texture of food materials: methods of texture evaluation, subjective and objective measurements, mechanical tests, firmness, hardness, dynamic hardness, objective methods of measuring texture, rheological properties of dairy products, strength of food materials.
UNIT IV
Aerodynamic and hydrodynamic characteristics: drag coefficient, terminal velocity and Reynolds’s number, application of aerodynamic properties to the separation, pneumatic handling and conveying of foods.
UNIT V
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.

Suggested Readings

DE 512  HEAT 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

Suggested Readings

DE 513 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
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.

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

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

Suggested Readings

DE 514 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 Enthalpy-composition 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
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 521 DAIRY AND FOOD ENGINEERING-II 3+0

Objective
To develop competence in shelf life simulation of dairy products.

Theory
UNIT I
Water activity and states: a thermodynamic quantity, water sorption isotherms, hysteresis, theories of sorption hysteresis, water activity measurement methods, water binding, control of water activity and moisture, principles of IMF and their application.

UNIT II
Permeability and shelf-life: theoretical considerations, permeability to gases and vapours, measurement methods, permeability of multilayer 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 ultrafiltration 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 Readings

**DE 522 BIO-THERMAL PROCESS ENGINEERING 3+0**

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
DE 524            ENVIROMENTAL ENGINEERING            2+0

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

Theory
UNIT I
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, flotation, 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
Lewis & Athony. 1976. Industrial Air Pollution Control Equipment for Particulate. CRC Press.

DE 525            INSTRUMENTATION AND PROCESS CONTROL            2+1

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 611     ADVANCES IN DAIRY PROCESS ENGINEERING    3+1

Objective
To learn process parameters estimations and designs of selected dairy equipment.

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.
DE 612  
ADVANCED HEAT TRANSFER  
3+0

Objective  
To develop analytical approach for heat transfer operation

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

DE 621  
COMPUTATIONAL METHODS & SIMULATION IN  
DAIRY AND FOOD ENGINEERING  
2+0

Objective  
To develop competence in developing statistical/theoretical models.

Theory

UNIT I  
Taylor’s series expansion in development of numerical differentiation numerical differentiation procedures, forward difference, backward difference, central difference.

UNIT II  
Numerical integration trapezoidal rule, Simpson’s rule, improper integrals, Gauss-Legendre Quadraturese method, numerical methods to solve ordinary differential equations.
UNIT III

UNIT IV
Simulation concept, simulation methods and their limitations, statistical and theoretical models.

UNIT V
Problem formulation and development of models; solution and validation of models; data collection; processing and analysis; basic modeling problems on unit operations involved in dairy and food processing.

Suggested Readings

DE 622 PHYSICO-CHEMICAL PROCESSES 3+0
Objective
To develop understanding with advanced processes, their operations and design

Theory
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, super critical fluid extraction.

UNIT III
Electrodialysis. Minimum energy requirements, selective iontransport, 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
Pre-requisite Courses in Dairy Engineering for M. Tech. (DE) Students with B. Tech. (Dairy Technology) background

DE 411 DAIRY PLANT MAINTENANCE 2+1

Objective
To develop confidence with the students in handling maintenance issues of dairy/food plant

Theory
UNIT I
Introduction of course and its relevance, basic concepts of plant maintenance.
UNIT II
Elements of preventive maintenance program: Equipment data collection, reporting and recording, principles of lubrication, lubricants and preparation of lubrication schedule.
UNIT III
Maintenance organization, development of optimum organization.
UNIT IV
Planned overhaul and PERT planning, engineering and general stores, workshop facilities in relation to the size and types of dairy plants.
UNIT V
Care and maintenance of S.S. surfaces, and insulations, rubber and gasket materials, properties, grade and their selection.

Practical
Pipe fittings, belt and chain conveyors, mechanical seals for milk pumps, method of determining plant performance, calibration procedure and set-up for gauges, performance evaluation of HTST and associated components, upkeep of electric motors and starters, study of IBR, fire and explosives safety regulations, study of IS, British SMS and DIN standards for dairy equipment, trouble shooting of few selected equipments, maintenance organization of experimental dairy. Estimation of the maintenance cost, PERT for overhauling – case study and with group discussion, various records, equipment date card, card file, log books of a dairy plant, specification writing for some select machines & their components.

Suggested Readings

DE 412 STRENGTH OF MATERIALS 2+0

Objective
To develop competence in stress analysis of machine parts.
Theory

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

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

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

Suggested Readings

DE 421 MACHINE TOOL ENGINEERING

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.

Suggested Readings
DE 422 UNIT OPERATIONS 2+0

Objective
To impart engineering knowledge of various unit operations related to agricultural and dairy processing.

Theory
UNIT I
Engineering properties of biological materials – Mechanical, electrical and thermal properties; aerodynamic characteristics and frictional properties; application of engineering properties in design and operation of processing equipment.

UNIT II
Handling of food products – Mechanics of bulk solids, selection of bulk handling equipment, operation and construction of conveyors and elevators.

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.

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, extraction and extrusion operations.

Suggested Readings

DE 515 DAIRY PROCESS ENGINEERING 2+1

Objective
A pre-requisite course for engineers admitted to masters program in dairy engineering. To make up the basic knowledge of dairy plant and mechanics used in dairy industry.

Theory
UNIT I
Hygienic design concepts, sanitary pipes and fittings, CIP system, corrosion process and their control milking machine, bulk milk coolers, milk collecting center milk chilling units.
UNIT II
Milk reception equipments, milk tanks, stirrers and mixers, pasteurizers, sterilizers, centrifugation, homogenizer, packaging and filling machines.

UNIT III
Equipments for cheese, ice-cream, butter manufacture, special milk products, casein, whey, evaporators, dryers, cyclone separators, fluidized bed dryer.

UNIT IV
Ultra filtration and reverse osmosis, thermo compressor, MVR, drum dryers, tray dryers, butter churn.

UNIT V
Equipment for indigenous milk product manufacturing. Small capacity milk processing equipment, village level sterilization and ascetic packaging.

Practical
Identification of hygienic characteristics of pipes and fittings; technical specifications of milking and storage equipment, equipment for chilling & pasteurization; features of centrifuges; ice-cream freezers & packing machine; cheese vat; milking machine; press & packing machine; butter manufacturing equipment; different types of evaporators; different types of dryers, design of dairy plants; design of milk collecting and chilling unit.

Suggested Readings
DAIRY ENGINEERING
List of Journals

- American Institute of Chemical Engineering
- ASME Journal of Heat Transfer
- Accessories for Mechanical Engineering Shop.
- Biochemical Engineering Journal
- Chemical Age of India
- Chemical Engineer
- Chemical Engineering Progress
- Dairy Science Abstract.
- IDF Monographs
- Indian Journal of Dairy Science
- Industrial Engineering Chemistry
- Institutions of Engineer’s Journal of Mechanical Engineering.
- International Journal of Heat and Mass Transfer
- International Journal of Refrigeration
- Journal of Agricultural Engineering
- Journal of American Society of Agricultural Engineers
- Journal of Dairy Research.
- Journal of Food Science & Technology
- Journal of the Institution of Engineers (India)
- Journal of Instrument Society of India
- Journal of Mechanical Engineers
- Journal of Milk Food Technology.
- Journal of Society of Dairy Technology
- Milchwissenschaft
- Science Direct-International Journal of Heat and Mass Transfer
- The Air conditioning and Refrigeration Journal of ISHRAE
Suggested Broad Topics for Master’s and Doctoral Research

- Engineering properties of dairy and food materials.
- Aerodynamic properties of food materials.
- Design of evaporators and dryers.
- Evaluation of major heat transfer resistances in dairy equipment and finding the scope of improvement in design and control of process parameters to minimize these resistances.
- To study the process of scale formation and finding the scale heat transfer resistances in various food/dairy-processing equipment for use in their research and development.
- Establishment of empirical correlation for heat transfer coefficients in some critical heat transfer situations where these are not available.
- Development of ‘computer software’ for the ‘performance analysis’ and design of heat exchanging equipments.
- Identification of waste heat and check the feasibility and devising effective means of reutilizing it in a Dairy plant.
- Simultaneous momentum, energy and mass transfer analysis.
- Measurement of diffusivity.
- Velocity profile measurement.
- Development of computer software helpful in design and balancing of refrigeration components.
- Establishment of heat transfer data for different kinds of refrigerant condensers and evaporators.
- Finding the least possible work or highest possible COP for a specific cooling application.
- Devising ways of minimizing the gap between theoretical and actual work required in producing refrigeration.
- Finding least possible energy consumption for refrigeration requirement of a variety of dairy products.
- Studies on the use of heat pumps in a dairy plant for energy conservation.
- Identification of waste heat and check the feasibility and devising effective means of reutilizing it in a Dairy plant.
- Application of computational methods for simulation of dairy process equipments.
- Development of design manuals for various dairy process equipments.
- Sanitary and hygienic design of jacketed kettle with agitator for process heat transfer.
- Water activity characterization of Milk Products.
- Shelf life estimation of moisture sensitive products.
- Shelf life estimation of oxygen sensitive products.
- Design of fermentors.
- Design of aeration systems.
- Thermal efficiency analysis of UHT systems.
- Application of MATLAB in designing bio thermal processes and equipments.
- Design of waste water treatment techniques.
- Characterization of dairy waste.
- Evaluation of waste disposal system.
• Microprocessor-based instrumentation for estimation of equilibrium moisture content in dairy products
• Model-based fault-detection for process engineering instrumentation
• Food colour measurement, Instrumentation and techniques
• Instrumentation for measurement of engineering properties of dairy and food materials
• Design of pH controller used in process mechanization of dairy product
• Measurement and control of flow using control valve
• Controlled atmosphere storage for enhancing the shelf-life of foods.
• Dryer design for hygroscopic material
• High pressure processing equipments
• Scale-up designs and performance evaluation
• Agglomeration, instantization and particle size evaluation.
• Engineering properties of food materials.
• Heat & mass balancing for evaporators of special duct
• Development of software model for predicting thermal properties of various dairy products
• Prediction of overall heat transfer coefficient for various dairy applications
• Analysis of heat transfer mechanism in heat exchangers for various dairy applications
• Development of simulation models for various unit operations in dairy and food processing.
• Super critical separation of lipids
• Two-phase gas-liquid exchange studies during oxidation
• Liquid-solid separation studies for acid-coagulated products
• Heat distribution on heat exchanger with different heating sources
• Thermal performance evaluation of processing equipment
• Energy optimization for unit production of milk and milk products
• Plant design for higher performance
• Non-destructive methods for quality identification
• Village level sterilization and ascetic packaging
• Small level milk processing equipments.
COMPULSORY NON-CREDIT COURSES
(Compulsory for Master’s programme in all disciplines; Optional for Ph.D. scholars)

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**PGS 501 LIBRARY AND INFORMATION SERVICES 0+1**

**Objective**
To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

**Practical**
- Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

**PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 0+1**

**Objective**
To equip the students/scholars with skills to write dissertations, research papers, etc.
To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

**Practical**
*Technical Writing* - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction,
review of literature, material and methods, experimental results and
discussion); Writing of abstracts, summaries, précis, citations etc.;
commonly used abbreviations in the theses and research communications;
illustrations, photographs and drawings with suitable captions; pagination,
numbering of tables and illustrations; Writing of numbers and dates in
scientific write-ups; Editing and proof-reading; Writing of a review article.

**Communication Skills** - Grammar (Tenses, parts of speech, clauses,
punctuation marks); Error analysis (Common errors); Concord;
Collocation; Phonetic symbols and transcription; Accentual pattern: Weak
forms in connected speech; Participation in group discussion: Facing an
interview; presentation of scientific papers.

**Suggested Readings**


**PGS 503**

**INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**

**Objective**

The main objective of this course is to equip students and stakeholders with
knowledge of intellectual property rights (IPR) related protection systems,
their significance and use of IPR as a tool for wealth and value creation in a
knowledge-based economy.

**Theory**

Historical perspectives and need for the introduction of Intellectual
Property Right regime; TRIPs and various provisions in TRIPS Agreement;
Intellectual Property and Intellectual Property Rights (IPR), benefits of
securing IPRs; Indian Legislations for the protection of various types of
Intellectual Properties; Fundamentals of patents, copyrights, geographical
indications, designs and layout, trade secrets and traditional knowledge,
trademarks, protection of plant varieties and farmers’ rights and bio-
diversity protection; Protectable subject matters, protection in
biotechnology, protection of other biological materials, ownership and
period of protection; National Biodiversity protection initiatives;
Convention on Biological Diversity; International Treaty on Plant Genetic
Resources for Food and Agriculture; Licensing of technologies, Material
transfer agreements, Research collaboration Agreement, License Agreement.

**Suggested Readings**


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**PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 0+1**

**Objective**

To acquaint the students about the basics of commonly used techniques in laboratory.

**Practical**

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

**Suggested Readings**


Objective
To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory
UNIT I
History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.
UNIT II
Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.
UNIT III
Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings
Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.
Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion

UNIT II
Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III
Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

Suggested Readings