Agriculture and Allied Science

Restructured and Revised Syllabi of Post-graduate Programmes

Volume 10 - Dairy Science and Technology

- Dairy Science
- Dairy Chemistry
- Dairy Microbiology

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Compiled By

Dean & Director of Instruction
Co-Ordination Committee
of SAU's 2022-23

Restructured and Revised Syllabus

M.Sc. & Ph. D. (Diary Science and Technology)

In

Diary Science, Dairy Chemistry and Dairy Microbiology

Submitted by

Broad Subject Coordinator
Head, Dept. of AHDS,
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Preamble

Dairy farming has been an important part of the agricultural scenario for thousands of years. India being a predominantly agrarian economy has about 70 per cent of its population living in villages, where livestock play a crucial role in the socio-economic life. Livestock provide high-quality foods such as milk, butter, ghee, many more traditional dairy products etc. India is not only one of the top producers of milk in the world, but also the largest consumer of milk and milk products in the world.

Dairy Science and Technology is a broad discipline which engaged with milk processing, value addition and quality control. The various sub disciplines are Dairy Science, Dairy Chemistry, Dairy Microbiology, etc. To impart the dairy education in India, National Dairy Research Institute (NDRI), Karnal (Haryana), Dairy technology colleges in some Animal Science Universities are playing a crucial role. Further these institutes provides research and development support for dairy development programmes of nation and also carries fundamental research and providing generous technical support to dairy industry of the nation. At the same time few Agriculture Universities undertaken Master and Doctoral degree programme of Agriculture in Dairy Science for the Agriculture and allied graduates. No doubt these post graduates will not be compotators to the students of NDRI and other such students of Dairy technology colleges.

These agriculture graduates are well acquainted with sufficient knowledge of Dairy Science field through different courses taught at UG level. Similarly, about 20 % of students used to have good understanding of various manufacturing processes and product handling through Experiential Learning Module (ELM) / Students READY Programme, a mandatory part of their UG degree syllabus in final year. These students gaining good deal of knowledge in discipline of Dairy Science and interested in further studies in Dairy Science will be deprived of their legitimate right if Post Graduation in Dairy Science is not recognized by BSMA. Because for Post Graduation in any specialized institute engaged in teaching of Dairy Science the basic requirement is B. Tech. (DT) degree. However continuation of PG degree programme in Dairy Science at Agricultural Universities will help in development of human resources at multi tier level and infusion of scientific knowledge in various sectors including, Agriculture Colleges, Banking, co-operative dairy farming, etc. With respect to equivalence of degree i.e. M.Sc. (Ag) or Ph. D. (Ag) in Dairy Science offered by any of Agricultural university will not be equivalent to M.Tech or Ph.D from specialized institute engaged exclusively in teaching and research of Dairy Science, however, the critical perusal of existing syllabus for Master's and Doctoral degree programmes, which is duly approved by BSAM is at par with syllabus implemented at National level of such degree programme.

Committee for ICAR-BSMA Broad Subject
Dairy Science and Technology

ICAR-BSMA Broad Subject	Disciplines	Degree Programmes		Broad Subject Coordinator (Chairman of all Disciplines' Sub Committees	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
Dairy Science and Technology	Dairy Science	M.Sc. (Agri.)	Ph.D.	Dr. G. K .Londhe, Head, Dept. of AHDS, VNMKV, Parbhani Email: glondhe71@gmail.com 9421449497	Dr. D.H.Kankhare Asso. Prof. AHDS MPKV, Rahuri, dkankhare2001@yahoo.com Dr. N. S. Kamble, Asstt. Prof. VNMKV, Parbhani
	Dairy Chemistry	M.Sc. (Agri.)	Ph.D.		Dr. D. D. Patange Asso. Prof. MPKV, Rahuri. patangedeshmukh1@gmail.com Dr. V. S. Dandekar, Asso. Prof. Dr. BSKKV, Dapoli. vsdandekar3063@gmail.com Dr. P. V. Padghan, Asso. Prof. VNMKV, Parbhani. Dr. R. J. Desale, Asso. Prof. MPKV, Rahuri.
	Dairy Microbiology	M.Sc. (Agri.)	Ph.D.		Dr. B. G. Desai, Head, Dept of AHDS, DBSKKV, Dapoli. Dr. R. R. Shelke Asso. Prof. PDKV, Akola. rrspkv@gmail.com Dr. S. G. Narwade, Asso. Prof., VNMKV, Parbhani. Dr. S. S. Ramod, Asstt. Prof. DBSKKV, Dapoli. Dr. D.M.Choudhari, SMS, KVK, Dhule. Dr.H.W. Deshpande, Asso. Prof. College of Food Technology, VNMKV, Parbhani.

Implementation of New Curriculum

The universities offering PG programmes in Dairy Science and Technology need to be supported for establishing specialized laboratories equipped with state-of-the art equipments for conducting practical classes especially of dairy science, dairy chemistry and dairy microbiology.

One time catch up grant should be awarded to each SAU, offering PG programmes in Dairy Science and Technology for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculty in each department under an SAU should be given on job training in reputed national and international institutes. To execute the new PG and Ph.D. programmes in different discipline of Forestry Agriculture (Dairy Science and Technology) in effective manner, special funds from ICAR State Government would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

The already existing M.Sc. and Ph.D. Programmes in Dairy Science will be considered at par with the recommended M.Sc. & Ph.D. programme by Vth Deans Committee for admission and employment.

Expected Outcome

- Revamping of post graduate programme in whole of Forestry Agriculture (Dairy Science and Technology) throughout the country Maharashtra
- Imparting quality education.
- Development of technical manpower to cater the need of governments, corporate sector and research organization in India and abroad.
- Exposure to the faculty in the latest technical knowhow.

Organization of Course Contents & Credit Requirements

- **Minimum Residential Requirement:**
  - **M.Sc.: 4 Semesters**
  - **Ph.D.: 6 Semesters**
- **Name of the Departments / Divisions:**
  - Dairy Science (DS)
  - Dairy Chemistry (DC)
  - Dairy Microbiology (DM)
- **Nomenclature of Degree Programme:**

(a) M.Sc. Programmes

i. M.Sc. (Agri.) in Dairy Science
ii. M.Sc. (Agri.) in Dairy Chemistry
iii. M.Sc. (Agri.) in Dairy Microbiology

(b) Ph. D. Programmes

i. Ph.D. (Agri.) in Dairy Science
ii. Ph.D. (Agri.) in Dairy Chemistry
iii. Ph.D. (Agri.) in Dairy Microbiology

- **Code Numbers:**
  - All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
  - 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
  - Deficiency courses will be of 400 series.
  - Master's research: 599 and Doctoral research: 699
- **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 obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
  - A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.
  - Teaching Schedule and practical schedule has also been given at the end of each course to facilitate the teacher to complete the course in an effective manner.

- **Eligibility for Admission:**
  - **Master's Degree Programme:**

    B.Sc.(Agri.)/ B.Sc.(Hons.) Agriculture/ B.Sc.(Hort.)*/ B.Sc.(Hons.) Horticulture/ B.Sc.(Forestry)*/ B.Sc.(Hons.) Forestry/ B.Sc.(Agri. Bio-Tech.)*/ B.Tech. (Biotechnology)*/ B.Tech. (Agricultural Biotechnology)*/ B.B.M.(Agri.)*/ B.Sc.(ABM)*/ B.Sc.(Hons.) Agri. Business Management*/ B.B.A.(Agri.)*/ B.Tech.(Agril. Engg.)*/ B.Tech.(Food Tech.)*/ B.Sc.(Hons.) Home Science*/ B.Sc.(Hons.) Community Science*/ B.Sc.(Animal Husbandry)*#/ B.Sc. (Hons.) Sericulture* or equivalent degree* with four years duration of agriculture-related Universities and having the Common Entrance Test in Agriculture faculty conducted by MAUEB, Pune or competent authority as applicable.

  - **Doctoral Degree Programme:**

    Master Degree in the concerned Department/Discipline of Agriculture in Dairy Science, Dairy Chemistry and Dairy Microbiology and having appearing the Common Entrance Test of respective subject conducted by competent authority.

Sr. No	Name of Department	Specialization in Ph. D	Eligibility criteria
1.	Dairy Science (DS)	Ph. D. Dairy Science	M.Sc. (Agri.) in Dairy Science/M.Sc. (Agri.) in Dairy chemistry/M.Sc. (Agri.) in Dairy Microbiology
2.	Dairy Chemistry (DC)	Ph. D. Dairy Chemistry	M.Sc. (Agri.) in Dairy Chemistry/M.Sc. (Agri.) in Dairy Science/M.Sc. (Agri.) in Dairy Microbiology
3.	Dairy Microbiology (DM)	Ph. D. Dairy Microbiology	M.Sc. (Agri.) in Dairy Microbiology/M.Sc. (Agri.) in Dairy Science/M.Sc. (Agri.) in Dairy chemistry

- **Course and Credit Requirements:**

Course Details	Masters Degree	Doctoral Degree
Major Courses	20	15
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

Compulsory Common Non Credit PGS Courses (05 credits)

	e Title	e Code	ts
	y and Information Services	501	
	ical Writing and Communications Skills	502	
	ctual Property and its management in ılture	503	
	Concepts in Laboratory Techniques	504	
	ıltural Research, Research Ethics and Rural Development Programs	505	

Compulsory Non Credit Deficiency Courses (Those who are non Agriculture Graduates):

Course Code	Semester	Course Title	Credit Hrs.
AHDS 411	I	Livestock Production and Management	1+1
AHDS 412	I	Technology of Milk and Milk Products	1+1

Students from other than Agriculture stream will be required to complete Non credit deficiency courses (2 to 4 credits) from the above courses related to the discipline in which admitted and as decided by the Student Advisory committee.

Course Structure and Layout
M.Sc. (Agri.) in Dairy Science Degree Programme

Major Courses:

Course Code	Semester	Course Title	Credit Hours
DS 511*	I	Advances in Dairy Processing	4 = 3+1
DS 512	I	Advances in Food Processing	4 = 3+1
DS 513*	I	Rheology of Dairy and Food Products	3 = 2+1
DS 514	I	Biotechnology for Dairy Applications	3 = 2+1
DS 515	I	Advances in Traditional Indian Dairy Products	3 = 2+1
DS 516	I	Non-conventional Processes for Dairy and Food Industry	3 = 2+1
DS 521*	II	Membrane Processing for Dairy Applications	3 = 2+1
DS 522*	II	Advances in Dairy and Food Packaging	3 = 2+1
DS 523	II	Technology of Food Emulsions, Foams and Gels	3 = 2+1
DS 524*	II	Functional Foods and Nutraceuticals	4 = 3+1
DS 525	II	Production and Applications of Dairy Ingredients	3 = 2+1
DS 526	II	Advances in Cheese Technology	3 = 2+1
Minimum 20 credits will be selected from above major courses			
DS 591*	III	Master's Seminar	1=1+0
DS 599	III & IV	Master's Research	30=0+30

***Core Courses**

- **Minor Courses:** The courses will be selected from major courses of the allied disciplines closely related to a student's major subject as mentioned below to meet the minimum credit (08) requirements.

Sr. No.	Name of Disciplines
1	Dairy Chemistry
2	Dairy Microbiology
3	Livestock Product Technology
4	Livestock Production Management

Suggestive Minor Courses:

Course Code	Semester	Course Title	Credit Hours
DC 511	I	Physico-chemical Aspect of Milk Constituents	3 = 2+1
DM 514	I	Microbiology of Fluid Milk and Dairy Products	3 = 2+1

LPM-601	I	Cattle and Buffalo Production Management	3 = 2+1
		Total	**9 = 6+3**

- **Supporting Courses:** The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overall competence. The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. The courses from following disciplines will be offered based on the requirement (minimum 06 credits).

Sr. No.	Name of Disciplines
1	Agricultural Statistics
2	Computer Application
3	Bioinformatics
4	Soil Science
5	Microbiology/ Plant Pathology

Suggestive Supporting courses:

Course Code	Title	Credit Hours
STAT 511	Experimental Designs	**3= 2+1**
BIOCHEM 501	Basic Biochemistry	**4= 3+1**
	Total	**7=5 +2**

Common Compulsory Non Credit PGS Courses:

The following courses (one credit each) will be offered to all students undergoing Master's degree programme.

Sr. No.	Course Title	Credit Hours
1	Library and Information Services	1=0+1
2	Technical Writing and Communications Skills	1=0+1
3	Intellectual Property and its management in Agriculture	1=1+0
4	Basic Concepts in Laboratory Techniques	1=0+1
5	Agricultural Research, Research Ethics and Rural Development Programmes	1=1+0

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related

courses with the prior approval of the Head of Department (HoD)/Board of Studies (BoS).

Course Structure and Layout
M.Sc. (Agri.) in Dairy Chemistry Degree Programme

- **Major Courses:**

Course Code	Semester	Course Title	Credit Hours
DC 511	I	Physico-chemical Aspects of Milk Constituents	3=2+1
DC 512*	I	Milk Carbohydrates, Minerals and Water Soluble Vitamins	3=2+1
DC 513*	I	Chemistry of Milk Lipids	3=2+1
DC 514	I	Chemistry of food constituents	3=2+1
DC 521*	II	Chemistry of Milk Proteins	4=3+1
DC 522*	II	Chemistry of Processed Dairy Foods	4=3+1
DC 523	II	Chemical Quality Assurance and Management Tools	3=2+1
DC 524	II	Research Techniques	3=1+2
Minimum 20 credits will be selected from above major courses			
DC 591*	III	Master's Seminar	1=1+0
DC 599	III & IV	Master's Research	30=0+30

***Core Courses**

- **Minor Courses:** The courses will be selected from major courses of the allied disciplines closely related to a student's major subject as mentioned below to meet the minimum credit (08) requirements.

Sr. No.	Name of Disciplines
1	Dairy Science
2	Dairy Microbiology
3	Livestock Product Technology
4	Livestock Production Management

Suggestive Minor Courses:

Course Code	Semester	Course Title	Credit Hours
DS 515	I	Advances in Traditional Indian Dairy Products	3 = 2+1
DS 524	II	Functional Food and Nutraceuticals	4=3+1

DM 514	I	Microbiology of Fluid Milk and Dairy Products	3 = 2+1
		Total	**10=7+3**

- **Supporting Courses:** The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overall competence. The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. The courses from following disciplines will be offered based on the requirement (minimum 06 credits).

Sr. No.	**Name of Disciplines**
1	Agricultural Statistics
2	Computer Application
3	Bioinformatics
4	Soil Science
5	Microbiology/ Plant Pathology

Suggestive Supporting courses:

Code Course	**Title**	**Credit Hours**
STAT 511	Experimental Designs	**3= 2+1**
BIOCHEM 501	Basic Biochemistry	**4= 3+1**
Total		**7=5 +2**

- **Common Courses:** The following courses (one credit each) will be offered to all students undergoing Master's degree programme.

Sr. No.	**Course Title**	**Credit Hours**
1	Library and Information Services	1=0+1
2	Technical Writing and Communications Skills	1=0+1
3	Intellectual Property and its management in Agriculture	1=1+0
4	Basic Concepts in Laboratory Techniques	1=0+1
5	Agricultural Research, Research Ethics and Rural Development Programmes	1=1+0

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed

any of these courses during UG, he/ she may be permitted to registerfor other related courses with the prior approval of the Head of Department (HoD)/Board of Studies (BoS).

Course Structure and Layout
M.Sc. (Agri.) in Dairy Microbiology Degree Programme

- **Major Courses:**

Course Code	Semester	Course Title	Credit Hours
DM 511*	I	Microbial Physiology	3=2+1
DM 512*	I	Microbiology of Processed Dairy Foods	4=3+1
DM 513	I	Microbial Morphology and Taxonomy	3=2+1
DM 514	I	Microbiology of Fluid Milk and Dairy Products	3=2+1
DM 515	I	Microbial Genetics	3=2+1
DM 516	I	Environmental Microbiology	3=2+1
DM 517	II	Biotechnology in Dairy Industry	3=2+1
DM 521*	I	Dairy Starter Cultures	3=2+1
DM 522*	II	Microbial Safety and Quality	4=3+1
DM 523	II	Microbiology of Cheese and Fermented Dairy Foods	3=2+1
DM 524	II	Probiotics and Prebiotics	3=2+1
DM 525	II	Research Techniques	3=2+1
DM 526	II	Microbial Fermentation Technology	3=2+1
Minimum 20 credits will be selected from above major courses			
DM 591	III	Seminar	1=0+1
DM 599	III & IV	Master's Research	30=0+30

***Core courses**

- **Minor Courses:**The courses will be selected from major courses of the allied disciplines closely related to a student's major subject as mentioned below to meet the minimum credit (08) requirements.

Sr. No.	Name of Disciplines
1	Dairy Science
2	Dairy Chemistry
3	Livestock Production Management
4	Biochemistry

5	Microbiology/ Plant Pathology

Suggestive Minor Courses:

Course Code	Semester	Course Title	Credit Hours
DS 524	I	Functional Foods and Neutraceuticals	3 = 2+1
DC 523	II	Chemical Quality Assurance and Management Tools	2=1+1
DM 514	I	Advances in Traditional Indian Dairy Products	3 = 2+1
		Total	**8=5+3**

- **Supporting Courses:** The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overall competence. The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. The courses from following disciplines will be offered based on the requirement (minimum 06 credits).

Sr. No.	Name of Disciplines
1	Agricultural Statistics
2	Computer Application
3	Bioinformatics
4	Soil Science
5	Microbiology/ Plant Pathology

Suggestive Supporting courses:

Course Code	Course Title	Credit Hours
STAT 511	Experimental Designs	**3= 2+1**
BIOCHEM 501	Basic Biochemistry	**4= 3+1**
Total		**7=5 +2**

- **Common Courses (Non Credit):** The following courses (one credit each) will be offered to all students undergoing Master's degree programme.

Course code	Semester	Course Title	Credit Hours
PGS 501	I	Library and Information Services	1=1+0
PGS 502	I	Technical Writing and Communications Skills	1=1+0
PGS 503	II	Intellectual Property and its management in Agriculture	1=1+0
PGS 504	II	Basic Concepts in Laboratory Techniques	1=1+0
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	1=1+0

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to registerfor other related courses with the prior approval of the Head of Department (HoD)/Board of Studies (BoS).

Course Structure and Layout
Ph. D. (Agri.) in Dairy Science Degree Programme

- **Major Courses:**

Course Code	Semester	Course Title	Credit Hrs.
DS 611	I	Advances in Lipid Technology	3 = 3+0
DS 612	I	Advances in Protein Technology	3 = 3+0
DS 621	II	Product Monitoring and Process Control	3 = 3+0
DS 622	II	R and D Management in Dairy Industry	3 = 3+0
DS 623	I	Advances in Carbohydrates Technology	3 = 3+0
DS 691*	III	Doctoral Seminar-I	1= 1+0
DS 692*	IV	Doctoral Seminar-II	1= 1+0
DS 699*		Doctoral Research	75= 0+75

*** Core Courses**

- **Minor Disciplines :**

The courses will be selected from the major courses of the following disciplines to meet the minimum credit requirements.

A. Dairy Chemistry
B. Dairy Microbiology
C. Livestock Production Management
D. Biochemistry

.Suggestive Minor Courses:

Course Code	Semester	Course Title	Credit Hrs.
DC 612	I	Advances in Chemistry of Milk Lipid	3 = 3+0
DM 621	II	Advances in Dairy and Food Microbiology	3 = 3+0
LPM 708	I	Precision Livestock Farming	2= 1 +1
		Total	**6 = 6+0**

- **Supporting Courses:**

The supporting courses will be picked from the basket of courses offered in agricultural statistics, computer applications and IT, and other related relevant disciplines to meet the minimum credit requirements.

Course Structure and Layout
Ph. D. (Agri.) in Dairy Chemistry Degree Programme

- **Major Courses**

Course Code	Semester	Course Title	Credit Hrs.
DC 611*	I	Advances in Chemistry of Milk Proteins	3 =3+0
DC 612*	I	Advances in Chemistry of Milk Lipids	3 =3+0
DC 621*	II	Advances in Chemistry of Dairy Processing	3 =3+0
DC 622	II	Advances in Analytical Techniques in Dairy Chemistry	3=3+0
DC 691*	III	Doctoral Seminar-I	1= 1+0
DC 692*	IV	Doctoral Seminar-II	1= 1+0
DC 699*		Doctoral Research	75= 0+75

*** Core Courses**

- **Minor Courses :**

The courses will be selected from the major courses of the following disciplines to meet the minimum credit requirements.

A. Dairy Science
B. Dairy Microbiology
C. Livestock Production Management
D. Biochemistry

.Suggestive Minor Courses:

Course Code	Semester	Course Title	Credit Hrs.
DS 623	I	Advances in Carbohydrate Technology	3= 3+0
DM 621	II	Advances in Dairy and Food Microbiology	3 = 3+0
		Total	**6 = 6+0**

- **Supporting Courses:**

The supporting courses will be picked from the basket of courses offered in agricultural statistics, computer applications and IT, and other related relevant disciplines to meet the minimum credit requirements.

Course Structure and Layout
Ph. D. (Agri.) in Dairy Microbiology Degree Programme

- **Major Courses:**

Course Code	Semester	Course Title	Credit Hrs.
DM 611*	I	Advances in Microbial Physiology	3=3+0
DM 612	II	Advances in Microbial Genetics	3=3+0
DM 621*	II	Advances in Dairy and Food Microbiology	3=3+0
DM 622	I	Advances in Food Safety of Dairy Products	3=3+0
DM 623	I	Advances in Probiotics and Functional Foods	3=3+0
DM 691*	III	Doctoral Seminar-I	1= 1+0
DM692*	IV	Doctoral Seminar-II	1= 1+0
DM 699*		Doctoral Research	75 = 0+75

*** Core Courses**

- **Minor Courses :**

The courses will be selected from the major courses of the following disciplines to meet the minimum credit requirements.

A. Dairy Science
B. Dairy Chemistry
C. Livestock Product Technology
D. Biochemistry

.Suggestive Minor Courses:

Course Code	Semester	Course Title	Credit Hrs.
DS 622	II	R and D Management in Dairy Industry	3=3+0
DC 621	II	Advances in Chemistry of Dairy Processing	3=3+0
		Total	**6 = 6+0**

- **Supporting Courses:**

The supporting courses will be picked from the basket of courses offered in agricultural statistics, computer applications and IT, and other related relevant disciplines to meet the minimum credit requirements.

Course Syllabus and Contents
M.Sc. (Agri) in Dairy Science

I. Course Title : Advances in Dairy Processing

II. Course Code : DS 511

III. Credit Hours : 4=3+1

IV. Why this course?

The basic principles of dairy processing have been understood at undergraduate level. Any dairy plant has to be abreast with the latest developments taking place in the arena of dairy processing, dairy product preservation, quality assurance and public health safety, automation, mechanization, etc. Knowledge of such aspects will help in controlling milk solids losses, aid in process optimization and help in catering to quality dairy products to the consumers.

V. Aim of the course

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

VI. Theory:

Unit I

Use of bio-protective factors for preservation of raw milk: effects on physico-chemical, micro-bial and nutritional properties of milk and milk products; Present status of preservation of raw milk.

Unit II

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; Nutritional aspects of UHT treated milk vis-à-vis retort sterilized/ HTST treated milk.

Unit III

Principles and equipment for bactofugation and bactotherm processes; Partial homogenization and its application in dairy industry, Low pressure homogenization; Microfluidization of milk: Principle, equipment, effects and applications.

Unit IV

Concentration processes and their impact on quality of finished products; Dehydration: advances in drying of milk and milk products; Freeze dehydration: physico-chemical changes and in-dustrial developments; Glass Transition Temperature and its relevance to dried milks.

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; Automation, Ultrasonic techniques in cleaning; Bio-films; Bio-detergents, innovations in sanitizers - chemical, radiation; Mechanism of fouling and soil removal; Assessing the effectiveness of cleaning and sanitization of dairy equipment, Water conservation methods.

VII. Practical:

- Measurement of thiocyanate in milk system
- LP system for extending the keeping quality of raw milk
- Determination of HCT-pH profile of milk
- Determination of water activity and sorption isotherms of milk products
- Determination of WPNI of milk powders
- Functional properties of milk powders
- Determination of HMF content in dried milks
- Freeze drying of milk and milk products
- Homogenization efficiency
- Cleaning and sanitization efficiency of dairy equipment
- Visit to a UHT Processing plant.

VIII. Teaching Methods/Activities:

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various dairy plants

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge to ensure delivery of safe and quality product from the dairy plant to the consumers
- To process the milk and dairy products in such a manner that losses of milk solids are minimal
- Be able to suggest to the dairy plant personnel, the latest type of tools that can be harnessed to produce quality products, without impairing the nutritive value of milk
- To suggest the dairy industry personnel regarding the formulation of detergent and/or acid and sanitizers which would help in efficient cleaning and sanitization of dairy equipment.

X. Suggested Reading

- Barbosa-CA, GV, Fontana Jr, AJ, Schmidt SJ, and Labuza TP. (Eds.). 2008. *Water Activity in Foods: Fundamentals and Applications* (Vol. 13). John Wiley and Sons.
- Britz T and Robinson RK. (Eds.). 2008. *Advanced Dairy Science and Technology*. John Wiley and Sons.

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- Subramaniam P and Wareing P. (Eds.). 2016. *The stability and shelf life of food*. Woodhead Publishing.
- TetraPak Dairy Processing Handbook. 2015. www.dairypeocessinghandbook.com
- Thompkinson DK and Sabikhi L. 2012. *Quality milk production and processing technology*. New India Publishing Agency.

Websites:

- GEA Dairy Processing Industry-https://gea.com/en/applications/dairy-processing/index.jsp
- IndiaDairy.com-https://indiaDairy.com
- Scherjon Dairy Equipment Holland: Dairy processing equipment-https://scherjon.eu/
- National Dairy Council-https:/nationaldairycouncil.org/
- Alfa Laval – Dairy Processing-https://alfalaval.in/industries/food-dairy-and-beverage/dairyprocessing

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Use of bio-protective factors for preservation of raw milk: effects on physico-chemical, microbial and nutritional properties of milk and milk products; Present status of preservation of raw milk.	6
2	**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; Nutritional aspects of UHT treated milk vis-à-vis retort sterilized/ HTST treated milk.	10
3	**Unit III** Principles and equipment for bactofugation and bactotherm processes; Partial homogenization and its application in dairy industry, Low pressure homogenization; Microfluidization of milk: Principle, equipment, effects and applications.	8
4	**Unit IV** Concentration processes and their impact on quality of finished products; Dehydration: advances in drying of milk and milk products; Freeze dehydration: physico-chemical changes and industrial developments; Glass Transition Temperature and its relevance to dried milks.	8
5	**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	8
6	**Unit VI** Current trends in cleaning and sanitization of dairy equipment; Automation, Ultrasonic techniques in cleaning; Bio-films; Bio-detergents, innovations in sanitizers - chemical, radiation; Mechanism of fouling and soil removal; Assessing the effectiveness of cleaning and sanitization of dairy equipment, Water conservation methods.	8
	TOTAL	**48**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	LP system for extending the keeping quality of raw milk	2
2	Measurement of thiocyanate in milk system	1

3	Determination of HCT-pH profile of milk, Determination of WPNI of milk powder	2
4	Determination of water activity and sorption isotherms of milk products	2
5	Functional properties of milk powders	1
6	Determination of HMF content in dried milks	2
7	Freeze drying of milk and milk products	1
8	Homogenization efficiency	2
9	Cleaning and sanitization efficiency of dairy equipment	1
10	Visit to a UHT Processing plant.	2
	Total	**16**

I. Course Title : Advances in Food Processing

II. Course Code : DT 512

III. Credit Hours : 4=3+1

IV. Why this course?

The basic principles of food processing, including dairy processing has been understood at undergraduate level. Any food plant has to be abreast with the latest developments taking place in the sphere of food processing, food product preservation, quality assurance and public health safety, automation, mechanization, etc. Information on composite foods may give an idea about foods formed using amalgamation of dairy foods with other food materials and ingredients. Knowledge of such aspects will help in developing value-added food products, cater to functional (health promoting) foods, adopting non-thermal processing methods to obtain food products having freshness and preserved nutrients and colour, etc.

V. Aim of the course

To provide in-depth understanding of advances in theoretical and practical aspects of food processing keeping in mind the nutritive value of product and its perishability.

VI. Theory:

Unit I

Status of food processing industry in India and abroad; Prospects and constraints in development of Indian food industry.

Unit II

Development in Post-harvest management of Fruits and Vegetables (Controlled and Modified Atmospheric Storage, Designing aspects of CAS/MAS, Components of CAS/MAS), hypobaric storage, harvesting indices for fruits and vegetables**.**

Unit III

Newer methods of drying of foods (Super-heated steam drying, Freeze drying, infra-red drying and microwave drying; Osmodrying process), Concepts of UHT and retort sterilization of food products, packaging materials for thermally processed foods.

Unit IV

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 V

Advances in milling of rice (solvent extractive milling) and Turbo milling of wheat. Emerging concepts in cereal processing including gluten free products, Low calories bakery products, Technologies for breakfast cereals, Utilization and importance of dairy ingredients in bakery products**.**

Unit VI

Definition, classification and technologies of fabricated and formulated foods and their nutritional aspects. Imitation dairy products and dairy analogues; meat 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. Fortification of staples

Unit VII

Non-thermal processing technologies for food: Principles, Effect on food constituents and Salient application in food sector/industry**.**

Unit VIII

Enzymes in food processing; newer concepts in food processing including organic foods; Processing of organic raw material; Genetically modified foods; Space foods, Nutrigenomics, metabolomics and other Omics concepts in food processing.

VII. Practical

- Experiments on MAS of fruits and vegetables
- Application of microwave for blanching and drying of foods
- Osmo air drying of fruits and vegetable
- Retort processing of food products
- Application of milk ingredients in caramel, egg-less cake, mayonnaise
- Enzymatic extraction and clarification of fruit juices
- Preparation of soymilk and tofu, Manufacture of sauerkraut/ fermented vegetables
- Preparation of protein isolates
- Application of extrusion processing for breakfast cereal and meat analogue manufacture
- Application of hydrocolloids in stabilization of proteins in acidified beverages
- Manufacture of low calorie and gluten-free cereal products.

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various food plants

IX. Learning outcome

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the latest post-harvest management of fresh produce with limited shelf life.
- To have an idea about the processing methods that do not diminish the quality attributes of food being processed.
- To know about the recent packaging methodologies that can enhance the shelf life of fresh as well as processed produce/food..
- To have any idea about the enzymes that can be used as processing aids.

X. Suggested Reading:

- Corredig M. 2009. *Dairy Derived ingredients: Foods and Nutraceutical Uses*. Washington DC: CRC press.
- Eskin Michael NA and Shahidi F. 2013. *Biochemistry of Foods*. 3rd Edn, Elsevier Publication.

- Fellows PJ. 2000. *Food Processing Technology: Principles and Practices*. 2nd Edn, CRC Press, London: Woodhead Publishing Ltd.
- Fennema CR. 1975. *Principles of Food Science*. Part-II: Physical principles of Food preservation. New York: Marcel Dekker.
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- Hui YH, Nip WK, Rogers RW and Young DA. 2001. *Meat Science and Application.* New York: Marcel Decker.
- Muthukumarappan K and Knoerzer K. 2020. *Innovations in Food Processing Technologies: A comprehensive review*, 1st ed., Elsevier.
- Penfield MP, and Campbell AM. 1990. *Experimental Food Science*. 3rdEdn. New York: Academic Press.
- Ramaswamy H and Marcotte M. 2006. *Food Processing: Principles and Applications*. USA: Taylor and Francis Group.
- Wrigley CW and Batey IL. 2010. *Cereal Grains: Assessing and Managing Quality.* Washington DC: CRC Press.

Websites:

- Ministry of Food Processing Industry-https://india.gov.in/official-website-ministry-food processing- industries-0
- Indian Food Industry, Food Processing Industry in India, Statistics-https://ibef.org
- *Food Processing – Make in India*-https://makeinindia.com/sector/food-processing
- *Welcome to APEDA*-https//*apeda.gov.in/*
- *Food safety and quality: Chemical risks and JECFA-FAO-https//fao.org/food/food-safetyquality/ scientific-advice/jecfa/en/*
- HACCP and GHP: Standards in Food Industry: (EUFIC)-https://eufic.org/en/food-safety/ article/food-industry-standards-focus-on-haccp

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Status of food processing industry in India and abroad; Prospects and constraints in development of Indian food industry.	4
2	**Unit II** Development in Post-harvest management of Fruits and Vegetables (Controlled and Modified Atmospheric Storage, Designing aspects of CAS/MAS, Components of CAS/MAS), hypobaric storage, harvesting indices for fruits and vegetables**.**	6

3	**Unit III** Newer methods of drying of foods (Super-heated steam drying, Freeze drying, infra-red drying and microwave drying; Osmodrying process), Concepts of UHT and retort sterilization of food products, packaging materials for thermally processed foods.	6
4	**Unit IV** 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	6
5	**Unit V** Advances in milling of rice (solvent extractive milling) and Turbo milling of wheat. Emerging concepts in cereal processing including gluten free products, Low calories bakery products, Technologies for breakfast cereals, Utilization and importance of dairy ingredients in bakery products	8
6	**Unit VI** Definition, classification and technologies of fabricated and formulated foods and their nutritional aspects. Imitation dairy products and dairy analogues; meatanalogues. 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. Fortification of staples.	8
7	**Unit VII** Non-thermal processing technologies for food: Principles, Effect on food constituents and Salient application in food sector/industry	4
8	**Unit VIII** Enzymes in food processing; newer concepts in food processing including organic foods; Processing of organic raw material; Genetically modified foods; Space foods, Nutrigenomics, metabolomics and other Omics concepts in food processing.	6
	Total	**48**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Experiments on MAS of fruits and vegetables	1
2	Application of microwave for blanching and drying of foods	1
3	Osmoair drying of fruits and vegetable	1
4	Retort processing of food products	1
5	Application of milk ingredients in caramel, egg-less cake, mayonnaise	2
6	Enzymatic extraction and clarification of fruit juices	1
7	Preparation of soymilk and tofu, Manufacture of sauerkraut/ fermented vegetables	2
8	Preparation of protein isolates	1

9	Application of extrusion processing for breakfast cereal and meat analogue manufacture	2
10	Application of hydrocolloids in stabilization of proteins in acidified beverages	2
11	Manufacture of low calorie and gluten-free cereal products.	2
	Total	**16**

I. Course Title : Rheology of Dairy and Food Products
II. Course Code : DS 513
III. Credit Hours : 3=2+1

IV. Why this course?

The mouth feel of processed food product is one of the parameters for the acceptance of foods. The sensory textural quality of food is closely related to the rheology of that pertinent food product. Any technological treatment meted out to dairy/food product leads to change in its rheological characteristics. Such treatment can be specifically practiced to improve the textural quality of food product. Rheology canbe used as a quality control tool to monitor the quality of food product being processed or manufactured.

V. Aim of the course

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.

VI. Theory:

Unit I

Introduction to rheology of foods: Definition of texture, rheology and psychophysics– their structural basis; Physical considerations in study of foods; Salient definition of 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; Mechanisms and relevant models for non-Newtonian flow; Effect of temperature on rheology; Composition alfactors affecting flow behaviour; Viscosity of food dispersions: dilute and semi dilute systems, concentration effects.

Unit III

Viscometers; Types (Co-axial cylinders, Spindle or Impeller type, Cone-plate, Capillary, Falling sphere, Vibratory, Extrusion, and Orifice), comparative assessment, merits and limitations; Rheometer: principles and operational features.

Unit IV

Rheological characterization of semi-solid and solid foods; 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 ofextensional 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; Microstructure of dairy products; Tribology and its applications.

VII. Practical:

- Study of different types of viscometers.
- Flow behaviour of fluid dairy products.
- Thixotropy in ice-cream mix.
- Force-deformation study in selected dairy products using Texture Analyzer.
- Effect of test conditions on the texture profile parameters of dairy products.
- Stress relaxation studies in solid foods.
- Use of Cone Pen-etrometer and FIRA-NIRD extruder for measurement of butter texture.
- Assessment of pasting profile of starch/flours using visco analysers.
- Oscillatory measurements using Rheometer.

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various food plants

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- Classify food products based on their rheological characteristics
- Understand the relationship between instrumental rheology and sensory perception of food
- To recommend use of textural analysis of dairy and food product for its quality control aspect
- To recommend specific type of instrument for textural analysis of specific type offood (fluid or solid)

X. Suggested Reading

- Ahmed J, Ptaszek P and Basu S. (Eds.). 2016. *Advances in Food Rheology and itsApplications.* Amsterdam: Woodhead Publishing.
- Barnes HA, Hutton JF and Walters K. 1989. *An introduction to rheology*. Elsevier Pub.
- Bourne M 2002. *Food texture and viscosity: Concept and Measurement*. London: Elsevier Pub.
- Irgens F. 2014. *Rheology and Non-Newtonian Fluids*. New York: Springer International Publishing.
- Malkin AY and Isayev AI. 2017. *Rheology: Concepts, methods, and applications*. Toronto: ChemTec Publishing.
- Mezger TG. 2006. *The Rheology Handbook: For Users of Rotational and Oscillatory Rheometers.* Hannover: Vincentz Network GmbH and Co KG.
- Mohsenin NN. 1970. Physical properties of plant and animal materials. Vol. 1. Structure, physical characteristics and mechanical properties. New York: Gordon and Breach Science Publishers.

- Norton IT, Spyropoulos F and Cox P. (Eds.). 2010. *Practical Food Rheology: An Interpretive Approach*. John Wiley and Sons.
- Rao MA. 2013. *Rheology of fluid, semisolid and solid foods: Principles and applications.*New York: Springer Science and Business Media.
- Sherman P. 1979. *Food texture and rheology*. London: Academic press.

Websites:

- Texture in Food Production – Food Technology Corporation https://www.foodtechcorp.com/texture-food-production
- Universal testing / Tensile testing machine: SCHIMADZU https//shimadzu.com/an/test/universal/index.html
- Texture Analysis System and Software –Food Online https://foodonline.com/doc/texture-analysis-system-and-software-0001

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Introduction to rheology of foods: Definition of texture, rheology and psychophysics– their structural basis; Physical considerations in study of foods; Salient definitions of stress tensor and different kinds of stresses.	4
2	**Unit II** Rheological classification of Fluid Foods: Shear-rate dependence and time dependence of the flow-curve; Non-Newtonian fluids; Mechanisms and relevantmodels for non-Newtonian flow; Effect of temperature on rheology; Compositional factors affecting flow behaviour; Viscosity of food dispersions: dilute and semi dilute systems, concentration effects.	6
3	**Unit III** Viscometers; Types (Co-axial cylinders, Spindle or Impeller type, Cone-plate, Capillary, Falling sphere, Vibratory, Extrusion, and Orifice), comparative assessment, merits and limitations; Rheometer: principles and operational features.	4
4	**Unit IV** Rheological characterization of semi-solid and solid foods; Mechanical models forvisco elastic foods (Maxwell, Kelvin, Burgers and generalized models) and their application; Dynamic measurement of viscoelasticity.	6
5	**Unit V** Large Deformations and failure in foods: Definitions of fracture, rupture and othe rrelated phenomena; Texture Profile Analysis; Instrumental measurements: Empirical and fundamental methods; Rheometers and Texture Analyzers; Measurement ofextensional viscosity; Acoustic measurements on crunchy foods	6
6	**Unit VI** Rheological and textural properties of selected dairy products; Measurement modes and techniques; Effect of processing and	6

	additives (stabilizers and emulsifiers) onfood product rheology; Relationship between instrumental and sensory data; Microstructure of dairy products; Tribology and its applications.	
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1.	Study of different types of viscometers.	1
2.	Flow behavior of fluid dairy products.	2
3.	Thixotropy in ice-cream mix	2
4.	Force-deformation study in selected dairy products using Texture Analyzer	2
5.	Effect of test conditions on the texture profile parameters of dairy products	2
6.	Solubility index of milk product	2
7.	Use of Cone Penetrometer and FIRA-NIRD extruder for measurement of butter texture	2
8.	Assessment of pasting profile of starch/flours using visco analysers	2
9.	Oscillatory measurements using Rheometer	1
	Total	**16**

I. Course Title : Biotechnology for Dairy Applications

II. Course Code : DT-514

III. Credit Hours : 3=2+1

IV. Why this course?

Biotechnology is a tool for the value addition to dairy foods. Genetic techniques have been employed to manipulate bacteria that have significance to the dairy industry. Biotechnological means can be used to regulate the production of flavor enhancing metabolites and to develop starter cultures that are resistant to bacteriophage and bacteriocins. Genetic engineering will be able to deliver dairy foods that can be tolerated by lactose intolerant persons or for persons who are allergic to milk proteins too.

V. Aim of the course

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

VI. Theory:

Unit I

Introduction to process biotechnology; Principles of recombinant DNA technique; Development and impact of biotechnology on dairy and food industry.

Unit II

Microbial rennet and recombinant chymosin - characteristics and applications in cheese making; exogenous free and microencapsulated enzymes. Immobilized enzymes - their application in continuous coagulation of milk in cheese making; Enzyme modified cheeses (EMC) - their utilization in various food formulations.

Unit III

Technological requirements of modified micro-organisms for applications in cheese, Probiotic and fermented milk products; physiologically active bio-peptides/ nutraceuticals.

Unit IV

Protein hydrolysates - production, physico-chemical, therapeutic properties and application in food formulations; Enzymatic hydrolysis of lactose for preparation of whey and UF-permeate beverages; Continuous lactose hydrolysis of whey.

Unit V

Microbial polysaccharides - their properties and applications in foods; Production of alcoholic beverages; Bio-sweeteners - Types, properties and their applications in dairy and food industry.

Unit VI

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

VII. Practical:

- Effect of exogenous enzymes on hydrolysis of protein and fat in culture containing milk systems
- Factors affecting the coagulation of milk by microbial and vegetable rennets
- Manu-facture and evaluation of probiotic cheese and fermented milks
- Preparation of Enzyme Modified Cheese

- Determination of glycolysis, proteolysis and lipolysis in cheese and fermented milks
- Enzymatic process for manufacture of low lactose milk/whey products
- Preparation of casein hydrolysates
- Visit to a bio-processing unit.

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various Cheese plants

IX. Learning outcome

After undergoing this course, the students are expected to deliver the following:

- To have any idea about the enzymes that can be used as processing aids.
- Have knowledge on the latest biotechnological approaches to add value to the dairy product
- Ability to produce protein hydrolysates
- Application of biotechnology for bio-preservation of dairy foods

X. Suggested Reading

- Aluko RE. (Ed.). 2012. *Functional Foods and Nutraceuticals*. Springer.
- Bhat R, Alias AK and Paliyath G. 2012. *Progress in Food Preservation*. John Wiley and Sons Ltd. (Print ISBN: 9780470655856. Online ISBN: 9781119962045) DOI: 10.1002/ 9781119962045.
- Coffey AG, Daly C and Fitzgerald G. 1994. The impact of biotechnology on the dairy industry. Biotechnology Advances, 12(4): 625-633. Elsevier Pub. doi.org/10.1016/0734-9750(94)90003-5

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Introduction to process biotechnology; Principles of recombinant DNA technique; Development and impact of biotechnology on dairy and food industry.	4
2	**Unit II** Microbial rennet and recombinant chymosin - characteristics and applications in cheese making; exogenous free and microencapsulated enzymes. Immobilized enzymes - their application in continuous coagulation of milk in cheese making; Enzyme modified cheeses (EMC) - their utilization in various food formulations.	6
3	**Unit III**	6

	Technological requirements of modified micro-organisms for applications in cheese, Probiotic and fermented milk products; physiologically active bio-peptides/nutraceuticals.	
4	**Unit IV** Protein hydrolysates - production, physico-chemical, therapeutic properties and application in food formulations; Enzymatic hydrolysis of lactose for preparation of whey and UF-permeate beverages; Continuous lactose hydrolysis of whey	**6**
5	**Unit V** Microbial polysaccharides - their properties and applications in foods; Production of alcoholic beverages; Bio-sweeteners - Types, properties and their applications in dairy and food industry.	**6**
6	**Unit VI** Bio-preservatives - characteristics and their applications in enhancing the shelf life	**4**
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical's
1	Effect of exogenous enzymes on hydrolysis of protein and fat in culture containing milk systems	**2**
2	Factors affecting the coagulation of milk by microbial and vegetable rennet's	**2**
3	Manufacture and evaluation of probiotic cheese and fermented milks	**2**
4	Preparation of Enzyme Modified Cheese	**2**
5	Determination of glycolysis, proteolysis and lipolysis in cheese and fermented milks	**2**
6	Enzymatic process for manufacture of low lactose milk/whey products	**2**
7	Preparation of casein hydrolysates	**2**
8	Visit to a bio-processing unit.	**2**
	Total	**16**

I. Course Title : Advances in Traditional Indian Dairy Products

II. Course Code : DS 515

III. Credit Hours : 3=2+1

IV. Why this course?

Traditional Indian dairy products (TIDP) especially the sweetmeats have its own significance in Indian diet and have tremendous export potential. The application of strict hygiene in manufacture of such TIDPs is the need of the day and its technology up gradation (especially mechanization and automation) from research level to industry level needs to be harnessed. Even there is an urgent need to have knowledge about the 'Techno-economic aspects for establishing commercial units for traditional dairy products'. Enhancement in the shelf life of TIDPs has been still a challenging task in the dairy industry. Dairy Science and Technology: Dairy Technology

V. Aim of the course

To project the present status, modernization and globalization of production of traditional Indian dairy products with a focus on process innovation, shelf life, quality and functionality enhancement.

VI. Theory;

Unit I

Global prospects and export potential of traditional Indian dairy products.

Unit II

Differences in quality of traditional dairy products from cow, buffalo, goat, camel, and sheep milks; Process innovations in commercial production of heat-desiccated ,coagulated and fermented traditional dairy products; Mechanized production of traditional milk based sweets; Automation for manufacture of ghee, *paneer*, *dahi*,*lassi* and traditional sweetmeats.

Unit III

Composite traditional milk products; Application of membrane technology and microwave processing for industrial production of traditional Indian dairy products.

Unit IV

Technologies for region specific traditional Indian dairy products and their value addition, their application as a vehicle for delivering functional ingredients; Manufacture of dietetic traditional dairy products.

Unit V

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

Unit VI

Convenience traditional dairy products; Food safety issues; Shelf life extension of food using newer techniques; Novel packaging and preservatives.

VII. Practical:

- Production of reduced calorie, composite and functional traditional Indian dairy products.
- Microwave heating of traditional Indigenous milk delicacies for shelf life extension.

- Membrane technology for improving the quality of traditional Indigenous products made from cow and buffalo milk.
- Preparation of feasibility report for establishing commercial units for traditional dairy products.

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various dairy plants

IX. Learning outcome

After undergoing this course, the students are expected to deliver the following:

- Have an idea about the global prosper and export potential of TIDPs.
- Be an entrepreneur in delivering mechanized production of certain TIDPs including automation, wherever feasible.
- Be able to recommend the methods to enhance the shelf life of perishable TIDPs and recommend the type of packaging technology to be used for safety and shelf life extension.

X. Suggested Reading:

- Aneja RP, Mathur BN, Chandan RC and Banerjee AK. 2002. *Technology of Indian dairy products.* A Dairy India Publication. Restructured and Revised Syllabi of Post-graduate Programmes Vol. 4
- Goyal MR, Kumar A and Gupta AK. 2018. *Novel Dairy Processing Technologies: Techniques, Management, and Energy Conservation*. CRC Press.
- Puniya AK. 2015. *Fermented Milk and Dairy Products;* CRC Press/Taylor and Francis (ISBN9781466577978)
- Shrott C and O'Brien. 2003. *Handbook of Functional Dairy Products*. CRC Press
- *TetraPak Dairy Processing Handbook.* 2015. www.dairypeocessinghandbook.com.

Websites:

- Indian Dairy Product Market–Indian Council of Food and Agriculture–https//icfa.org.in/assets/doc/reports/Indian_Dairy_Product_Market.pdf
- Mechanized production of Indian Dairy Products–AMEFT–https//download.ameft.com/MechanisedProduction.pdf
- Indian Dairy Industry–Aavin – https//aavinmilk.com/dairyprofile.html
- Present Status of Traditional Dairy Products–Technische–TIB–https://www.tib.eu/en/search/id/./Present-Status-of-Traditional-Dairy-Products/

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Global prospects and export potential of traditional Indian dairy products.	**2**
2	**Unit II** Differences in quality of traditional dairy products from cow, buffalo, goat, camel, and sheep milks; Process innovations in commercial production of heat-desiccated, coagulated and fermented traditional dairy products; Mechanized production of traditional milk based sweets; Automation for manufacture of ghee, *paneer*, *dahi*, *lassi*and traditional sweetmeats.	**10**
3	**Unit III** Composite traditional milk products; Application of membrane technology and microwave processing for industrial production of traditional Indian dairy products.	**4**
4	**Unit IV** Technologies for region specific traditional Indian dairy products and their value addition, their application as a vehicle for delivering functional ingredients; Manufacture of dietetic traditional dairy products.	**10**
5	**Unit V** Techno-economic aspects for establishing commercial units for traditional products.	**2**
6	**Unit VI** Convenience traditional dairy products; Food safety issues; Shelf life extension of food using newer techniques; Novel packaging and preservatives.	**4**
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Production of desiccated Indian dairy products	2
2	Production of heat acid coagulated Indian dairy products	2
3	Production of reduced calorie Indian dairy products.	2
4	Production of composite Indian dairy products.	2
5	Production of functional traditional Indian dairy products.	3
6	Microwave heating of traditional Indigenous milk delicacies for shelf life extension	2
7	Membrane technology for improving the quality of traditional Indigenous products made from cow and buffalo milk.	1
8	Preparation of feasibility report for establishing commercial units for traditional dairy products	2
	Total	**16**

I. Course Title : Non-Conventional Processes for Dairy and Food Industry

II. Course Code : DT 516

III. Credit Hours : 3= 2+1

IV. Why this course?

Unravelling the truths based on the knowledge of 'science and technology' has paved the way for development of several non-conventional technologies. These when used judiciously can have advantage in minimizing the changes in the colour, nutritive value and textural quality of dairy and food products. Certain nonconventional processes may be used as adjunct to the conventional processing technology to reap the benefits from use of such synergistic effects**.**

V. Aim of the course

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

VI. Theory:

Unit I

Irradiation: sources and properties of ionizing radiation; Mechanism of interaction with microorganisms and food components; Chemi-cal effects; Industrial irradiation systems, benefits and limitations; UV pasteurization of milk; Safety aspects inradiation processing; National and international regulations in relation to radiation processing; Cold plasma processing**.**

Unit II

High frequency heating (Microwave and Radio frequency processing): Principles, merits and demerits; Design and working of processing units; Applications in dairyand food processing; Microwavable packaging; Safety aspects**.**

Unit III

Infra-red (IR) heating and Ohmic heating: Principle, equipment and applications.

Unit IV

Ultrasonic treatment of food: Mechanism of ultrasound induced cell damage, generation of ultrasound, design of power ultrasonic system, types of ultrasonic reactors, application of power ultrasound in food processing, effects on food constituents, ultrasound in amalgamation with other food processing operations – thermo-sonication, manosonication, thermo-manosonication, advantages and future prospects.

Unit V

High hydrostatic pressure (HHP) processing: Principle of microbial inactivation, barotolerance of microorganisms, effect on food constituents; equipment; dairy and food applications; Merits and demerits of HHP.

Unit VI

Pulsed electric field processing; Description/ mechanism and factors affecting microbial inactivation; effects on food components; Present status and future scope for food applications**.**

Unit VII

Super-critical Fluid Extraction; Principle, instrumentation and applications.

VII. Practical:

- Market survey of food products processed using non-conventional technologies • Pasteurization and concentration of milk using ohmic heating
- Degassing of fluids using ultrasound
- Determination of power output and temperature profile of a microwave oven
- Effect of chemical composition on heating behaviour of milk and milk products
- Microwave pasteurization of milk
- Effect of shape and size of container on microwave heating
- Preparation of 'instant' products in a microwave oven
- Visit to a commercial food processing facility.

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various food processing plants

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To recommend use of feasible non-conventional technology for processing and shelf life extension of food
- Application of non-conventional processing technology as adjunct processing for accomplishing hurdle technology for dairy and food products
- To visualize the difference in the physico-chemical properties and microbial changes in dairy/food product when adopting traditional vs. non-conventional technology

X. Suggested Reading

- Chen D, Sharma SK and Mudhoo A. 2012. *Handbook on applications of ultrasound sonochemistry*
- *for sustainability*. Boca Raton: Taylor and Francis Group, LLC, 273-739.
- Delgado A, Kulisiewicz L, Rauh C and Wiersche A. 2012. *Novel thermal and non-thermal technologies for fluid foods.* New York: Academic Press.
- Monika Willert-Porada. 2001. Advances in Microwave and Radio Frequency Processing. Report from the 8th International Conference on 'Microwave and high frequency heating 'held in Bayreuth, Germany, 2001.
- Nanda V and Sharma S. 2017. *Novel food processing technologies.* New India Publishing Agency, New Delhi, India.
- Raso J and Heinz V. 2006. *Pulsed electric fields technology for the food industry fundamentals and applications*. Springer Science + Business Media, LLC, USA.
- Zhang HQ, Barbosa-Canovas GV, Balasubramaniam VM, Dunne CP, Farkas DF and Yuan JT. (Eds.). 2011. *Non-thermal processing technologies for food* (Vol. 45). John Wiley and Sons.

Websites:

- Microwave-assisted green extraction technology for sustainable food processing- https:// intechopen.com/books/emerging-microwave-technologies-in-industrial-agricultural-medicaland- food-processing/microwave-assisted-green-extraction-technology-for-sustainable-foodprocessing
- Ultrasound in the food industry– https://hielscher.com/food_01.htm; Microwave assisted extraction (MAE)-https://slideshare.net/Nabiilah/microwave-assisted-extraction

Teaching Schedule:

Theory :

Sr. No.	Topic	No of lecture (s)
1	**Unit I** Irradiation: sources and properties of ionizing radiation; Mechanism of interaction with microorganisms and food components; Chemical effects; Industrial irradiation systems, benefits and limitations; UV pasteurization of milk; Safety aspects in radiation processing; National and international regulations in relation to radiation processing; Cold plasma processing**.**	**6**
2	**Unit II** High frequency heating (Microwave and Radio frequency processing): Principles, merits and demerits; Design and working of processing units; Applications in dairy and food processing; Microwavable packaging; Safety aspects**.**	**6**
3	**Unit III** Infra-red (IR) heating and Ohmic heating: Principle, equipment and applications.	4
4	**Unit IV** Ultrasonic treatment of food: Mechanism of ultrasound induced cell damage, generation of ultrasound, design of power ultrasonic system, types of ultrasonic reactors, application of power ultrasound in food processing, effects on food constituents, ultrasound in amalgamation with other food processing operations –thermo-sonication, manosonication, thermo-manosonication, advantages and future prospects.	**6**
5	**Unit V** High hydrostatic pressure (HHP) processing: Principle of microbial inactivation, barotolerance of microorganisms, effect on food constituents; equipment; dairy and food applications; Merits and demerits of HHP.	**4**
6	**Unit VI** Pulsed electric field processing; Description/ mechanism and factors affecting microbial inactivation; effects on food components; Present status and future scope for food applications**.**	**4**
7	**Unit VII** Super-critical Fluid Extraction; Principle, instrumentation and applications.	**2**
	Total	**32**

Practical :

Sr. No.	Topic	No. of Practical's
1	Market survey of food products processed using non-conventional technologies	2
2	Pasteurization and concentration of milk using ohmic heating	2
3	Degassing of fluids using ultrasound	2
4	Determination of power output and temperature profile of a microwave oven	2
5	Effect of chemical composition on heating behaviour of milk and milk products	2
6	Microwave pasteurization of milk	1
7	Effect of shape and size of container on microwave heating	1
8	Preparation of 'instant' products in a microwave oven	2
9	Visit to a commercial food processing facility	2
	Total	**16**

I. Course Title : Membrane Processing for Dairy Applications

II. Course Code : DS 521

III. Credit Hours : 3=2+1

IV. Why this course?

Amongst non-thermal processes for dairy applications, membrane processing is one of the significant illustrations. Membrane processing has helped the dairy industry, not only to obtain dairy ingredients with high protein and low lactose content, but even to recover the important whey proteins from the by-product – whey. Salient application of use of membrane processed milk concentrate is in cheese making and in concentrated and dried milk manufacture.

V. Aim of the course

To elucidate the basics of membrane technology and its applications in dairy Processing.

VI. Theory:

Unit I

Membrane techniques; Classification and characteristics of filtration processes; types of commercially available membranes; membrane hardware, design of membrane plants, modelling of ultrafiltration (UF) processes, mass transfer model, resistance model; Membrane fouling-problems and mitigation strategies; Cleaning and sanitization of different types of membranes.

Unit II

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

Unit III

Applications of ultrafiltration (UF), reverse osmosis, nanofiltration and microfiltrationin the dairy industry: food and pharmaceutical grade lactose, low lactose milk powder, dairy whiteners, WPC, WPI, MPC, MPI, Native micellar casein powder, etc. Preparation, properties and uses of Milk Protein Concentrate (MPC) and Milk Protein Isolate (MPI); Manufacture of some cheeses and fermented milk products and impact of membrane processing on quality of such products. Use of membrane processing techniques for separating prophylactic biological from milk.

Unit IV

Demineralization: principles, processes, equipment and applications.

Unit V

Functional properties of whey proteins (WPC and WPI), micellar casein and UF milk retentate and their modifications.

VII. Practical:

- Factors affecting permeate flux during membrane processing (type of feed, temperature, transmembrane pressure, etc.)
- Effect of microfiltration of skim milk and whey on fat content and microbial count
- Preparation of WPC, WPI, MPC, native micellar casein, etc.
- Evaluating the functional properties of milk proteins.

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various dairy plants

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To recommend use of membrane processed milk in manufacture of selected dairy products
- Application of specific membrane processes for milk/whey to prepare certain prophylactic biological
- To recommend the suitable cleaning and sanitization agents to take care of cleaning and sanitization of specific type of membrane used in membrane processing of milk.

X. Suggested Reading:

- Baker RW. (Ed.) 2012. *Membrane Technology and Applications*, 3rd Edn, Wiley Publishers.
- Cooper A.R. (Ed.) 2013. *Ultrafiltration Membranes and Applications* (Vol. 13). Springer Science and Business Media.
- Field RW, Bekassy-Molnar E, Lipnizki F and Vatai G. 2017. *Engineering Aspects ofMembrane Separation and Application in Food Processing*. CRC Press.
- Fuquay JW, Fox PF and Mc Sweeney PL. 2011. *Encyclopedia of Dairy Sciences.* Academic Press.
- Hu K and Dickson J. (Eds.). 2015. *Membrane Processing for Dairy Ingredient Separation.* John Wiley and Sons.
- Mohanty K and Purkait M. 2011. *Membrane Technologies and Applications*. CRC Press, Taylor and Francis Group.
- Tamime AY. (Ed.). 2013. *Membrane processing: Dairy and beverage applications.* Wiley-Blackwell Publishers, pp. 1-370.

Websites:

- Membrane technology in Dairy Industry – Slideshare https://slideshare.net/./membranetechnology-in-dairy-industry
- Specialty and Dairy – Products – Toray Membrane- https://toraywater.com/products/ specialty/index.html
- Membrane filtration in the dairy industry GEA-https://gea.com/en/binaries/gea-membranefiltration-brochure-for-dairy-industry_tcm11-17109.pdf

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Membrane techniques; Classification and characteristics of filtration processes; types of commercially available membranes; membrane hardware, design of membrane plants, modelling of ultrafiltration (UF) processes, mass transfer model, resistance model; Membrane fouling-problems and mitigation strategies; Cleaning and sanitization of different types of membranes	**10**
2	**Unit II** Factors affecting permeate flux during ultrafiltration and reverse osmo-sis of milk and sweet/sour whey, energy requirements for membrane processing of milk and whey.	**4**
3	**Unit III** Applications of ultrafiltration (UF), reverse osmosis, nanofiltration and microfiltration in the dairy industry: food and pharmaceutical grade lactose, low lactose milk powder, dairy whiteners, WPC, WPI, MPC, MPI, Native micellar casein powder, etc. Preparation, properties and uses of Milk Protein Concentrate (MPC) and Milk Protein Isolate (MPI); Manufacture of some cheeses and fermented milk products and impact of membrane processing on quality of such products. Use of membrane processing techniques for separating prophylactic biological from milk.	**10**
4	**Unit IV** Demineralization: principles, processes, equipment and applications.	**4**
5	**Unit V** Functional properties of whey proteins (WPC and WPI), micellar casein and U Fmilk retentate and their modifications.	**4**
6	**Total**	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Factors affecting permeate flux during membrane processing (type of feed temperature, transmembrane pressure, etc.)	4
2	Effect of microfiltration of skim milk and whey on fat content and microbial count	4
3	Preparation of WPC, WPI, MPC, native micellar casein, etc.	4
4	Evaluating the functional properties of milk proteins	4
	Total	**16**

I. Course Title : Advances in Dairy and Food Packaging
II. Course Code : DS 522
III. Credit Hours : 3=2+1

IV. Why this course?

Packaging of food though carried out towards the end of product manufacture has a great role to play in conserving the processed food in its original state – including freshness of fresh food. Packaging plays a crucial role in acceptance of the food product by the consumer and the extensibility of the shelf life of the food being packaged, especially using advanced techniques such as MAP, active packaging, etc.

V. Aim of the course:

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

VI. Theory:

Unit I

Trends in packaging industry; designing framework for packaging; Testing of packaging materials.

Unit II

Adhesives; Graphics; Coding (Barcode and Quick Response code), and labeling used in food packaging.

Unit III

Protective packaging of foods; Effect of light, oxygen and moisture on packaged food.

Unit IV

Packaging of dairy products, convenience foods, fresh produce and fruits and vegetable products, Packaging of fats and oils, spices, meat, poultry, fish and other sea foods.

Unit V

Modified atmosphere packaging, Shrink and stretch packaging; Self-heating and self-cooling cans.

Unit VI

Retort pouch technology, microwavable, biodegradable, and edible packages; Principles and applications of Active Packaging, Smart and Intelligent Packaging, Antimicrobial packaging.

Unit VII

Industrial packaging: unitizing, palletizing, containerizing, distribution systems for packaged foods.

Unit VIII

Safety aspects of packaging materials; sources of toxic materials and migration of toxins into food materials, packaging and flavour interaction.

VII. Practical:

- Testing of packaging materials for quality assurance: thickness, GSM, grease resistance, bursting strength, tearing resistance, WVTR, puncture resistance
- Estimation and prediction of shelf life of packaged foods

- Development of edible, biodegradable and antimicrobial films
- MAP of perishable foods
- Effect of edible coatings on respiration behaviour of fruits and vegetables
- Application of oxygen scavengers in packaged foods.
- Collection of packaging material and making a album

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various food processing plants

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To recommend the type of package suitable for specific type of dairy or other food Products
- To employ intelligent packaging techniques in food packaging to warn the public in case of impeding health hazard
- Recommending SOPs to the food industry personnel to avoid migration of toxic substances from the package into the food system

X. Suggested Reading:

- Coles R, McDowell D and Kirwan MJ. 2003. *Food Packaging Technology*. Oxford: OxfordBlackwell. Frank, A., Paine, H., and Paine, Y. (1983). *A Handbook of Food Packaging*. Glasgow: Leonard Hill.
- Gordon LR. 2013. *Food Packaging: Principles and Practi*ce, 3rd Edn., Florida, USA: CRCPress, Taylor and Francis Group.
- Han JH. 2005. *Innovations in Food Packaging*. Elsevier Science and Technology Books.
- Parry RT. 1993. *Principles and Applications of Modified Atmosphere Packaging of Foods*. Dordrecht: Springer Science+Business Media.
- Piergiovanni L and Limbo S. 2015. Food Packaging Materials. In: *Chemistry of Foods*, Springer Publishers.
- Raija A. 2006. *Novel Food Packaging*. England: Woodland Publishing Co.
- Robertson GL. (Ed.). 2012. *Food Packaging: Principles and Practice*. 3rd Edn., Florida, US: CRC Press.
- Robertson GL. 2010. *Food Packaging and Shelf Life: A Practical Guide*. Boca Raton: CRC Press.
- Yam KL. 2009. *The Wiley Encyclopedia of Packaging Technology*, 3rd Edn., USA: John Wileyand Sons, Inc.

Websites:

- Indian Institute of Packaging-https//iip-in.com.

- The Regulation of Food Packaging- https://www.packaginglaw.com/specialocus/regulation food-packaging
- Packaging Industry Servies-www.nsf.org/services/by-industry/food-safety-quality/packaging

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Trends in packaging industry; designing framework for packaging; Testing of packaging materials.	4
2	**Unit II** Adhesives; Graphics; Coding (Barcode and Quick Response code), and labeling used in food packaging.	4
3	**Unit III** Protective packaging of foods; Effect of light, oxygen and moisture on packaged food.	4
4	**Unit IV** Packaging of dairy products, convenience foods, fresh produce and fruits and vegetable products, Packaging of fats and oils, spices, meat, poultry, fish and other sea foods.	6
5	**Unit V** Modified atmosphere packaging, Shrink and stretch packaging; Self-heating and self-cooling cans.	2
6	**Unit VI** Retort pouch technology, microwavable, biodegradable, and edible packages; Principles and applications of Active Packaging, Smart and Intelligent Packaging, Antimicrobial packaging.	4
7	**Unit VII** Industrial packaging: unitizing, palletizing, containerizing, distribution systems for packaged foods.	4
8	**Unit VIII** Safety aspects of packaging materials; sources of toxic materials and migration of toxins into food materials, packaging and flavour interaction.	4
	Total	32

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Testing of packaging materials for quality assurance: thickness, GSM, grease resistance, bursting strength, tearing resistance, WVTR, puncture resistance	6
2	Estimation and prediction of shelf life of packaged foods	2
3	Development of edible, biodegradable and antimicrobial films	2
4	MAP of perishable foods	2

5	Effect of edible coatings on respiration behaviour of fruits and vegetables	2
6	Application of oxygen scavengers in packaged foods	2
7	Collection of packaging material and making a album	----
	Total	**16**

I. Course Title : Technology of Food Emulsions, Foams and Gels
II. Course Code : DT 523
III. Credit Hours : 3=2+1

IV. Why this course?

In order to improve the viscosity or rheological characteristics of food systems, certain food additives such as stabilizers, emulsifier and even foaming agents play a significant role. The chances of probability of defect in certain food products can be circumvented through use of such food additives. Emulsifiers play a great role in maintaining emulsion of two or multiple phases in the food system till its consumption. Foaming agents are of significance in ice cream, whipping cream, meringue, certain baked goods, etc.

V. Aim of the course:

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

VI. Theory:

Unit I

Food dispersions, their characteristics and factors affecting food dispersions.

Unit II

Food emulsions; Emulsifiers and their functions in foods; HLB concept for food emulsifiers; Emulsion formation and stability; Surfactants.

Unit III

Dairy based foams and their applications, structure of foams; Egg foams and uses; Foam formation and stability.

Unit IV

Theory of gel formation; Carbohydrate and protein based gels. Gelled milk products. Advances in food gels (organogel, hydrogel and nanogel).

Unit V

Structure of dairy based emulsions, foams and gels; blend of stabilizers and emulsifiers; Effect of stabilizers and/or emulsifiers on functional properties of dairy foods; Aerosols and propelling agents in foamed dairy products.

Unit VI

Techniques for evaluating the structure of food emulsions, foams and gels.

VII. Practical:

- Determination of emulsifying efficiency and emulsion stability
- Examination of foaming capacity and foam stability
- Gel formation and gel properties
- Preparation of hydrogels and organogels
- Preparation of single and double emulsions.

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review

- Student presentation
- Group Work and Group Discussion
- Visit to various food processing plants

IX. Learning outcome

After undergoing this course, the students are expected to deliver the following:

- To be able to recommend specific type of food additive from amongst stabilizers and emulsifiers for stability of the food system
- Be able to recommend solution to the food processor to improve upon the textural quality of food products through use of food additives like stabilizers and/or emulsifiers
- To make the food processors understand how the type of emulsion in question in the food product has a bearing on the functional property of that specific food product

X. Suggested Reading

- Rajah KK. (Ed.). 2014. Emulsifiers and stabilisers. Chapter 7.Young, N.W.G. *Fats in food technology*.UK: John Wiley and Sons Ltd. (ISBN: 9781405195423).
- Valdez B. (Ed.) 2012. Milani J and Maleki G. Hydrocolloids in food industry. Chapter in Book. *Food industrial processes – Methods and equipment*. In Tech Europe, Rijeka, Croatia, pp. 1-418 (www.InTechopen.com)
- Whitehurst RJ. (Ed.). 2004. *Emulsifiers in food technology*. 1st Edn. Wiley-Blackwell Publisher, pp. 1-264. (ISBN-13 978-1405118026).

Websites:

- Stabilizers – Specialty food ingredients – Federation of European Specialty Food Ingredients Industry-https://specialtyfoodingredients.eu/ingredients-and-benefits/group/stabilizers
- Emulsifier Solutions – Corbion-https://corbion.com/base/DownloadHelper/DownloadFile/ 8386

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture(s)
1	**Unit I** Food dispersions, their characteristics and factors affecting food dispersions.	4
2	**Unit II** Food emulsions; Emulsifiers and their functions in foods; HLB concept for food emulsifiers; Emulsion formation and stability; Surfactants.	6
3	**Unit III** Dairy based foams and their applications, structure of foams; Egg foams and uses; Foam formation and stability	4
4	**Unit IV**	6

	Theory of gel formation; Carbohydrate and protein based gels. Gelled milk products. Advances in food gels (organogel, hydrogel and nanogel).	
5	**Unit V** Structure of dairy based emulsions, foams and gels; blend of stabilizers and emulsifiers; Effect of stabilizers and/or emulsifiers on functional properties of dairy foods; Aerosols and propelling agents in foamed dairy products.	6
6	**Unit VI** Techniques for evaluating the structure of food emulsions, foams and gels	6
	Total	**32**

Practical's:

Sr,No.	Topic	No of Practical's
1	Determination of emulsifying efficiency and emulsion stability	4
2	Examination of foaming capacity and foam stability	4
3	Gel formation and gel properties	4
4	Preparation of hydrogels and organogels	2
5	Preparation of single and double emulsions	2
	Total	**16**

I. Course Title : Functional Foods and Nutraceuticals
II. Course Code : DS 524
III. Credit Hours : 4=3+1

IV. Why this course?

Ingestion of food possessing nutraceuticals can sustain and maintain human health – free from diseases. Today's consumers are aware about the health promoting foods and if the industry launches functional foods, there are takers for such foods. Several herbs and spices are known to contain components that have nutraceutical value. Ayurveda system is built on such naturally available materials. However, consumer does want to seek food that can sustain their health and nutritional requirement – not to rely on medicines. Fermented probiotic foods are the latest prominent functional foods.

V. Aim of the course:

To impart knowledge about functional ingredients and nutraceuticals and their utilization in developing physiologically beneficial health foods, functional foods and speciality foods.

VI. Theory:

Unit I

Classes of functional foods and their status.

Unit II

Functional ingredients; Classification; Dietary and therapeutic significance.

Unit III

Food fortification; Significance and techniques of fortifying foods with functional ingredients.

Unit IV

Infant nutrition; Dietary formulations, special needs, additives; Geriatric Foods: Design considerations, ingredients, special needs; Sports foods: Significance, strategies and design considerations.

Unit V

Reduced calorie foods: Significance, strategies, additives (fat replacers, bulking agents, non-nutritive sweeteners).

Unit VI

Low sodium and low lactose foods: Nutritional and health significance.

Unit VII

Herbs; Classification; Therapeutic potential, applications; Phytochemicals; Classes; Physiological role; Applications; Bioactive ingredients from animal and marine sources.

Unit VIII

Probiotic, prebiotic and synbiotic foods: Concept and applications.

VII. Practical

- Determination of soluble and insoluble fibre
- Determination of antioxidant activity of functional ingredient/food.
- Determination of in vitro bioavailability of nutrients
- b-galactosidase activity for low-lactose dairy products

- Prebiotic potential of selected plant/milk components
- Probiotic potential of selected microorganisms
- Preparation of functional foods

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various food processing plants

IX. Learning outcome

After undergoing this course, the students are expected to deliver the following:

- Be able to identify food in which fortification with necessary nutrients are required
- Be able to evolve Geriatric foods and food for infants based on their requirement and physiological functions
- To make food available to the consumers amalgamated with functional ingredients such as herbs, phytochemicals, etc.

X. Selected Reading

- Earle M, Earle R and Anderson A. (Eds.). 2001. Food product development.1st Edn., Woodhead Publishing, pp. 1-392 (eBook ISBN: 9781855736399).
- Francesco C. (Ed.). 2017. Advances in dairy products. John Wiley and Sons Ltd. pp. 1-448. Chapter 4.2 - Consumer insight in the process of new dairy products development(ISBN: 9781118906460).
- Kanekanian A. (Ed.). 2014. Milk and dairy products as functional foods. John Wiley and Sons, Ltd., UK: West Sussex, pp. 1-373.
- Leong TSH, Manickam S, Martin GJ, Li W and Ashok kumar M. 2018. Ultrasonic Production of Nano-emulsions for Bioactive Delivery in Drug and Food Applications. Springer.
- Saarela M. (Ed.). 2007. Functional dairy products (2007) Vol. 2, Series in Food Science, Technology and Nutrition, Woodhead Pub., pp. 521-539.
- Shortt C and O'Brien J. (Eds.). 2003. Handbook of functional dairy products – Functional foods and Nutraceuticals, 1st Edn. Boca Raton, FL: CRC Press, pp. 1-312.

Websites

- Foods for Specified Health Uses (FOSHU)-https://mhlw.go.jp/english/topics/food safety/fhc/ 02.html
- A New Definition for Functional Food by FFC-https//functionalfoodscenter.net/files/ 111174880.pdf
- Food-info.net: Functional Foods-https//food-info.net/uk/ff/intro.htm

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Classes of functional foods and their status.	**4**
2	**Unit II** Functional ingredients; Classification; Dietary and therapeutic significance.	**4**
3	**Unit III** Food fortification; Significance and techniques of fortifying foods with functional ingredients.	**4**
4	**Unit IV** Infant nutrition; Dietary formulations, special needs, additives; Geriatric Foods: Design considerations, ingredients, special needs; Sports foods: Significance , strategies and design considerations.	**4**
5	**Unit V** Reduced calorie foods: Significance, strategies, additives (fat replacers, bulking agents, non-nutritive sweeteners).	**4**
6	**Unit VI** Low sodium and low lactose foods: Nutritional and health significance.	**4**
7	**Unit VII** Herbs; Classification; Therapeutic potential, applications; Phytochemicals; Classes; Physiological role; Applications; Bioactive ingredients from animal and marine sources.	**4**
8	**Unit VIII** Probiotic, prebiotic and synbiotic foods: Concept and applications.	**4**
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Determination of soluble and insoluble fibre	2
2	Determination of antioxidant activity of functional ingredient/food.	1
3	b-galactosidase activity for low-lactose dairy products	1
4	Prebiotic potential of selected plant/milk components	1
5	Probiotic potential of selected microorganisms	1
6	Preparation of functional foods:	2
7	Preparation of reduced calories dairy food	2
8	Utilization of herbs in ghee and milk	2
9	Preparation of low lactose food	2
10	Utilization of artificial sweeteners in dairy products	2
	Total	**16**

I. Course Title : Production and Applications of Dairy Ingredients

II. Course Code : DT 525

III. Credit Hours : 3= 2+1

IV. Why this course?

Milk is a source of several components, which may contribute to nutrients, nutraceuticals, flavour, colour, texture to the food products in which they may be incorporated. Nowadays, we have perfected technologies to separate the dairy components having specified function for use in dairy as well as food products. The by-products such as whey and buttermilk can be salvaged through separation of components, which are of significance to the dairy and food industries alike.

V. Aim of the course

The aim of this course is to give comprehensive information of various milk components used as ingredients in food processing with regard to their separation, properties and applications.

VI. Theory:

Unit I

An overview of dairy ingredients for food processing; Composition, nutritive value and health attributes of dairy ingredients; Important quality indices; National and international regulatory standards.

Unit II

Principles of conventional and novel approaches for separation, concentration and fractionation of milk components(Ig, lf, b-Lg): centrifugal separation, concentration, drying, membrane processing, enzyme-assisted separation, supercritical fluid extraction, electric field assisted membrane technique, etc**.**

Unit III

Chemical, physical and functional characteristics of concentrated and dried dairy ingredients (SMP, WMP, lactose, whey powder, WPC, WPI, MPC, casein and caseinates, cream powder, butter powder, cheese powder, yogurt powder, buttermilk powder, etc.).Miscellaneous dairy ingredients, viz. dairy permeates, hydrolysates, coprecipitates and lactoferrin.

Unit IV

Interactions of dairy ingredients with other food components and its effect on product quality**.**

Unit V

Applications of dairy ingredients in food industry: bakery and confectionery; Infant, adult and sports nutrition; Processed meat products; spreads; functional Foods; edible films and coatings**.**

VII. Practical

- Manufacture of whey powder, caseinates, whey protein/milk protein concentrates, lactose, sweet cream butter milk powder, cream powder, yogurt powder and cheese powder.
- Determination of functional and nutraceutical properties of dried dairy ingredients.
- Manufacture of enzyme-modified dairy ingredients
- Production of eggless cakes using WPC

- Production of processed meat products incorporating caseinates
- Visit to a dairy ingredients manufacturing industry.

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various food processing plants

IX. Learning outcome

After undergoing this course, the students are expected to deliver the following:

- Be able to separate the various important components from milk/dairy byproduct having significance in dairy and food industries
- Be able to recommend the required type of specialized dairy ingredient for use in formulated and composite foods
- To be able to erect a dairy factory producing specialized dairy ingredients with immense value addition

X. Suggested Reading

- Chandan RC and Kilara A. 2011. *Dairy Ingredients for Food Processing*. Iowa, USA: Blackwell Publishing Ltd.
- Corredig M. 2009. *Dairy Derived Ingredients: Food and Nutraceutical Uses*. Cambridge, UK: Woodhead Publishing Ltd. Restructured and Revised Syllabi of Post-graduate Programmes Vol. 4
- 30
- Fox PF. 1985. *Developments in Dairy Chemistry*. Vol.3.Lactose and minor constituents, New York: Elsevier Applied Science.
- Fox PF. 1989. *Developments in Dairy Chemistry.* Vol.4. Functional milk proteins, New York: Elsevier Applied Science.
- McSweeney PLH and Fox PF. 2013. *Advanced Dairy Chemistry.* Vol.1A: Proteins: Basic aspects. 4th Edn. Springer Publication.
- McSweeney PLH and O'Mahony JA. 2016. *Advanced Dairy Chemistry.* Vol.1B: Proteins: Applied Aspects. Springer Science + Business Media.

Teaching Schedule:

Theory:

Sr. No.	Topic	No of Lecturer (s)
1	**Unit I** An overview of dairy ingredients for food processing; Composition, nutritive value and health attributes of dairy ingredients; Important quality indices; National and international regulatory standards..	6
2	**Unit II** Principles of conventional and novel approaches for separation, concentration and fractionation of milk components (Ig, lf, b-Lg): centrifugal separation,	7

	concentration, drying, membrane processing, enzyme-assisted separation, supercritical fluid extraction, electric field assisted membrane technique, etc.	
3	**Unit III** Chemical, physical and functional characteristics of concentrated and dried dairy ingredients (SMP, WMP, lactose, whey powder, WPC, WPI, MPC, casein and caseinates, cream powder, butter powder, cheese powder, yogurt powder, butter milk powder, etc.). Miscellaneous dairy ingredients, viz. dairy permeates, hydrolysates, coprecipitates and lactoferrin.	**6**
4	**Unit IV** Interactions of dairy ingredients with other food components and its effect on product quality.	**5**
5	**Unit V** Applications of dairy ingredients in food industry: bakery and confectionery; Infant, adult and sports nutrition; Processed meat products; spreads; functional Foods; edible films and coatings	**8**
	Total	**32**

Practical :

Sr. No	Topic	No of Practical (s)
1	Manufacture of whey powder, caseinates, whey protein/milk protein concentrates, lactose, sweet cream butter milk powder, cream powder, yogurt powder and cheese powder.	4
2	Determination of functional and nutraceutical properties of dried dairy ingredients	4
3	Manufacture of enzyme-modified dairy ingredients	2
4	Production of eggless cakes using WPC	2
5	Production of processed meat products incorporating caseinates	2
6	Visit to a dairy ingredients manufacturing industry.	2
	Total	**16**

I. Course Title : Advances in Cheese Technology

II. Course Code : DS 526

III. Credit Hours : 3=2+1

IV. Why this course?

There is an array of cheese varieties; use of different starter cultures can lead to the development of specific cheese variety too. However, the technological principles involved in Cheddar cheese making are common to several varieties of cheeses with some modifications. Cheese is getting popularized in India, especially the Pizza cheese variety that is preferentially used as a topping on pizza pie. The functional properties of cheese dictate its end use functionality in food system. Basically, some cheese varieties can be produced by two methods – starter culture and direct acidification. Whey less cheese making from ultra-filtrated milk concentrate is one unique possibility. There has been trend to produce cheeses having low-fat and low salt for the health conscious consumers.

V. Aim of the course

To impart advanced knowledge on milk coagulants, theory of milk coagulation, the technology, biochemistry and microbiology of cheese.

VI. Theory:

Unit I

Rennet coagulation: Measurement of milk clotting activity and gelation properties, Catalytic mechanism and milk-clotting properties of rennet and rennet substitutes. Advances in renneting of milk; recombinant rennet.

Unit II

Acid coagulated milk gels: formation, rheology, structural properties, etc.

Unit III

Advances in cheese starters; genetics of Lactic Acid Bacteria (LAB); Exo Polysaccharide (EPS) starters; Genetic engineering of LAB.

Unit IV

Biochemistry of cheese ripening: Metabolism of residual lactose and lactate, protein hydrolysis, lipid hydrolysis, amino acid catabolism; Development of cheese flavor and body and texture; Cheese microstructure. Accelerated cheese ripening.

Unit V

Mold-ripened cheeses; Starter cultures, technology, ripening process (Blue, Roquefort, Camembert, etc.).

Unit VI

Low fat and low-sodium cheeses: challenges, strategies and advances; Membrane technology in cheese; Cheese as an ingredient in food systems.

Unit VII

Technology of non-bovine cheese: popular varieties, challenges, strategies; Technology of cheeses prepared by coagulation other than rennet and acid (Ricotta, Brown whey cheese, etc.); Advances in cheese packaging; Automation in cheese making; Cheese analogues.

VII. Practical:

- Instrumental determination of rennet coagulation time
- Rheology of acid-coagulated milk gels
- Fermentation dynamics of common cheese starters
- Evaluation of cheese ripening behaviour
- Manufacture of mold ripened-, low sodium-, low fat-cheeses
- Manufacture of Goat and Ewe milk cheeses
- Manufacture of Ricotta cheese
- Microstructure of cheese

VIII. Teaching Methods/Activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work and Group Discussion
- Visit to various cheese plants

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- Be able to manufacture various varieties of cheeses
- Try to employ various non-thermal pre-treatment to milk to obtain value added cheese
- Be able to develop low-calorie and low-salt cheeses
- Recommend the cheese makers for appropriate mechanization

X. Suggested Readings:

- Jana AH and Thakar PN. 1996. Recombined milk cheeses – A review. *Australian Journalof Dairy Technology*, **51**(1), 33-43.
- Jana AH and Tagalpallewar GP. 2017. Functional properties of Mozzarella cheese for its end use application – A Review. *Journal of Food Science and Technology*, **54**(12), 3766-3778.
- Johnson ME, Kapoor R, McMahon DJ, McCoy DR and Narasimmon RG. 2009. Reduction of sodium and fat levels in natural and processed cheeses: Scientific and technological aspects. *Comprehensive Reviews in Food Science and Food Safety*, **8**(3), 252-268.
- Lucey JA and Singh H. 1997. Formation and physical properties of acid milk gels: are view. *Food Research International*, **30**(7), 529-542.
- Mc Sweeney PLH. 2004. Biochemistry of cheese ripening. *International Journal of Dairy Technology*, **57**(2 3), 127-144.
- Mc Sweeney PLH, Fox PF, Cotter PD and Everett DW. (Eds.) 2017. *Cheese: Chemistry, physics and microbiology*, 4th Edn, Vol. 1, Academic Press.

Websites

- Cheeses and related cheese products – Proposal to permit the use of ultra-filtered milkhttps://ederalregister.gov/documents/2005/10/19/05-20874/cheeses-and-related- eeseproducts-proposal-to-permit-the-use-of-ultrafiltered-milk

- Go cheese to add new products in its portfolioBW Businessworld-http://businessworld.in / article/GO-Cheese-To-Add-New-Products-In-Its-Portfolio/10-07-2018-154382
- American Cheese Society: Serving the Cheese Industry-https://cheesesociety.org/
- Cheese: Dairy Processing Handbook-https://dairyprocessinghandbook.com/chapter/cheese

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Rennet Coagulation: Measurement of milk clotting activity and gelation properties, Catalytic mechanism and milk-clotting properties of rennet and rennet substitutes. Advances in renneting of milk; recombinant rennet.	5
2	**Unit II** Acid coagulated milk gels: formation, rheology, structural properties, etc.	4
3	**Unit III** Advances in cheese starters; genetics of Lactic Acid Bacteria (LAB); Exo Polysaccharide (EPS) starters; Genetic engineering of LAB.	4
4	**Unit IV** Biochemistry of cheese ripening: Metabolism of residual lactose and lactate, protein hydrolysis, lipid hydrolysis, amino acid catabolism; Development of cheese flavor and body and texture; Cheese microstructure. Accelerated cheese ripening.	6
5	**Unit V** Mold-ripened cheeses; Starter cultures, technology, ripening process (Blue, Roquefort, Camembert, etc.).	4
6	**Unit VI** Low fat and low-sodium cheeses: challenges, strategies and advances; Membrane technology in cheese; Cheese as an ingredient in food systems.	4
7	**Unit VII** Technology of non-bovine cheese: popular varieties, challenges, strategies; Technology of cheeses prepared by coagulation other than rennet and acid (Ricotta, Brown whey cheese, etc.); Advances in cheese packaging; Automation in cheese making; Cheese analogues.	5
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Familiarization with equipments, accessories and standardization numerical	1
2	Instrumental determination of rennet coagulation time	1
3	Rheology of acid-coagulated milk gels	1
4	Fermentation dynamics of common cheese starters	1
5	Evaluation of cheese ripening behavior	1
6	Manufacture of Cheddar cheese.	2
7	Manufacture of mold ripened-, low sodium-, low fat-cheeses	2
8	Manufacture of Goat and Ewe milk cheeses	2
9	Manufacture of Ricotta cheese	2
10	Microstructure of cheese	1
11	Manufacture of quarg cheese	1
12	Manufacture of Mozzarella cheese	1
	Total	**16**

Course Syllabus and Contents
M.Sc. (Agri) in Dairy Chemistry

I. Course Title : Physico-Chemical Aspects of Milk Constituents
II. Course No. : DC 511
III. Credit Hours : 3 = 2+1

IV. Why this course?

This course will help the students while working in dairy industry/research institutes for better understanding of behaviour of milk constituents with respect to their chemical reactions and physical state. This course is going to cover all these aspects.

V. **Aim of the course**:

To impart knowledge on the physico-chemical aspects of milk and milk products with special reference to their processing and quality assurance.

VI. Theory:

Unit I: Chemical and Enzymatic reactions

Basics of chemical reaction kinetics, Order and molecularity of a reaction., Kinetics of denaturation of whey proteins and Maillard browning., Kinetics of enzymatic reactions; the role of enzymes as biological catalysts; factors affecting the rate of enzyme reaction: concentration of substrate, concentration of enzyme, concentration of reaction products, pH, temperature, time, activators and inhibitors. Thermal inactivation of enzymes present in milk. Concept of activation energy

Unit II: Physico-chemical changes in milk and milk products

Physical changes taking place during manufacture of various products and in individual milk constituents., Chemical changes taking place during manufacture of various products in individual milk constituents., Desirable and undesirable changes due to processing and storage., Redox reactions and photo-oxidation of milk.

Unit III: Surface Chemistry

Fat globule membrane - physics and chemistry., Factors affecting fat globules size and distribution., Fat globules- creaming phenomena, factors involved in creaming

Unit IV: Foams and Emulsions

Colloidal and surface phenomena in milk; adsorption at solid-liquid and liquidliquid interphases; Gibb's equations., Interfacial tension, surface tension, surface active agents, general aspects of foaming, churning and whipping of cream; emulsion and emulsion stability; coalescence and dispersion; an introduction to the concept of Nano emulsion and Nano micelles.

Unit V: Micelles and Gelation

Micelles: definition, critical micelle concentration, formation and stability; Colloidal stability of casein micelles in milk, zeta potential, size distribution of casein

micelles and fat globules; Gels and their formation, structure and stability; acid and rennet gels.

VII. Practical:

- Determination of lactose in milk and milk products by chemical method
- Determination of milk fat by Mojoner method in milk products
- Measurement of hydrolysis of a carbohydrate and measurement of activation energy.
- Analysis of effect of substrate concentration on hydrolysis of p-nitrophenyl phosphate by milk alkaline phosphatase.
- Michaelis constant determination for the digestion of casein by trypsin.
- Measurement of pH and buffering capacity of different types of milk.
- Stability analysis of an oil-in-water emulsion stabilised by milk proteins
- Foaming capacity and foam stability of caseins/whey proteins.
- Study of the gel formation and gel stability of milk proteins.
- Drawing of an adsorption isotherm of water on casein.
- Measurement of thermal inactivation of enzymes (Alkaline phosphatase, Lactoperoxidase).

VIII. Teaching Methods/ Activities:

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work
- Guest Lectures

IX. Learning outcome:

After successful completion of this course, the students are expected to be able to: – Apply basics of reaction kinetics in understanding different phenomenon in milk during processing and storage. – Role of different constituents of milk in formation and stability of emulsions, foams and gel

X. Suggested Reading:

- Ancheyta J. 2017. Chemical Reaction Kinetics: Concepts, Methods and Case Studies. John Wiley and Sons.
- Dickinson E. 1995. Food Macromolecules and Colloids, RSC Special Publication.
- Dickinson E. 2005. Food Colloids: Interactions, Microstructure and Processing, RSC advancing chemical series.
- Fox PF, Uniacke-Lowe T, McSweeney PLH and O'Mahony JA. 2015. Dairy Chemistry and Biochemistry. Springer International Publishing-Switzerland.
- McClements DJ. 2016. Food Emulsions: Principles, Practices and Techniques, 3rd Edn, CRC press Taylor and Fracis group.
- Puri BR, Sharma LR, Pathania MS. 2016. Principles of Physical Chemistry, 47th Edition Vishal Publishing Co.
- Rockland LB and Beuchat LR. 1987. Water Activity: Theory and Applications to Food, Marcel Dekker Inc, NY.
- Walstra P and Jenness R. 1984. Dairy Chemistry and Physics. John Wiley and Sons.

Teaching Schedule:
Theory:

Sr. No.	Units	No. of Lecture (s)
1	**Unit I: Chemical and Enzymatic reactions** Basics of chemical reaction kinetics, Order and molecularity of a reaction. Kinetics of denaturation of whey proteins and Maillard browning. Kinetics of enzymatic reactions; the role of enzymes as biological catalysts; factors affecting the rate of enzyme reaction: concentration of substrate, concentration of enzyme, concentration of reaction products, pH, temperature, time, activators and inhibitors. Thermal inactivation of enzymes present in milk. Concept of activation energy.	**6**
2	**Unit II: Physico-chemical changes in milk and milk products.** Physical changes taking place during manufacture of various products and in individual milk constituents. Chemical changes taking place during manufacture of various products in individual milk constituents. Desirable and undesirable changes due to processing and storage. Redox reactions and photo-oxidation of milk.	**7**
3	**Unit III: Surface Chemistry** Fat globule membrane - physics and chemistry. Factors affecting fat globules size and distribution. Fat globules- creaming phenomena, factors involved in creaming	**6**
4	**Unit IV: Foams and Emulsions** Colloidal and surface phenomena in milk; adsorption at solid-liquid and liquid-liquid interphases; Gibb's equations. Interfacial tension, surface tension, surface active agents, general aspects of foaming, churning and whipping of cream; emulsion and emulsion stability; coalescence and dispersion; an introduction to the concept of Nano emulsion and Nano micelles.	**6**
5	**Unit V: Micelles and Gelation** Micelles: definition, critical micelle concentration, formation and stability; Colloidal stability of casein micelles in milk, zeta potential, size distribution of casein micelles and fat globules. Gels and their formation, structure and stability; acid and rennet gels.	**6**
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1.	Determination of lactose in milk and milk products by chemical method	2
2.	Determination of milk fat by Mojoner method in milk products	2

3.	Measurement of hydrolysis of a carbohydrate and measurement of activation energy.	2
4.	Analysis of effect of substrate concentration on hydrolysis of p-nitrophenyl phosphate by milk alkaline phosphatase.	2
5.	Michaelis constant determination for the digestion of casein by trypsin.	1
6.	Measurement of pH and buffering capacity of different types of milk.	1
7.	Stability analysis of an oil-in-water emulsion stabilized by milk proteins	1
8.	Foaming capacity and foam stability of caseins/whey proteins.	1
9.	Study of the gel formation and gel stability of milk proteins.	1
10.	Drawing of an adsorption isotherm of water on casein.	1
11.	Measurement of thermal inactivation of enzymes (Alkaline phosphatase, Lactoperoxidase).	2
	Total	**16**

I. Course Title : Milk Carbohydrates, Minerals and Water Soluble Vitamins
II. Course No. : DC 512
III. Credit Hours : 3 = 2+1

IV. Why this course?

This course will give an overview of carbohydrates, minerals and vitamins present in milk. This knowledge will help the students to understand the various physicochemical reactions occur during processing and storage of dairy foods.

V. Aim of the course

To impart basic knowledge on 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. The course is organized as follows:

VI. Theory :

Unit I: Chemistry of lactose

Lactose: occurrence, isomers, molecular structure, levels in milk of different species.

Unit II: Physical properties of lactose

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

Unit III: Chemical properties of lactose

Chemical properties of lactose: hydrolysis; Pyrolysis; Oxidation; Reduction; Degradation with strong bases; Derivatives; Dehydration and Fragmentation; Browning reaction; Oligosaccharides in milk-health significance.

Unit IV: Mineral in Milk

Minerals: major and minor minerals; Factors affecting variation in salt composition of milk; Distribution and importance of trace elements in milk.

Unit V: Physical equilibrium amongst milk salts

Physical equilibrium amongst milk salts; Effect of various treatments on salt equilibrium; Partitioning of salts and factors affecting them.

Unit VI: Effect of Processing on Minerals

Salt balance and its importance in the processing of milk; Protein-mineral interactions.

Unit VII: Water soluble vitamins

Water soluble vitamins: molecular structure, levels in milk and milk products; factors affecting their levels; Biological significance; Ascorbic acid structure; Relation with redox potential (Eh) of milk and milk products.

VII. Practical:

- Estimation of lactose in milk by volumetric method
- Estimation of lactose in milk by gravimetric method
- Estimation of lactose in milk by polarimetric method
- Estimation of lactose in milk by colorimetric methods
- Determination of sodium and potassium by (flame photometry)
- Determination of calcium and magnesium by EDTA method
- Determination of phosphorus by colorimetric method (Fiske and Subba Rao)

- Estimation of citric acid by colorimetric methods
- Determination of iron by colorimetric methods
- Estimation of vitamin C in milk by volumetric method
- Determination of HMF content in heated milk

VIII. Teaching Methods/ Activities:

- Lecture
- Student's Book/Publication Review
- Group Work
- Assignment (Reading/Writing)
- Student presentation
- Guest Lectures

IX. Learning outcome:

After successful completion of this course, the students are expected to be able to:

- Appreciate the significance of milk as a source of carbohydrates, minerals and water soluble vitamins.
- Understand the importance of these constituents in chemical, physical, technological, nutritional and physiological properties of milk.

X. Suggested Reading:

- Fox PF, Uniacke-Lowe T, McSweeney PLH and O'Mahony JA. 2015. Dairy Chemistry and Biochemistry. Springer International Publishing-Switzerland.
- Jennes RG. 1995. Handbook of Milk Composition. Academic Press.
- McSweeney PLH and Fox PF. 2009. Advanced Dairy Chemistry Volume 3: Lactose, Water, Salts and Minor Constituents. Springer-Verlag New York.
- Paques M and Lindner C. (Eds.). 2019. Lactose: Evolutionary Role, Health Effects, and Applications. Academic press.
- Walstra P and Jenness R. 1984. Dairy Chemistry and Physics. John and Wiley.
- Watson RR, Collier RJ and Preedy VR. (Eds.). 2017. Nutrients in dairy and their implications for health and disease. Academic Press.
- Young W. Park and George F.W. Haenlein. 2013. Milk and Dairy Products in Human Nutrition. John Wiley and Sons, UK.
- Zadow JG. 1992. Whey and Lactose Processing. Elsevier Science Publishers Ltd-Springer Netherlands.

Teaching Schedule:

Theory:

Sr. No.	Units	No. of Lecture (s)
1	**Unit I: Chemistry of lactose** Lactose: occurrence, isomers, molecular structure, levels in milk of different species.	4
2	**Unit II: Physical properties of lactose** Physical properties of lactose: crystalline habits, hydrates, lactose glass, specific rotation, equilibrium of different isomers in solution, solubility, density, sweetness.	4

3	**Unit III: Chemical properties of lactose** Chemical properties of lactose: hydrolysis; Pyrolysis; Oxidation; Reduction; Degradation with strong bases; Derivatives; Dehydration and Fragmentation; Browning reaction; Oligosaccharides in milk-health significance.	6
4	**Unit IV: Mineral in Milk** Minerals: major and minor minerals; Factors affecting variation in salt composition of milk; Distribution and importance of trace elements in milk.	4
5	**Unit V: Physical equilibrium amongst milk salts** Physical equilibrium amongst milk salts; Effect of various treatments on salt equilibrium; Partitioning of salts and factors affecting them.	4
6	**Unit VI: Effect of Processing on Minerals** Salt balance and its importance in the processing of milk; Protein-mineral interactions.	4
7	**Unit VII: Water soluble vitamins** Water soluble vitamins: molecular structure, levels in milk and milk products; factors affecting their levels; Biological significance; Ascorbic acid structure; Relation with redox potential (Eh) of milk and milk products.	6
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1.	Estimation of lactose in milk by volumetric method	1
2.	Estimation of lactose in milk by gravimetric method	1
3.	Estimation of lactose in milk by polarimetric method	1
4.	Estimation of lactose in milk by colorimetric methods	2
5.	Determination of sodium and potassium by (flame photometry)	2
6.	Determination of calcium and magnesium by EDTA method	1
7.	Determination of phosphorus by colorimetric method (Fiske and Subba Rao)	1
8.	Estimation of citric acid by colorimetric methods	1
9.	Determination of iron by colorimetric methods	2
10.	Estimation of vitamin C in milk by volumetric method	2
11.	Determination of HMF content in heated milk	2
	Total	**16**

I. Course Title : Chemistry of Milk Lipids

II. Course No. : DC 513

III. Credit Hours : 3 = 2+1

IV. Why this course?

The course will provide in-depth coverage of milk lipids. It makes the students capable to understand various chemical reactions occur during processing and storage of milk and milk products. This course is going to cover all these aspects.

V. Aim of the course:

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

VI. Theory:

Unit I: Classification of milk lipids

Milk lipids: General classification, neutral and polar lipids (phospholipids) in milk, gross composition of milk lipids in different species, physico-chemical properties of milk lipids; role of major milk lipids in milk and milk products and biological significance of milk lipids; Composition of milk fat globule membrane.

Unit II: Properties of milk lipids

Fatty acid profile of milk lipids; factors affecting the profile of fatty acids; Different properties of fatty acids

Unit III: Unsaponifiable matter Unsaponifiable matter and its importance

Composition of unsaponifiable matter; Chemistry, levels and physiological functions of sterols; Fat soluble vitamins and carotenoids in milk.

Unit IV: Chemical Reaction of milk fat

Chemical properties of milk lipids: hydrolysis by alkali, water and enzymes; hydrogenation, halogenation, transesterification, inter-esterification and fractionation.

Unit V: Oxidation of milk fat

Autoxidation: Definition, theories, induction period, secondary products of autoxidation, factors affecting, prevention and measurement; various methods for evaluating primary and secondary oxidation products; Antioxidants: Definition, types, reaction mechanism and estimation. Thermal oxidation of fat.

VII. Practical:

- Determination of melting point/slip point and B.R reading of milk fat.
- Determination of conjugated dienes, peroxide value and anisidine value of milk fat.
- Analysis of milk fat for its thiobarbituricacid-(TBA) value.
- Estimation of carbonyl value of milk fat
- Determination of unsaponifiable matter in milk fat.
- Total cholesterol estimation in milk fat.
- Determination of vitamin A and D in milk fat
- Estimation of total phospholipids and free fatty acids in milk fat.
- Preparation of fatty acid methyl esters and their analysis by GLC.
- Quantitative determination of butylatedhydroxylanisole (BHA) in milk fat.

VIII. Teaching Methods/ Activities:

- Lecture – Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work

- Guest Lectures

IX. Learning outcome:

After successful completion of this course, the students are expected to be able to:

- Understand the basic aspects of milk lipids in terms of quality of dairy products and human health
- Understand the different reactions taking place during processing and storage of milk fat

X. Suggested Reading:

- Akoh CC and Min DB. 1997. Food Lipids: Chemistry, Nutrition and Biotechnology. Marcel Dekker.
- Fox PF and McSweeney PLH. 2006. Advanced Dairy Chemistry Volume 2: Lipids. SpringerUS.
- Fox PF, Uniacke-Lowe T, McSweeney PLH and O'Mahony JA. 2015. Biochemistry. Springer International Publishing-Switzerland.
- Mathur MP, Datta Roy D and Dinakar P. 1999. Text Book of Dairy Chemistry. ICAR.
- Truong T, Lopez C, Bhandari B and Prakash S. 2020. Dairy Fat Products and Functionality.
- Walstra P and Jenness R. 1984. Dairy Chemistry and Physics. John Wiley and Sons.
- Wong NP, Jenness R, Keeney M and Elmer HM. 1988 Fundamentals of Dairy Chemistry. Van Nostrand Reinhold Co.

Teaching Schedule:

Theory:

Sr. No.	Units	No. of Lecture (s)
1	**Unit I: Classification of milk lipids** Milk lipids: General classification, neutral and polar lipids (phospholipids) in milk, gross composition of milk lipids in different species, physico-chemical properties of milk lipids; role of major milk lipids in milk and milk products and biological significance of milk lipids; Composition of milk fat globule membrane.	**7**
2	**Unit II: Properties of milk lipids** Fatty acid profile of milk lipids; factors affecting the profile of fatty acids; Different properties of fatty acids	**6**
3	**Unit III: Unsaponifiable matter Unsaponifiable matter and its importance** Composition of unsaponifiable matter; Chemistry, levels and physiological functions of sterols; Fat soluble vitamins and carotenoids in milk.	**6**
4	**Unit IV: Chemical Reaction of milk fat**	**7**

	Chemical properties of milk lipids: hydrolysis by alkali, water and enzymes; hydrogenation, halogenation, transesterification, inter-esterification and fractionation.	
5	**Unit V: Oxidation of milk fat** Autoxidation: Definition, theories, induction period, secondary products of autoxidation, factors affecting, prevention and measurement; various methods for evaluating primary and secondary oxidation products; Antioxidants: Definition, types, reaction mechanism and estimation. Thermal oxidation of fat.	**6**
	Total	**32**

Practical:

Sr. No.	**Topic**	**No. of Practical (s)**
1.	Determination of melting point/slip point and B.R reading of milk fat.	1
2.	Determination of conjugated dienes, peroxide value and anisidine value of milk fat.	3
3.	Analysis of milk fat for its thiobarbituricacid-(TBA) value.	1
4.	Estimation of carbonyl value of milk fat.	1
5.	Determination of unsaponifiable matter in milk fat.	2
6.	Total cholesterol estimation in milk fat.	2
7.	Determination of vitamin A and D in milk fat	2
8.	Estimation of total phospholipids and free fatty acids in milk fat.	1
9.	Preparation of fatty acid methyl esters and their analysis by GLC.	1
10.	Quantitative determination of butylatedhydroxylanisole (BHA) in milk fat.	2
	Total	**16**

I. Course Title : Chemistry of Food Constitutes

II. Course No. : DC 514

III. Credit Hours : 3 = 2+1

IV. Why this course?

This course will help the students to get more insight into chemistry of food constituents such as water, carbohydrates, protein, lipids, phytochemicals and food additives. This course will also enrichthe knowledge of students for working in food industry/research institutes for better understanding of processed food products development.

V. Aim of the course:

To impart knowledge on different chemical aspects of food components

VI. Theory:

Unit I: Water

Water: Forms of water in foods; water- solute interactions, and food stability in relation to water activity; solute mobility; property of ice crystals; role of ice in the stability of food at sub-freezing temperatures.

Unit II: Carbohydrates

Carbohydrates: Starch; Types, swelling behaviour, gelatinization and their role in bread making; modification of starches for industrial applications, physico-chemical changes taking place during malting. Oligosaccharides: Structural units of commercially available oligosaccharide, their properties and preparation methods, Hydrocolloids, their properties and utilization in different food preparations; mutual interactions among hydrocolloids and interactions with proteins.

Unit III: Proteins

Proteins: Classification, distribution and physico-chemical properties of food proteins from various sources; structure-function relationship and their modifications; denaturation of food proteins. Application of enzymes in food Industry; Immobilized enzymes, Browning reactions in foods: enzymatic browning and non-enzymatic browning (caramelization and maillard reaction).

Unit IV: Food Lipids

Food Lipids: Physico-chemical properties of food lipids and their modifications; Composition of various types of edible oils/fats with special reference to their quality; auto-oxidation of food lipids.

Unit V: Phyotchemicals

Phytochemicals: Chemistry of polyphenols, phenolic acid, flavonoids, phytosterols, phytostanol.

Unit VI: Food Additives

Food Additives: Sweeteners, anticaking agents, antioxidants, humectants, preservatives, neutralizers, stabilizers, emulsifiers, texture modifiers, flavours and colours etc.

VII. Practical:

- Estimation of fat content in cereal products by Soxhlet method.
- Determination of total nitrogen in cereal products.
- Determination of gluten content in wheat flour.

- Analysis of starch in flour by polarimetric method.
- Estimation of crude fibre in food product.
- Determination of polyphenol content in tea and coffee.
- Determination of antioxidant activity in various foods using DPPH/FRAP methods
- Detection of adulteration of mustard oil with argemone oil.
- Detection of artificial colours in various spices.
- Determination of level of artificial sweeteners (saccharin and aspartame)
- Visit to a food plant.

VIII. Teaching Methods/ Activities:

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work
- Guest Lectures

IX.Learning outcome:

After successful completion of this course, the students are expected to be able to:

- Forms of water in food and its role in stability of food during storage at low temperature
- Types of carbohydrates, proteins, lipids in various types of foods, changes in such constituents during processing, interaction of carbohydrates and proteins, application of enzymes in food industry including immobilization of enzymes
- Types of phytochemicals in foods and role of additives to impart various functions in foods.

X. Suggested Reading:

- Belitz HD, Grosch W and Schieberle P. 2004. *Food Chemistry*. 3rd Ed. Springer. Restructured and Revised Syllabi of Post-graduate Programmes Vol. 4
- Connie M. Weave. 2017. *The Food Chemistry Laboratory: A Manual for Experimental Foods*, Dietetics, and Food Scientists, Second Edition CRC Press.
- Damodaran S, Parkin KL and Feenema OR. 2008. *Fennema's Food Chemistry*. 4th Ed. CRC Press.
- Dwidvedi A. 2016. *Enzyme Immobilization: Advances in Industry, Agriculture, Medicine, and the Environment*. 1st edition. Springer.
- Fennema OR. 1985. *Food Chemistry*. Marcer Dekker.
- Peter CK and Bhavbhuti M. 2015. *Handbook of Food Chemistry.* Springer-Verlag Berlin Heidelberg.
- Srinivas D and Alan Praf. 1997. *Food Proteins and their Applications*. Marcel Dekker.
- Velisek J, Koplik R and Cejpek K. 2020. *The Chemistry of Food.* John Wiley and Sons.

Teaching Schedule:

Theory:

Sr. No.	Units	No. of Lecture (s)
1	**Unit I: Water**	5

	Water: Forms of water in foods; water- solute interactions, and food stability in relation to water activity; solute mobility; property of ice crystals; role of ice in the stability of food at sub-freezing temperatures.	
2	**Unit II: Carbohydrates** Carbohydrates: Starch; Types, swelling behaviour, gelatinization and their role in bread making; modification of starches for industrial applications, physico-chemical changes taking place during malting. Oligosaccharides: Structural units of commercially available oligosaccharide, their properties and preparation methods, Hydrocolloids, their properties and utilization in different food preparations; mutual interactions among hydrocolloids and interactions with proteins.	**6**
3	**Unit III: Proteins** Proteins: Classification, distribution and physico-chemical properties of food proteins from various sources; structure-function relationship and their modifications; denaturation of food proteins. Application of enzymes in food Industry; Immobilized enzymes, Browning reactions in foods: enzymatic browning and non-enzymatic browning (caramelization and maillard reaction).	**6**
4	**Unit IV: Food Lipids** Food Lipids: Physico-chemical properties of food lipids and their modifications; Composition of various types of edible oils/fats with special reference to their quality; auto-oxidation of food lipids.	**5**
5	**Unit V: Phyotchemicals** Phytochemicals: Chemistry of polyphenols, phenolic acid, flavonoids, phytosterols, phytostanol.	**5**
6	**Unit VI: Food Additives** Food Additives: Sweeteners, anticaking agents, antioxidants, humectants, preservatives, neutralizers, stabilizers, emulsifiers, texture modifiers, flavours and colours etc	**5**
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1.	Estimation of fat content in cereal products by Soxhlet method.	1
2.	Determination of total nitrogen in cereal products.	1
3.	Determination of gluten content in wheat flour.	1
4.	Analysis of starch in flour by polarimetric method.	1
5.	Estimation of crude fibre in food product.	2

6.	Determination of polyphenol content in tea and coffee.	2
7.	Determination of antioxidant activity in various foods using DPPH/FRAP methods.	2
8.	Detection of adulteration of mustard oil with argemone oil.	1
9.	Detection of artificial colours in various spices.	1
10.	Determination of level of artificial sweeteners (saccharin and aspartame)	2
11.	Visit to a food plant.	2
	Total	**16**

I. Course Title : Chemistry of Milk Proteins

II. Course No. : DC 521

III. Credit Hours : 3 = 2+1

IV. Why this course?

This course will help the students of dairying to get more insight into chemistry of milk proteins and in understanding the various physicochemical reactions occur during milk processing. This course is going to cover all these aspects.

V. Aim of the course

To impart knowledge on different aspects of milk proteins.

VI. Theory:

Unit I: Basic concept of milk proteins

Milk proteins of different species and their variability. Distribution and fractionation of different nitrogen fractions of milk proteins; nomenclature of milk proteins; genetic polymorphism and biological significance of milk proteins.

Unit II: Major milk proteins

Major milk proteins: caseins (acid and micellar), methods of isolation; Fractionation of casein and heterogeneity; Physico-chemical properties; amino acid composition; Casein micelle models; Primary structure of different caseins; Modification of casein: Physical, chemical (glycosylation, phosphorylation) and enzymatic.

Unit III: Whey proteins

Alpha-lactalbumin and beta-lactoglobulin, bovine serum albumin: distribution and methods of isolation and their physico-chemical properties; Minor milk proteins: Proteose-peptone, immunoglobulins, lactoferrin, and fat globule membrane proteins.

Unit V: Denaturation of proteins

Denaturation of milk proteins, various factors affecting denaturation; Casein-whey protein interactions.

Unit VI: Enzymes

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

VII. Practical:

- Estimation of different nitrogen fractions of milk by Kjeldahl method.
- Preparation of acid and rennet casein; urea fractionation of acid casein; isolation of alpha-lactalbumin and beta-lactoglobulin by ammonium sulphate precipitation.
- Milk protein estimation by Folin method.
- Polyacrylamide gel electrophoresis of milk proteins.
- Assay of indigenous milk enzyme activity like protease, lipase, alkaline phosphatase and lactoperoxidase.
- Estimation of hexoses and sialic acid in casein.
- Measurement of degree of hydrolysis of milk proteins.
- Measurement of denaturation of whey proteins.

VIII. Teaching Methods/ Activities:

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work
- Guest Lectures

IX. Learning outcome:

After successful completion of this course, the students are expected to be able to:

- Understand the basic aspects of milk proteins in terms of major and minor milk proteins
- Understand the effect of different processing of milk on interaction of milk proteins

X. Suggested Reading:

- Boland M and Singh H. (Eds.). 2019. Milk proteins: from expression to food. Academic Press.
- Fox PF, Uniacke-Lowe T, McSweeney PLH and O'Mahony JA. 2015. *Dairy Chemistry and Biochemistry*. Springer International Publishing-Switzerland.
- Mathur M, Datta Roy D and Dinakar P. 1999. *Text Book of Dairy Chemistry*. ICAR.
- McSweeney PLH, O'Mahony and James A. 2013. *Advanced Dairy Chemistry Volume 1A: Proteins: Applied Aspects*. Springer-Verlag, New York.
- McSweeney PLH, O'Mahony and James A. 2016. *Advanced Dairy Chemistry Volume 1B: Proteins: Applied Aspects*. Springer-Verlag, New York.
- Robert G Jensen 1991. *Handbook of Milk Composition*. Academic Press.

Teaching Schedule:

Theory:

Sr. No.	Units	No. of Lecture (s)
1	**Unit I: Basic concept of milk proteins** Milk proteins of different species and their variability. Distribution and fractionation of different nitrogen fractions of milk proteins; nomenclature of milk proteins; genetic polymorphism and biological significance of milk proteins.	6
2	**Unit II: Major milk proteins** Major milk proteins: caseins (acid and micellar), methods of isolation; Fractionation of casein and heterogeneity; Physico-chemical properties; amino acid composition; Casein micelle models; Primary structure of different caseins; Modification of casein: Physical, chemical (glycosylation, phosphorylation) and enzymatic.	6
3	**Unit III: Whey proteins** Alpha-lactalbumin and beta-lactoglobulin, bovine serum albumin: distribution and methods of isolation and their physico-chemical properties. Minor milk proteins: Proteose-peptone, immunoglobulins, lactoferrin, and fat globule membrane proteins.	6
4	**Unit V: Denaturation of proteins**	6

	Denaturation of milk proteins, various factors affecting denaturation; Casein-whey protein interactions.	
5	**Unit VI: Enzymes** Indigenous milk enzymes: Properties and their significance with particular reference to lipases, proteases, phosphatases, catalase, peroxidase, xanthine oxidase, lysozyme, lactoperoxidase and galactosyltransferase	**6**
	Total	**48**

Practical:

Sr. No.	**Topic**	**No. of Practical (s)**
1.	Estimation of different nitrogen fractions of milk by Kjeldahl method.	2
2.	Preparation of acid and rennet casein; urea fractionation of acid casein.	2
3.	Isolation of alpha-lactalbumin and beta-lactoglobulin by ammonium sulphate precipitation	2
4.	Milk protein estimation by Folin method.	2
5.	Polyacrylamide gel electrophoresis of milk proteins.	1
6.	Assay of indigenous milk enzyme activity like protease, lipase, alkaline phosphatase and lactoperoxidase.	2
7.	Estimation of hexoses and sialic acid in casein.	1
8.	Measurement of degree of hydrolysis of milk proteins.	2
9.	Measurement of denaturation of whey proteins.	2
	Total	**16**

I. Course Title : Chemistry of Processed Dairy Foods

II. Course No. : DC 522

III. Credit Hours : 4 = 3+1

IV. Why this course?

To gain insights in the underlying chemical changes during processing of milk for preparation of concentrated, dried, fermented and fat rich dairy products and frozen desserts. This course is going to cover all these aspects.

V. Aim of the course:

To understand the physico-chemical changes and effects of various milk constituents of milk products during manufacture and storage of processed dairy foods.

VI. Theory:

Unit I: Process induced changes in concentrated and dried milks:

Process induced changes in milk constituents during preparation and storage of concentrated and dried milks.

Unit II: Human milk and infant food

Role of biologically active components in human milk; Standards, composition and properties of infant milk and infant food formulations.

Unit III: Heat induced changes in milk

Heat induced changes in milk leading to coagulation; Heat stability of concentrated milk as affected by different process variables, Milk constituents and additives; Age gelation: Mechanism and control.

Unit IV: Cheese and other fermented dairy products

Biochemical changes during ripening of different varieties of cheese; Lactic acid fermentation in cheese and other fermented dairy products; chemical defects in cheese.

Unit V: Cream, butter and ghee

Storage stability of cream, butter and ghee. Physico-chemical properties of ghee; Ghee flavour, texture (grains) and colour in ghee.Role of different ingredients during processing and storage of ice cream/ frozen desserts; Concept of antifreeze protein/ice structuring protein in ice cream

VII. Practical:

- Determination of lactose and sucrose in condensed milk and ice-cream.
- Determination of weight per litre of ice-cream.
- Determination of heat stability of milk and concentrated milks.
- Determination of WPNI of skim milk powder.
- Determination of fat in cream and butter by Mojonnier method.
- Determination of 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 soluble proteins, salt and free fatty acids in cheese.
- Determination of rennet clotting time of milk.

VIII. Teaching Methods/ Activities:

- Lecture
- Student's Book/Publication Review
- Group Work
- Assignment (Reading/Writing)
- Student presentation
- Guest Lectures

IX. Learning outcome:

After successful completion of this course, the students are expected to be able to:

- Understand the basic aspects of dairy chemistry in terms of processing of different dairy products
- Understand the different reactions taking place during storage of dairy products

X. Suggested Reading:

- Fox PF, Uniacke-Lowe T, McSweeney PLH and O'Mahony JA. 2015. *Dairy Chemistry and Biochemistry*. Springer International Publishing-Switzerland.
- Koca N. (Ed.). 2018. *Technological Approaches for Novel Applications in Dairy Processing*. BoD–Books on Demand.
- Mathur MP, Roy DD and Dinakar P. 1999. *Textbook of Dairy Chemistry*. ICAR.
- Official methods of AOAC. 11th and 15th Eds.
- Walstra P and Jenness R. 1984. *Dairy Chemistry and Physics*. John Wiley and Sons.
- Wong NP, Jeness R, Keeney M and Elmer HM. 1988. *Fundamentals of Dairy Chemistry*. Van Nostrand Reinhold Co.

Teaching Schedule:
Theory:

Sr. No.	Units	No. of Lecture (s)
1	**Unit I: Process induced changes in concentrated and dried milks:** Process induced changes in milk constituents during preparation and storage of concentrated and dried milks.	**9**
2	**Unit II: Human milk and infant food** Role of biologically active components in human milk; Standards, composition and properties of infant milk and infant food formulations	**9**
3	**Unit III: Heat induced changes in milk** Heat induced changes in milk leading to coagulation; Heat stability of concentrated milk as affected by different process variables, Milk constituents and additives; Age gelation: Mechanism and control.	**10**
4	**Unit IV: Cheese and other fermented dairy products** Biochemical changes during ripening of different varieties of cheese; Lactic acid fermentation in cheese and other fermented dairy products; chemical defects in cheese.	**10**

5	**Unit V: Cream, butter and ghee** Storage stability of cream, butter and ghee. Physico-chemical properties of ghee; Ghee flavour, texture (grains) and colour in ghee. Role of different ingredients during processing and storage of ice cream/ frozen desserts; Concept of antifreeze protein/ice structuring protein in ice cream	**10**
	Total	**48**

Practical:

Sr. No.	Topic	No. of Practical (s)
1.	Determination of lactose and sucrose in condensed milk and ice-cream.	2
2.	Determination of weight per liter of ice-cream.	1
3.	Determination of heat stability of milk and concentrated milks.	1
4.	Determination of WPNI of skim milk powder.	2
5.	Determination of fat in cream and butter by Mojonnier method.	1
6.	Determination of salt in butter.	2
7.	Determination of diacetyl and acetyl methyl carbinol in butter/ cultured products.	2
8.	Determination of RM, Polenske value, iodine value, saponification value of ghee.	2
9.	Determination of soluble proteins, salt and free fatty acids in cheese. Determination of rennet clotting time of milk	3
	Total	**16**

I. Course Title : Chemical Quality Assurance and Management Tools

II. Course No. : DC 523

III. Credit Hours : 3 = 2+1

IV. Why this Course?

The course will provide in depth knowledge in preparing the reagents, testing methodologies and quality tools to understand the concept of 'Quality Assurance' in dairy industries. This course is going to cover all these aspects.

V. Aim of the Course:

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

VI. Theory:

Unit I: Quality Tools and Management System

Concept of quality assurance and quality control in relation to dairy industry; Quality management systems - good manufacturing practices (GMP); HACCP certification; ISO 9001, ISO 22000, FSSC, total quality management (TQM); Lean and Six sigma, Five –S, Kaizen, Kanban and other quality tools; Good laboratory practices (GLP), laboratory accreditation.

Unit II: International and National Organisations

Role of international organisations such as ISO, IDF, CAC, AOAC, WTO and national organisations like BIS, FSSAI, AgMark and APEDA in dairy industry, Quality Council of India (QCI), Export Inspection Council (EIC); Guidelines for setting up quality control laboratory and chemical safety aspects; sampling of milk and milk product; Food labeling guidelines.

Unit III: Assessment of Quality of Milk and Milk Products

Detergents, sanitizers and disinfectants; Calibration of milk testing glassware; Preparation of standard reagents; Detection of adulterants in milk and milk products; Quality of packaging material for dairy products; Instrumentation in analysis of milk and milk products.

Unit IV: Contaminants and Food Traceability

Agro-chemicals/veterinary drug residues; occurrence of pesticide residues, antibiotic residues, heavy metals etc. in dairy products and their testing methods, Laboratory auditing, Food traceability systems, Food recall and withdrawal.

VII. Practical:

- Preparation of standard solutions
- Testing of available chlorine content in hypochlorites/ bleaching powder
- Determination of purity of common salt to be used for butter and cheese making
- Detection of common adulterants in milk and foreign fat/ oil in ghee
- Checking the accuracy of calibration of hydrometers/ lactometers, butyrometers, milk pipette and thermometer
- Qualitative colour tests to distinguish between azo dyes and natural dyes in butter
- Maintenance of records as per NABL and ISO criteria.
- Visit to a food analytical laboratory.

VIII. Teaching Methods/ Activities:

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work
- Guest Lectures

IX. Learning outcome:

After successful completion of this course, the students are expected to be able to:

- Understand the requirements and policy relating to implementation of various quality management tools.
- Apply the food safety standards to specific situations

X. Suggested Reading:

- Hoorfar J. 2012. *Case Studies in Food Safety and Authenticity*. 1st Ed. Woodhead Publishing
- IDF. 1993. *Quality Assurance* (*QA*) *and Good Lab. Practices* (*GLP*) *in Dairy Laboratories*. Special Issue No. 9302.
- IDF. 1997. *Monograph on Residues and Contaminants in Milk and Milk Products.* Special Issue No. 9701.
- Konieczka P and Namiesnik J. 2018. *Quality Assurance and Quality Control in The Analytical Chemical Laboratory: A Practical Approach*. CRC Press.
- Ralph Early. 1995. *Guide to Quality Management System for Food Industry*. Blackie.
- Schrenk D and Cartus A. 2017. *Chemical Contaminants and Residues in Food.* 2nd Ed. Woodhead Publishing.
- Young W. Park and George FW. Haenlein 2013. *Milk and Dairy Products in Human Nutrition*. John Wiley and Sons, UK.

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I: Quality Tools and Management System** Concept of quality assurance and quality control in relation to dairy industry; Quality management systems – good manufacturing practices (GMP); HACCP certification; ISO 9001, ISO 22000, FSSC, total quality management (TQM); Lean and Six sigma, Five –S, Kaizen, Kanban and other quality tools; Good laboratory practices (GLP), laboratory accreditation.	**8**
2	**Unit II: International and National Organisations** Role of international organisations such as ISO, IDF, CAC, AOAC, WTO and national organisations like BIS, FSSAI, AgMark and APEDA in dairy industry, Quality Council of India (QCI), Export Inspection Council (EIC); Guidelines for setting up quality control	**8**

	laboratory and chemical safety aspects; sampling of milk and milk product; Food 84abelling guidelines.	
3	**Unit III: Assessment of Quality of milk and milk products** Detergents, sanitizers and disinfectants; Calibration of milk testing glassware; Preparation of standard reagents; Detection of adulterants in milk and milk products; Quality of packaging material for dairy products; Instrumentation in analysis of milk and milk products.	**8**
4	**Unit IV: Contaminants and Food Traceability** Agro-chemicals/veterinary drug residues; occurrence of pesticide residues, antibiotic residues, heavy metals etc. in dairy products and their testing methods, Laboratory auditing, Food traceability systems, Food recall and withdrawal.	**8**
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1.	Preparation of standard solutions	1
2.	Testing of available chlorine content in hypochlorites/ bleaching powder	3
3.	Determination of purity of common salt to be used for butter and cheese making	1
4.	Detection of common adulterants in milk and foreign fat/ oil in ghee	2
5.	Checking the accuracy of calibration of hydrometers/ lactometers, butyrometers, milk pipette and thermometer	2
6.	Qualitative colour tests to distinguish between azo dyes and natural dyes in butter	2
7.	Maintenance of records as per NABL and ISO	2
8.	Visit to a food analytical laboratory	3
	Total	**16**

Course Syllabus and Contents
M.Sc. (Agri) Dairy Microbiology

I. Course Title : Microbial Physiology
II. Course Code : DM 511
III. Credit Hours : 3=2+1

IV. Why this course?

Microbial physiology is the study of how microbial cell structures, growth and metabolism function in living organisms. It covers the study of nutritional transport system of bacteria, electron transport chain in prokaryotes and nutritional requirements of bacteria for their growth.

V. Aim of the course

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

VI. Theory:

Unit I: Bacterial growth

Growth phases and kinetics; synchronous, continuous, and associative growth; factors affecting bacterial growth; growth measurement; sporulation.

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; mechanism of action of antimicrobials.

Unit III: Bacterial nutrition

Nutrient media; Nutritional groups of bacteria; Role of growth factors; Active and passive transport.

Unit IV: Energy metabolism

Electron transport chain, fermentation, respiration and photosynthesis.

VII. 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.

VIII. **Teaching Methods:**

- Lecture

- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the effect of environmental factors on microbial growth of bacteria.
- To have an idea about nutritional transport system of bacteria.
- To know about the electron transport chain in prokaryotes.
- To have any idea about the nutritional requirements of bacteria during their growth using various growth measurement techniques.

X. Suggested Reading:

- Dean Watson. 2017. *Microbial Physiology*.
- Seaman GR and Mary JD. 2012. *Experiments in Microbial Physiology and Biochemistry*. Literary Licensing, LLC, USA.
- Willey J, Sherwood L and Woolverton CJ. 2017. *Prescott's Microbiology*, 10th Edition.
- Madigan MT, Martinko JM and Parker J. 2020. *Brock Biology of Microorganisms*. 16th edition, Prentice Hall, London, UK.
- Moat AG, Foster JW and Spector MP. 2002. *Microbial Physiology*. 4th Ed. Wiley-Liss.
- Poole RK. 2006. *Advances in Microbial Physiology*. Apple Academic Press (CRC Press), USA
- Rose AH. 2009. *Chemical Microbiology: An Introduction to Microbial Physiology*. Plenum Pub. Corp.
- Tortora GJ, Funke BR and Case CL. 2020. *Microbiology: An Introduction*, 13th Edn, Pearson, Harlow, UK.

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Bacterial growth: Growth phases and kinetics; synchronous, continuous, and associative growth; factors affecting bacterial growth; growth measurement; sporulation.	8
2	**Unit II**	10

	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; mechanism of action of antimicrobials	
3	**Unit III** Bacterial nutrition; Nutrient media; Nutritional groups of bacteria; Role of growth factors; Active and passive transport	8
4	**Unit IV** Energy metabolism: Electron transport chain, fermentation, respiration and photosynthesis	6
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Measurement of bacterial growth by direct methods (cell number, SPC, DMC) and indirect methods (turbidometric methods, MPN, cell mass)	3
2	Preparation of growth curve; determination of generation time	3
3	Determination of cell activity; Carbohydrate fermentation; Acid production/pH alteration; Starch, lipid, casein and gelatin hydrolysis	4
4	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	6
	Total	**16**

I. Course Title : Microbiology of Processed Dairy Foods

II. Course Code : DM 512

III. Credit Hours : Credit: 3+1

IV. Why this course?

Different types of processing are done in dairy and foods industry for improving the quality and shelf life of the products. Each processing step affects microbial quality. Students should have idea about such changes. Course will also coverbio-preservation system of processed dairy foods, antimicrobial or bioactive packaging systems and GMO and their regulatory systems.

V. Aim of the course:

To understand the microbiology of processed foods, types of processing and their effect on microbiological quality, significance of different food microorganisms, their control and other related aspects.

VI. Theory:

Unit I

Introduction to microbes in foods, history and development of food microbiology, microorganisms important in foods, microbial ecology of processed foods and food ecosystem, factors influencing microbial growth in foods; Intrinsic factors and extrinsic factors.

Unit II

High temperature food preservation, factors affecting heat resistance in microorganisms, thermal destruction of microorganisms, low temperature food preservation, food preservation by irradiation, food preservation by drying and fermentation, modern processing techniques-ohmic heating, high pressure processing, infra-red heating, cold plasma, pulsed electric field, ultra sound etc., bio preservation of foods - concepts: metabolites of lactic acid bacteria; Bacteriocins, Antifungal substances etc., protective cultures and other antimicrobials (herbs, spices and other natural antimicrobial compounds), Nanoscience in food preservation; microencapsulation.

`Unit III

Microbial stress response in the food environment; Stress adaptation, sublethal stress and injury, antibiotic resistance in food bacteria, predictive modelling for food spoilage, industrial strategies for ensuring safe foods, HACCP; GMP, GHP

Unit IV

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

Unit V

New prospects and problems in processed dairy foods. Genetically modified foods

VII. Practical

- D and Z-value calculation of common food pathogens.
- Production of antimicrobial substances-bacteriocins.
- Production of antifungal substances.
- Application of bacteriocins for bio preservation of foods.
- Application of hurdle concepts for enhanced shelf stability of processed foods.

- Induction of bacterial cell injury and recovery of injured cells.
- Antibiotic resistance of food pathogens.
- Shelf life enhancement using antimicrobial packaging.

VIII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the latest technologies for processing of foods, biopreservation system of processed dairy foods
- To have an idea about the processing methods that do not diminish the quality attributes of food being processed
- To know about the recent antimicrobial or bioactive packaging systems that can enhance the shelf life of fresh as well as processed produce/food.
- To have any idea about the GMO and their regulatory systems.

X. Suggested Reading:

- Ozer B and Evrendilek GA. 2014. *Dairy Microbiology and Biochemistry: Recent Developments.* CRC Press.
- Silva ND, Taniwaki MH, Junqueira VC, Silveira N, Nascimento MDSD and Gomes RAR. 2012. *Microbiological Examination Methods of Food and Water: A Laboratory Manual*. CRC Press, USA.
- Erkmen O and Bozoglu TF. 2016. *Food Microbiology: Principles into Practice*, 2 Volume Set. Wiley Publishing.
- Papademas P. 2014. *Dairy Microbiology: A Practical Approach*. CRC Press.
- Prajapati JB and Behare PV. 2018. *Textbook of Dairy Microbiology*. Directorate of Knowledge Management in Agriculture, ICAR, ISBN: 978-81-7164-182-6.
- Ray RC and Didier M. 2014. *Microorganisms and Fermentation of Traditional Foods*. CRC Press, USA.
- Ray B. 2003. *Fundamental Food Microbiology*. CRC Press.
- Hutkins RW. 2019. *Microbiology and Technology of Fermented Foods*, 2nd Ed, Wiley Blackwell, New Jersey, USA.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Introduction to microbes in foods, history and development of food microbiology, microorganisms important in foods, microbial ecology of processed foods and food ecosystem, factors influencing microbial growth in foods; Intrinsic factors and extrinsic factors.	8
2	**Unit II** High temperature food preservation, factors affecting heat resistance in microorganisms, thermal destruction of microorganisms, low temperature food preservation, food preservation by irradiation, food preservation by drying and fermentation, modern processing techniques-ohmic heating, high pressure processing, infra-red heating, cold plasma, pulsed electric field, ultra sound etc., bio preservation of foods - concepts: metabolites of lactic acid bacteria; Bacteriocins, Antifungal substances etc., protective cultures and other antimicrobials (herbs, spices and other natural antimicrobial compounds), Nanoscience in food preservation; microencapsulation.	15
3	**Unit III** Microbial stress response in the food environment; Stress adaptation, sublethal stress and injury, antibiotic resistance in food bacteria, predictive modelling for food spoilage, industrial strategies for ensuring safe foods, HACCP; GMP, GHP.	12
4	**Unit IV** Antimicrobial packaging; concepts and development, modified atmosphere packaging (MAP), intermediate moisture foods (IMF), and hurdle technology in processed foods.	8
5	**Unit V** New prospects and problems in processed dairy foods. Genetically modified foods.	5
	Total	**48**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	D and Z-value calculation of common food pathogens	2
2	Production of antimicrobial substances-bacteriocins	2
3	Production of antifungal substances	2
4	Application of bacteriocins for bio preservation of foods	2
5	Application of hurdle concepts for enhanced shelf stability of processed foods	2

6	Induction of bacterial cell injury and recovery of injured cells	2
7	Antibiotic resistance of food pathogens	2
8	Shelf life enhancement using antimicrobial packaging	2
	Total	**16**

I. Course Title : Microbial Morphology and Taxonomy

II. Course Code : DM 513

III. Credit Hours : 4=3+1

IV. Why this course?

Morphology is the study of the form of bacteria. This covers morphological features such as shape, size, cell structure, motility (ability to move in a liquid), and sporeand capsule formation, different staining methods and micrometry etc.

V. Aim of the course

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

VI. Theory

Unit I

Evolution of life on earth, history and diversity of microorganisms.

Unit II

Principles of classification and taxonomy of Eubacteria (Bacteria and Archaea); Major characteristics used in taxonomy; Cultural, Morphological, Biochemical;Physiological, Genetic and Molecular; 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 ofendospore, composition and function of spore constituents, induction andgermination.

Unit IV

Fungi: Distribution, importance and recent classification, study of yeasts and moulds in dairy foods

Unit V

History, development and scope of virology; classification and nomenclature, characteristics of viruses (acellular organization and viral genome), viral reproduction, brief account of viroids and prions

VII. Practical

- Staining: Simple staining; differential staining - Gram's staining, spore staining, acid fast staining; special staining - cell wall staining, flagella staining, nucleoids staining, capsule staining, inclusion/storage bodies staining..
- Preparation of bacterial protoplasts and spheroplasts.
- Measuring dimensions of microorganisms (bacteria) using micrometry.
- Morphology of fungi: yeast and moulds.
- Application of computer software in bacterial identification.

VIII. Teaching Methods/ Activities

- Lectures

- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the Principles of classification and taxonomy of Eubacteria.
- To have knowledge on the advanced techniques help in classification of organisms.
- To know about the ultrastructure of microorganisms.
- To acquire the knowledge on different staining methods and micrometry.

X. Suggested Reading

- Cowan MK. 2012. *Microbiology: A Systems Approach*, 3rd Edition. The McGraw Hill Companies, New York, USA.
- Holt JG, Krieg NR, Sneath PHA, Staley JT and Williams ST. 1997. *Bergey's Manual of Determinative Bacteriology* (9th edition). Williams and Wilkins, Baltimore, Maryland, USA.
- Krejer van-Rij NJW. 1998, *The Yeasts: A Taxonomic Study*, 4th edn, Elsevier Science Publishers, Amsterdam, The Netherlands.
- Madigan MT, Martinko JM and Parker J. 2020. *Brock Biology of Microorganisms*. 16th edition, Prentice Hall, London, U.K.
- Prescott LM, Harley JP and Klein DA. 2002, *Microbiology*, 5th edn, McGraw Hill, New York, USA.
- Tolaro KP. 2011. *Foundations in Microbiology*, 8th Edn. The McGraw Hill Companies, New York, USA.
- Tortora GJ, Funke BR and Case CL. 2020. *Microbiology: An Introduction*, 13th Edn, Pearson, Harlow, UK.

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Evolution of life on earth, history and diversity of microorganisms	4
2	**Unit II** Principles of classification and taxonomy of Eubacteria (Bacteria and Archaea); Major characteristics used in taxonomy; Cultural, Morphological, Biochemical;	16

	Physiological, Genetic and Molecular; Numerical Taxonomy (Taxometrics) and Chemotaxonomy. Assessing Microbial Phylogeny: Chronometers; Phylogenetic trees, r-RNA, DNA and proteins as indicators of phylogeny.	
3	**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.	15
4	**Unit IV** Fungi: Distribution, importance and recent classification, study of yeasts and mouldsin dairy foods	7
5	**Unit V** History, development and scope of virology; classification and nomenclature, characteristics of viruses (acellular organization and viral genome), viral reproduction, brief account of viroids and prions	6
	Total	**48**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Staining: Simple staining; differential staining - Gram's staining, spore staining, acid fast staining; special staining - cell wall staining, flagella staining, nucleoids staining, capsule staining, inclusion/storage bodies staining	5
2	Preparation of bacterial protoplasts and spheroplasts	3
3	Measuring dimensions of microorganisms (bacteria) using micrometry	2
4	Morphology of fungi: yeast and moulds	3
5	Application of computer software in bacterial identification	3
	Total	**16**

I. Course Title : Microbiology of Fluid Milk and Dairy Products

II. Course Code : DM-514

III. Credit Hours : 3=2+1

IV. Why this course?

Milk is a complex biological fluid secreted in the mammary glands of mammals. It contains all the nutrients which help the organisms to grow well. For the safe processing and production of milk and milk products, student should have good knowledge of various handling and processing practices on market milk. Novel technologies must be applied in milk and milk product processing for the inactivation of food borne microorganisms or toxins produced by the organisms during transportation or storage or raw milk.

V. Aim of the course

To familiarize the students with microbes in milk and milk products, microbiological aspects of processing, microbiology of milk products and safety aspects

VI. Theory:

Unit I

Common microbes in milk and their significance, Microflora of mastitis milk and its importance in dairy industry, Sources of microbial contamination of raw milk and their relative importance in influencing quality of milk during production, collection, transportation and storage; Clean milk production and natural antimicrobial systems in raw milk, Microbial changes in raw milk during long storage, Microbiological grading of raw milk.

Unit II

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

Unit III

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

Unit IV

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

Unit V

Food poisoning- Food intoxications, Food infections and Toxi-infections, pathogens associated with fluid milks, dairy products and their public health significance; Sources of pathogens and their prevention; Importance of biofilms, their role in transmission of pathogens in dairy products and preventive strategies.

VII. Practical:

- Grading of raw milk based on SPC, coliforms and dye reduction tests.
- Effect of different storage temperatures on microbiological quality of fluid milk.
- Tests for mastitic milk and brucellosis.
- Microbiological quality evaluation of cream and butter for coliforms, yeasts and moulds, lipolytic and proteolytic bacteria.
- Detection of *Cronobacter sakazakii* in infant dairy foods.
- Microbial evaluation of burfiand pedafor SPC, *S. aureus*, yeast and mould counts.
- Detection of *Bacillus cereus, Salmonella,Shigella* and coagulase positive staphylococci in milk powder.
- Evaluation of ice cream for coliforms and *Escherichia coli*.
- Microbiological quality of paneer.
- Enumeration of aerobic and anaerobic spores in condensed, sterilized and driedmilks.
- Line testing for determining the source of contamination of dairy products.
- Detection of toxins (staphylococcal, aflatoxins/mycotoxins) in dairy foods

VIII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the novel technologies applied in milk and milk product processing for the inactivation of food borne microorganisms.
- To have an idea about the latest standards formulated by FSSAI on milk and milk products (Microbiological Standards).
- To know about the different toxins produced by microorganisms in milk and milk products.
- To have knowledge on Microbiological quality of traditional dairy products in India.

X. Suggested Reading

- Eozer B. 2014. *Dairy Microbiology and Biochemistry: Recent Developments*. CRC Press, USA.
- Law BA. 2012. *Microbiology and Biochemistry of Cheese and Fermented*

Milks. Springer Publisher.

- Quin M. 1989. *Applied Microbiology in the Dairy Industry*. Hobsons Publishing PLC.
- Poltronieri P (Editor). 2017. *Microbiology in Dairy Processing: Challenges and Opportunitie* John Wiley and Sons Inc.
- Prajapati JB and Behare PV. 2018. *Textbook of Dairy Microbiology*: Directorate of Knowledge Management in Agriculture, ICAR, ISBN: 978-81-7164-182-6.
- Fernandes R (Editor). 2009. *Microbiology Handbook: Dairy Products*. RSC Publishing

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1.	**Unit I** Common microbes in milk and their significance, Microflora of mastitis milk and its importance in dairy industry, Sources of microbial contamination of raw milk and their relative importance in influencing quality of milk during production, collection, transportation and storage; Clean milk production and natural antimicrobial systems in raw milk, Microbial changes in raw milk during long storage, Microbiological grading of raw milk	6
2.	**Unit II** Microbiological aspects of processing techniques like bactofugation, thermization, pasteurization, sterilization, boiling, UHT, non-thermal processes (pulsedelectric field) and membrane filtration of milk; Role of psychrotrophic, mesophillic, thermophilic and thermoduric bacteria in spoilage of processed milks, their sources and prevention; Heat induced damage in bacteria and role of resuscitation in recovery of injured microbial cells. Microbiological standards (BIS/ FSSAI) of heat- treated fluid milks	8
3.	**Unit III** Microbiological quality of dairy products; fat rich (cream and butter), frozen (ice cream), concentrated (evaporated and condensed milk), dried milks (roller and spray dried), infant dairy foods and legal standards; Sources of contamination and factors affecting microbial quality of these products during processing, storage and distribution; Microbiological defects associated with these products and their control	6
4.	**Unit IV** Microbiological quality of traditional dairy products in India; heat desiccated (khoa, burfi, peda, kheer, etc.), acid coagulated (paneer, chhana, rasogolla, etc.), fermented (dahi, lassi, srikhand, etc.) and frozen (kulfi); Sources of microbial contaminants and their role in spoilage; Importance of personnel and environmental hygiene on	6

	qualityof traditional milk products; Microbiological standards for indigenous dairy foods	
5	**Unit V** Food poisoning- Food intoxications, Food infections and Toxi-infections, pathogensassociated with fluid milks, dairy products and their public health significance; Sources of pathogens and their prevention; Importance of biofilms, their role in transmission of pathogens in dairy products and preventive strategies	6
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Grading of raw milk based on SPC, coliforms and dye reduction tests	2
2	Effect of different storage temperatures on microbiological quality of fluid milk	2
3	Tests for mastitic milk and brucellosis	1
4	Microbiological quality evaluation of cream and butter for coliforms, yeasts andmoulds, lipolytic and proteolytic bacteria	1
5	Detection of *Cronobacter sakazakii* in infant dairy foods	2
6	Microbial evaluation of burfi and peda for SPC, *S. aureus*, yeast and mould counts	1
7	Detection of *Bacillus cereus*, *Salmonella*,*Shigella* and coagulase positive staphylococci in milk powder	1
8	Evaluation of ice cream for coliforms and *Escherichia coli*	1
9	Microbiological quality of paneer	1
10	Enumeration of aerobic and anaerobic spores in condensed, sterilized and driedmilks	1
11	Line testing for determining the source of contamination of dairy products	1
12	Detection of toxins (staphylococcal, aflatoxins/mycotoxins) in dairy foods	2
	Total	**16**

I. Course Title : Microbial Genetics
II. Course Code : DM 515
III. Credit : 3= 2+1

IV. Why this course?

Microbial genetics is a subject area within microbiology and *genetic* engineering. *Microbial genetics* provides powerful tools for deciphering the regulation, as well as the functional and pathway organization, of cellular processes.

V. Aim of the course

To understand the fundamentals of structure, functions and synthesis of macromolecules and their genetic manipulation.

VI. Theory

Unit I

Macromolecules: DNA, RNA and their structure, types, organization, function and properties of macromolecules, DNA replication.

Unit II

Regulation and Gene Expression: Gene Expression and its regulation in Prokaryotes- Transcription, Genetic Code, Translation, Negative and Positive regulation in gene expression, Operon Models - Lac, Trp.

Unit III

Mutations: Mutations - Spontaneous and Induced, Type of mutations, Mutagenic agents – physical and chemical, Damage and repair system operating in Prokaryotes.

Unit IV

Plasmids and gene transfer systems: Plasmids and their properties, transposable elements, bacterial recombination, transformation, transduction and conjugation.

Unit V

Recombinant DNA technology, Fundamental aspects of genetic engineering/ recombinant DNA technology, restriction enzymes, plasmid vectors (cloning as wellas expression vectors), PCR and real time PCR.

VII. Practical

- Isolation and quantitative estimation of chromosomal DNA from *E. coli* and *Lactobacillus* by mini prep method.
- Isolation of plasmid DNA from *E. coli* by miniprep method.
- Calcium chloride induced transformation of *E. coli* hosts with plasmids.
- Digestion of plasmid DNA with restriction enzymes and ligation into plasmid vectorfor transformation
- PCR based detection of microorganisms
- Demo of real time PCR machine

VIII. Teaching Methods/ Activities

- Lectures

- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the macrostructure of DNA and RNA
- To have an idea about the genetic expression and regulation in Prokaryotic system
- To know about the recent advancements in genetic engineering/recombinant DNA technology.
- To have exposure on different types of PCR and their applications.

X. Suggested Reading

- Bansal MP. 2012. *Molecular Biology and Biotechnology: Basic Experimental Protocols*. Teri Press - New Delhi.
- Hofmann A and Clokie S. (Eds.). 2018. *Wilson and Walker's principles and techniques of biochemistry and molecular biology*. Cambridge University Press.
- Watson JD, Tania AB, Stephen PB, Alexander G, Michael L and Richard L. 2017. *Molecular Biology of the Gene*.
- Russell J. Peter. 2014. *IGenetics: a molecular approach*. Pearson.
- Synder L and Champness W. 2003. *Molecular Genetics of Bacteria*. ASM Publ.
- Uldis N Streips and Ronald E Yasbin (Eds.). 2004. *Modern Microbial Genetics*. John Wiley and Sons.
- Watson JD. 2003. *Molecular Biology of Genes*. W.A. Benjamin.

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1.	**Unit I** Macromolecules: DNA, RNA and their structure, types, organization, function and properties of macromolecules, DNA replication	5
2.	**Unit II** Regulation and Gene Expression: Gene Expression and its regulation in Prokaryotes- Transcription, Genetic Code, Translation, Negative and Positive regulation in gene expression, Operon Models - Lac, Trp	8

3.	**Unit III** Mutations: Mutations - Spontaneous and Induced, Type of mutations, Mutagenic agents – physical and chemical, Damage and repair system operating in Prokaryotes	6
4.	**Unit IV** Plasmids and gene transfer systems: Plasmids and their properties, transposable elements, bacterial recombination, transformation, transduction and conjugation	6
5	**Unit V** Recombinant DNA technology, Fundamental aspects of genetic engineering/ recombinant DNA technology, restriction enzymes, plasmid vectors (cloning as wellas eXpression vectors), PCR and real time PCR	7
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Isolation and quantitative estimation of chromosomal DNA from *E. coli* and *Lactobacillus* by mini prep method	3
2	Isolation of plasmid DNA from *E. coli* by miniprep method	2
3	Calcium chloride induced transformation of *E. coli* hosts with plasmids	2
4	Digestion of plasmid DNA with restriction enzymes and ligation into plasmid vectorfor transformation	3
5	PCR based detection of microorganisms	3
6	Demo of real time PCR machine	3
	Total	**16**

I. Course Title : Environmental Microbiology

II. Course Code : DM 516

III. Credit Hours : 3=2+1

IV. Why this course?

Environmental microbiology is the study of the composition and physiology of microbial communities in the environment. This includes: structure and activities of microbial communities, processing of waste water using microbes, microbial interactions with bioecosytem, environmentally transmitted microbial pathogens, various bio-geochemical cycles etc.

V. Aim of the course

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

VI. Theory

Unit I

Environmental microbiology; Aero-microbiology; Airborne pathogens, toXins, aerosols, nature and control of bio-aerosols, aquatic environments and microbial habitats; Soil as a microbial environment; Microbes in eXtreme environments.

Unit II

Bio-geochemical cycles; Carbon cycles (fiXation, energy flow and respiration), nitrogen cycle (fiXation, ammonia assimilation, nitrification and nitrate reduction) sulphur cycle (assimilatory sulphate reduction, sulphur mineralization, oXidation and reduction), iron cycle; microbial influenced metal corrosion, acid mine drainage, metal recovery and desulfurization.

Unit III

Environmentally transmitted microbial pathogens (*Salmonella*, *E. coli*, *ampylobacter*, *Yersinia* etc.) and viruses (enteric and respiratory); indicator microorganisms (concept, total and faecal coliforms, faecal streptococci, bacteriophage etc.); Biofouling and biofilms; microorganisms as indicators of environment pollution; microbial toXicants and bio-organic pollutants.

Unit IV

Waste water treatment: physical - screening, racks, miXing, flocculation,sedimentation, floatation, elutriation, vacuum filtration and incineration; biological unit operations- aerobic and anaerobic cycles; kinetics of biological growth, application of kinetics to treatment systems, aerobic waste treatment, anaerobic waste treatment; waste water utilization for value addition, disposal and reuse of Waste water after treatment, solid wastes management; environment laws.

VII. Practical

- Determination of composite microflora (i.e. total bacteria, coliforms, yeasts and moulds etc.) of soil, water, air.
- Determination of BOD in dairy and food industrial wastes.
- Determination of composite microflora of waste water samples.
- Detection of residual antibiotics/pesticides in waste water samples.

- Isolation of bacteria capable of degrading organic and microbial pollutants from waste water samples.
- Isolation and characterization of bio-indicators from environmental samples.
- Utilization of waste water for production of ethanol, microbial and biomass.
- Visit to a sewage and sludge treatment plant.

VIII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the environmental bioecosytem (aero-microbiology).
- To have an idea about the processing of waste water using microbes
- To know about the various bio-geochemical cycles
- To have idea on environmentally transmitted microbial pathogens.

X. Suggested Reading

- Hurst CJ, Crawford RL, Garland JL, Lipson DA and Mills AL. 2007. *Manual ofEnvironmental Microbiology*. 3rd Ed. ASM Press.
- Madsen, Eugene L. 2016. *Environmental microbiology: from genomes to biogeochemistry*.
- Maier RM, Pepper IL and Gerba CP. 2000. *Environmental Microbiology*. Elsevier.
- Maier RM, Pepper IL and Gerba CP. 2009. *Environmental Microbiology*. Elsevier Academic press, USA.
- Mitchell R and Gu JD. 2010. *Environmental Microbiology*. Wiley Blackwell.
- Varnam AH and Evans MG. 2000. *Environmental Microbiology*. Manson Publishing Ltd

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1.	**Unit I** Environmental microbiology; Aero-microbiology; Airborne pathogens, toxins, aerosols, nature and control of bio-aerosols, aquatic environments and microbial habitats; Soil as a microbial environment; Microbes in extreme environments	6
2.	**Unit II**	8

	Bio-geochemical cycles; Carbon cycles (fixation, energy flow and respiration), nitrogen cycle (fixation, ammonia assimilation, nitrification and nitrate reduction) sulphur cycle (assimilatory sulphate reduction, sulphur mineralization, oxidation and reduction), iron cycle; microbial influenced metal corrosion, acid mine drainage, metal recovery and desulfurization.	
3.	**Unit III** *Campylobacter*, *Yersinia* etc.) and viruses (enteric and respiratory); indicator microorganisms (concept, total and faecal coliforms, faecal streptococci, bacteriophage etc.); Biofouling and biofilms; microorganisms as indicators of environment pollution; microbial toxicants and bio-organic pollutants.	8
4.	**Unit IV** Waste water treatment: physical - screening, racks, mixing, flocculation, sedimentation, floatation, elutriation, vacuum filtration and incineration; biological unit operations- aerobic and anaerobic cycles; kinetics of biological growth, application of kinetics to treatment systems, aerobic waste treatment, anaerobic waste treatment; waste water utilization for value addition, disposal and reuse of Waste water after treatment, solid wastes management; environment laws	10
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Determination of composite microflora (i.e. total bacteria, coliforms, yeasts andmoulds etc.) of soil, water, air	3
2	Determination of BOD in dairy and food industrial wastes	2
3	Determination of composite microflora of waste water samples	2
4	Detection of residual antibiotics/pesticides in waste water samples	2
5	Isolation of bacteria capable of degrading organic and microbial pollutants fromwaste water samples	2
6	Isolation and characterization of bio-indicators from environmental samples	2
7	Utilization of waste water for production of ethanol, microbial and biomass	2
8	Visit to a sewage and sludge treatment plant	1
	Total	**16**

I. Course Title : Biotechnology in Dairy Industry

II. Course Code : DM 517

III. Credit Hours : 2+1

IV. Why this course?

Biotechnology is a tool for value addition to dairy foods. Genetic techniques have been employed to manipulate bacteria that have significance to the dairy industry. Biotechnological means can be used to regulate the production of flavour enhancing metabolites and to develop starter cultures that are resistant to bacteriophage and bacteriocins. Genetic engineering will be able to enhance the technological functions of Lactic acid bacteria for industrial applications using genetic approaches.

V. Aim of the course

To impart knowledge in the application of biotechnology in dairy/ food Industries

VI. Theory:

Unit I

History and development of biotechnology; Status of biotechnology industries in India to meet the demands of dairy and food Industries.

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 ofview.

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 foodborne pathogens and spoilage microorganisms.

Unit V

Molecular tools for studying biodiversity; Regulatory standards, value added products for GMOs and GM foods.

VII. Practicals:

- Plasmid isolation from *E. coli*.
- Agarose gel electrophoresis.
- Transformation of *E. coli* with plasmid (Amp^r).
- 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 foodborne pathogen detection
- Production of enzymes:protease/ â galactosidase
- Preparation of value added dairy products: fruit and probiotic based dahi/yoghurt/

lassi.

VIII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the nutrigenomics.
- To have knowledge on how to enhance the technological functions of Lactic acid bacteria for industrial applications using genetic approaches.
- To know about the advanced molecular tools for the detection of pathogens.
- To have knowledge on Biosensor and its application on dairy industry.

X. Suggested Reading:

- Pometto A, Shetty K, Paliyath G and Levin RE. 2005. *Food Biotechnology*. CRC Press, USA.
- Ratledge C and Kristiansen B. 2001. *Basic Biotechnology*. Cambridge University Press, USA.
- Bagchi D, Lau FC and Ghosh DK. 2010. *Biotechnology in Functional Foods and Nutraceuticals*. CRC Press, USA.
- Rai RV. 2015. *Advances in Food Biotechnology*. John Wiley and Sons Ltd.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** History and development of biotechnology; Status of biotechnology industries in India to meet the demands of dairy and food Industries	4
2	**Unit II** Genetic improvement of lactic starters to enhance their technological functions forindustrial 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,	10

	immunoglobulins etc. Detection of GMOs and GM foods and their safety from public health point ofview	
3	**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.	6
4	**Unit IV** Application of molecular tools, biosensors, etc. for detection of foodborne pathogens and spoilage microorganisms.	6
5	**Unit V** Molecular tools for studying biodiversity; Regulatory standards, value added products for GMOs and GM foods.	6
	Total	**32**

Practical:

Sr. No.	**Topic**	**No. of Practical (s)**
1	Plasmid isolation from *E. coli*	2
2	Agarose gel electrophoresis	2
3	Transformation of *E. coli* with plasmid (Amp^r)	2
4	Growth of starter cultures on MRS for “lac” marker	2
5	Induction of “lac”mutation using UV rays or ethidium bromide	2
6	PCR assays for identification of LAB and foodborne pathogen detection	2
7	Production of enzymes:protease/ â galactosidase	2
8	Preparation of value added dairy products: fruit and probiotic based dahi/yoghurt/ lassi	2
	Total	**16**

I. Course Title : Dairy Starter Cultures

II. Course Code : DM 521

III. Credit Hours : 3=2+1

IV. Why this course?

Starter cultures are those microorganisms that are used in the production of cultured dairy products such as dahi, yogurt, cheese etc. A starter culture can provide particular characteristics in a more controlled and predictable fermentation. This study covers isolation and characterization of Lactic acid bacteria, methods for selection and preservation, preparation of DVS cultures, control of starter slowness and control of phage in dairy industry.

V. Aim of the course:

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

VI. Theory:

Unit I

Taxonomy and characteristics of starter cultures: Taxonomy and natural habitat of starter cultures, Desirable properties of starter cultures with respect to various fermented milk products, Characteristics of starter organisms, bacteria (*Lactococcus, Leuconostoc, Streptococcus, Pediococcus, Lactobacillus, Bifdobacterium, Enterococcus, Propionibacterium, Brevibacterium*), yeasts and moulds.

Unit II

Carbohydrate, citrate and protein metabolism; Lactose, galactose and glucose metabolism-transport of sugars across the cell boundaries, homolactic and heterolactic fermentations, other pathways of sugar metabolism, formation of flavouring agents from citrate fermentation, proteolytic systems and protein metabolism in lactic acid bacteria: Genetics of starter bacteria: Plasmids and plasmid instability; Industrially significant genes; Genetic modification of lactic acid bacteria, transposons and insertion sequences. Genetics of flavor formation in starter bacteria; Major enzymes and pathways involved.

Unit III

Classification of starters: Single, mixed and multiple strain, mesophilic and thermophilic starter cultures; propagation and preservation of starter cultures; factors affecting propagation of starter, functional starters producing exopolysaccharides, vitamins and antimicrobial compounds, commercial starter preparations: concentrated and super concentrated starters; Production systems for bulk cultures: Lewis, Jones and Tetra-pack systems; growth media: nutritional requirements of lactic acid bacteria, growth media formulations; PIM/PRM, pH control during culturing- external and internal pH control systems; preservation of bulk starter cultures- frozen and freeze dried, spray dried cultures; direct vat starter cultures.

Unit IV

Growth inhibition of lactic acid bacteria by antibiotics, bacteriocins, bacteriophages, cleaning and sanitizing agents and naturally occurring antimicrobial systems in raw milk; sources, types and characteristics of phages associated with starters, morphology and taxonomy, phage host interaction, prevention and control of phages during starter handling and fermented milk products manufacturing, mechanisms of phage resistance in lactic acid bacteria, inhibitory substances produced by lactic acid bacteria.

VII. Practical:

- Morphological examination of dairy starter cultures.
- Isolation of lactic acid bacteria from fermented milk products.
- Examination of purity and activity of starter cultures.
- Effect of physical and chemical factors on starter cultures.
- Evaluation of homo and hetero fermentation by starter cultures.
- Production of bulk starter culture.
- Preservation of starter cultures by liquid, freeze drying and other methods.
- Preparation and quality evaluation of concentrated starters.
- Inhibition of starters by antibiotic residues and other inhibitors.
- Production of bacteriocins by lactic acid bacteria.
- Production of exopolysaccharides by lactic acid bacteria.
- Detection of bacteriophages in cheese whey.

VIII. Teaching Methods/ Activities

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the isolation and characterization of Lactic acid bacteria
- To have an idea about biochemical pathways of Lactic acid bacteria for carbohydrate metabolisms
- To know about the freeze drying and preparation of DVS cultures.
- To have idea about causes of slowness of starter and control of phage.

X. Suggested Reading

- Speranza B, Bevilacqua A, Corbo MR and Sinigaglia M. 2017. *Starter Cultures in Food Production*. Wiley Black Well, John Wiley and Sons, Ltd, UK.
- Marth EH and Steele JL. 2001. *Applied Dairy Microbiology*. Marcel Dekker Inn. New York.
- Prajapati JB and Behare PV. 2018. *Textbook of Dairy Microbiology: Microbiology*

of Starter Culture 147-183. Directorate of Knowledge Management in Agriculture, ICAR, ISBN: 978-81-7164-182-6.

- Puniya AK. 2015. *Fermented Milk and Dairy Products*; CRC Press/ Taylor and Francis (ISBN 9781466577978).
- Hutkins RW. 2019. *Microbiology and Technology of Fermented Foods*, 2nd Ed, Wiley Blackwell, New Jersey, USA.
- Gabriel V, Ouwehand A, Salminen S and Wright AV. 2019. *Lactic acid bacteria: microbiological and functional aspects*. CRC Press.
- Wood BJ and Warner PJ. (Eds.). 2003. *Genetics of Lactic Acid Bacteria*. Springer Verlag.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Taxonomy and characteristics of starter cultures: Taxonomy and natural habitat of starter cultures, Desirable properties of starter cultures with respect to various fermented milk products, Characteristics of starter organisms, bacteria (*Lactococcus, Leuconostoc, Streptococcus, Pediococcus, Lactobacillus, Bifdobacterium, Enterococcus, Propionibacterium, Brevibacterium*), yeasts and moulds	6
2	**Unit II** Carbohydrate, citrate and protein metabolism; Lactose, galactose and glucose metabolism-transport of sugars across the cell boundaries, homolactic and heterolactic fermentations, other pathways of sugar metabolism, formation of flavouring agents from citrate fermentation, proteolytic systems and protein metabolism in lactic acid bacteria: Genetics of starter bacteria: Plasmids and plasmid instability; Industrially significant genes; Genetic modification of lactic acid bacteria, transposons and insertion sequences. Genetics of flavor formation in starter bacteria; Major enzymes and pathways involved.	10
3	**Unit III** Classification of starters: Single, mixed and multiple strain, mesophilic and thermophilic starter cultures; propagation and preservation of starter cultures; factors affecting propagation of starter, functional starters producing exopolysaccharides, vitamins and antimicrobial compounds, commercial starter preparations: concentrated and super concentrated starters; Production systems for bulk cultures:	10

	Lewis, Jones and Tetra-pack systems; growth media: nutritional requirements of lactic acid bacteria, growth media formulations; PIM/PRM, pH control during culturing- external and internal pH control systems; preservation of bulk starter cultures- frozen and freeze dried, spray dried cultures; direct vat starter cultures.	
4	**Unit IV** Growth inhibition of lactic acid bacteria by antibiotics, bacteriocins, bacteriophages, cleaning and sanitizing agents and naturally occurring antimicrobial systems in raw milk; sources, types and characteristics of phages associated with starters, morphology and taxonomy, phage host interaction, prevention and control of phages during starter handling and fermented milk products manufacturing, mechanisms of phage resistance in lactic acid bacteria, inhibitory substances produced by lactic acid bacteria	6
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Morphological examination of dairy starter cultures	1
2	Isolation of lactic acid bacteria from fermented milk products	2
3	Examination of purity and activity of starter cultures	2
4	Effect of physical and chemical factors on starter cultures	1
5	Evaluation of homo and hetero fermentation by starter cultures	2
6	Production of bulk starter culture	1
7	Preservation of starter cultures by liquid, freeze drying and other methods	2
8	Preparation and quality evaluation of concentrated starters	1
9	Inhibition of starters by antibiotic residues and other inhibitors	1
10	Production of bacteriocins by lactic acid bacteria	1
11	Production of exopolysaccharides by lactic acid bacteria	1
12	Detection of bacteriophages in cheese whey	1
	Total	**16**

I. Course Title : Microbial Safety and Quality

II. Course Code : DM 522

III. Credit Hours : 3=2+1

IV. Why this course?

Food Quality and Standards Service is committed to the enhancement of *food safety and quality* along the *food* chain to prevent diseases and trade disruptions. This course covers principles of safety in a food microbiological laboratory, conventional and rapid methods for detection of hygiene indicators or pathogens, antibiotic resistance in bacteria etc.

V. Aim of the course:

To impart knowledge pertaining to quality and safety functions in dairy processing unit and measure to control quality and safety of dairy products.

VI. Theory:

Unit I

Principles of quality and safety functions in dairy processing unit: Introduction to ISO standards– ISO: 9000:2000; ISO: 9004:2000; ISO: 9001:2000: Brief concept and principles of QMS and standard requirements for certification HACCP, Hazard Analysis and Risk-Based Preventive Controls (HARPC), SAFE, GMP, SSOP, FSMS, personnel hygiene and food handling in dairy industry. Principles of safety in a food microbiological laboratory-Bio-safety concept, Biosafety level-1-4 containment design and layout; Standard microbiological practices for safe handling in food laboratory, safety equipment, facility design.

Unit II

General principles for establishment of microbiological criteria: Definition, purpose and components of microbiological criteria; mandatory and advisory criteria Sampling methods - two and three class sampling plan as per International council for microbiological standards for foods (ICMSF), Establishment of microbiological standards, guidelines and specifications for different dairy foods as recommended by ICMSF, CODEX, FSSAI.

Unit III

Conventional and rapid methods for detection of hygiene indicators; definition, selection criteria of indicator organisms as an index of food quality, Conventional detection methods for indicator organisms – Standard plate count (SPC), coliforms, *E. coli*, yeast and mould Counts (YMC), spore counts; enterobacteriaceae count; Faecal streptococci count; Dye reduction tests, Rapid techniques like D-count, petrifilm, ATP bioluminance including commercial kits for monitoring hygiene indicators.

Unit IV

Conventional and rapid methods for detection of safety indicators; definition, selection criteria of indicator Organisms as an index of food safety; Conventional detection methods for detection of pathogenic organisms as per ISO protocol specified by FSSAI – *Staphylococcus aureus*; *Bacillus cereus*; Pathogenic *E.coli*; *Salmonella*; *Shigella*; *Listeria monocytogenes*; *Enterobacter sakazakii*; Sulphite reducing clostridia (SRC),

Campylobacter jejuni; Rapid techniques like–VIDAS, SPR, RT-PCR including commercial kits, for monitoring safety indicators.

Unit V

Bio-sensors and micro-techniques for rapid monitoring of contaminants; definition, history, basic characteristics of bio-sensors; classification based on bio-recognition molecule - Microbial, spore, Aptamer, DNA, immune and enzyme etc. Biosensors based on Transducers - electrochemical, optical, mechanical and calorimetric etc. Bio-sensors for rapid detection of hygiene indicators, pathogenic bacteria, antibiotics, pesticides, heavy metal, aflatoxin M1 in milk.

VII. Practical

- Demonstration of safety principles in a food microbiological laboratory.
- Aseptic technique for ensuring safety of personnel, product and environment.
- Conventional and rapid methods for hygienic assessment of milk for SPC, coliforms, *E. coli*, YMC, Spore counts, Enterobacteriaceae count, faecal streptococci count,Dye reduction tests
- Conventional ISO methods for enumeration of safety indicators in dairy foods for *S. aureus*; *B. cereus*; *E.coli*; *Salmonella*; *Shigella*; *L. monocytogenes*; *E. sakazakii*;SRC; *Campylobacter jejuni* as per FSSAI standards.
- Rapid tests for detection of antibiotics, aflatoxin M1 and pesticides in milk.
- Determination of antibiotic resistance in bacteria using phenotypic methods.
- Shelf life studies of dairy products; effect of storage condition and packaging material on microflora of dairy foods.
- Determination of efficacy of detergents and sanitizers using capacity and suspensiontests.

VIII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on principles of safety in a food microbiological laboratory.
- To have an idea about the principles for establishment of microbiological criteria.
- To know about the conventional and rapid methods for detection of hygiene indicators/pathogens.
- To have knowledge on antibiotic resistance in bacteria.

X. Suggested Reading:

- M. Brown and M Stringer. 2012. *Microbiological: Risk Assessment in Food*

Processing. Woodhead Publishing 1st Edition

- Patel P. (Ed.). (2012). *Rapid Analysis Techniques in Food Microbiology*. Springer Science and Business Media.
- Borough LM. 2004. *Food Microbiology Laboratory,* CRC Press, USA.
- Nordenfelt, Pontus, Collin, Mattias. 2017. *Bacterial Pathogenesis* (1st edition) Springer.
- Arvanitoyannis IS. 2012. HACCP and ISO 22000: *Application to Foods of Animal Origin* (Institute of Food Science and Technology Series). Wiley Blackwell.
- Osiemo O. 2012. *Food Safety Standards in International Trade: The Case of the EU and the COMESA*. Routledge Publisher.
- Bhunia AK. 2016. *Sensors for Food Safety and Quality*. eBook.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Principles of quality and safety functions in dairy processing unit: Introduction to ISO standards– ISO: 9000:2000; ISO: 9004:2000; ISO: 9001:2000: Brief concept and principles of QMS and standard requirements for certification HACCP, Hazard Analysis and Risk-Based Preventive Controls (HARPC), SAFE, GMP, SSOP, FSMS, personnel hygiene and food handling in dairy industry. Principles of safety in a food microbiological laboratory-Bio-safety concept, Bio safety level-1-4 containment design and layout; Standard microbiological practices for safe handling in food laboratory, safety equipment, facility design.	6
2	**Unit II** General principles for establishment of microbiological criteria Definition, purpose and components of microbiological criteria; mandatory and advisory criteria Sampling methods – two and three class sampling plan as per International council for microbiological standards for foods (ICMSF) Establishment of microbiological standards, guidelines and specifications for different dairy foods as recommended by ICMSF, CODEX, FSSAI.	6
3	**Unit III** Conventional and rapid methods for detection of hygiene indicators; definition, selection criteria of indicator organisms as an index of food quality Conventional detection methods for indicator organisms – Standard plate count (SPC), coliforms, *E. coli*, yeast and mould Counts (YMC), spore counts; enterobacteriaceae count; Faecal streptococci count; Dye reduction tests Rapid techniques like D-count, petrifilm, ATP bioluminance including commercial kits for monitoring hygiene indicators.	8
4	**Unit IV**	6

	Conventional and rapid methods for detection of safety indicators; definition, selection criteria of indicator Organisms as an indeX of food safety; Conventional detection methods for detection of pathogenic organisms as per ISO protocol specified by FSSAI – *Staphylococcus aureus*; *Bacillus cereus*; Pathogenic *E.coli*; *Salmonella*; *Shigella*; *Listeria monocytogenes*; *Enterobacter sakazakii*; Sulphite reducing clostridia (SRC), *Campylobacter jejuni*; Rapid techniques like–VIDAS, SPR, RT-PCR including commercial kits, for monitoring safety indicators.	
5	**Unit V** Bio-sensors and micro-techniques for rapid monitoring of contaminants; definition, history, basic characteristics of bio-sensors; classification based on bio- recognition molecule - Microbial, spore, Aptamer, DNA, immune and enzyme etc. Biosensors based on Transducers - electrochemical, optical, mechanical and calorimetric etc. Bio-sensors for rapid detection of hygiene indicators, pathogenic bacteria, antibiotics, pesticides, heavy metal, aflatoXin M1 in milk.	6
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Demonstration of safety principles in a food microbiological laboratory	1
2	Aseptic technique for ensuring safety of personnel, product and environment	2
3	Conventional and rapid methods for hygienic assessment of milk for SPC, coliforms, *E. coli*, YMC, Spore counts, Enterobacteriaceae count, faecal streptococci count, Dye reduction tests	3
4	Conventional ISO methods for enumeration of safety indicators in dairy foods for *S. aureus*; *B. cereus*; *E.coli*; *Salmonella*; *Shigella*; *L. monocytogenes*; *E. sakazakii*; SRC; *Campylobacter jejuni* as per FSSAI standards	3
5	Rapid tests for detection of antibiotics, aflatoXin M1 and pesticides in milk	2
6	Determination of antibiotic resistance in bacteria using phenotypic methods	1
7	Determination of antibiotic resistance in bacteria using phenotypic methods	2
8	Shelf life studies of dairy products; effect of storage condition and packaging material on microflora of dairy foods	1
9	Determination of efficacy of detergents and sanitizers using capacity and suspension tests	1
	Total	**16**

I. Course Title : Microbiology of Cheese and Fermented Dairy Foods

II. Course Code : DM 523

III. Credit Hours : 3=2+1

IV. Why this course?

There are several types of cheeses in the world; use of different starter culture canlead to development of specific cheese variety too. However, the technological principles involved in Cheddar cheese making are common to several varieties ofcheeses, with some modifications. Cheese is getting popularized in India, especiallythe Pizza cheese variety that is preferentially used as a topping on pizza pie. The functional properties of cheese depend on the starter cultures used and ripening of cheeses. Specific cheese has its own typical flavour and aroma depending on typeof starter cultures used for particular ripening conditions.

V. Aim of the course

To impart knowledge on basic and applied aspects of cheese and fermented dairyfoods

VI. Theory:

Unit I

Evolution and classification of cheeses and fermented Dairy foods; Introduction, classification and types of cheeses and fermented dairy foods. Market share and recent market trends.

Unit II

Microbiology of cheese, Cheese starter cultures involved in the manufacture, their types, roles, Current classification and metabolic pathways. Rennet, rennet substitutes; Microbial and recombinant rennet used in cheese preparation. Bacteriophages of cheese starters. Microbes associated with spoilage, defects, causative organisms and preventive measures. Health aspects of cheese.

Unit III

Microbiology of cheese ripening: Microbiological changes, Factors Influencing Growth of Microorganisms, Flavourdevelopment, Role of starter flora and supplementary flora in cheese ripening. Accelerated cheese ripening through biotechnological approaches, Cheese with highlinoleic acid content, Enzyme-modified cheese, GMO, Microbiological and biochemical aspects of major cheese varieties - Cheddar, Swiss- Type Cheeses - Emmental, Very hard cheese - Parmesan, Dutch cheese varieties - Edam, Gouda, Pasta Filata/Pizza Cheese - Mozzarella, Unripened cheese - Cottage, Internal mould ripened cheese - Roquefort, Surface mould ripened cheese - Camembert, Bacterial surface ripened cheese- Limburger; Microbiology of processed cheese.

Unit IV

Microbiology of Fermented dairy foods; Dahi, lassi, yoghurt, Kefir, Koumiss, functional fermented dairy based beverages, fermented whey drinks, and dairy based fermented cereal foods, fortified fermented dairy foods - Microbes associated with spoilage and preventive measures. Safety and standards of fermented foods.

Unit V

Functional cheeses, Cheese as matrix for probiotic delivery; Health aspects of cheese and fermented foods: nutritional value, and therapeuticbenefits.

VII. Practical:

- Preparation and evaluation of ethnic fermented dairy products.
- Preparation of cheese with mesophilic dairy starter cultures and different microbialrennets.
- Preparation of functional/probiotic cheese.
- Microbial analysis of cheeses.
- Identification and characterization of specific starter cultures from different varieties of cheeses (*Leuconostoc* for Dutch type cheese, *Propioni bacterium* for Swiss type cheese).
- Determination of ß-galactosidase activity of microorganisms.
- Accelerated cheese ripening using different interventions.

VIII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group work
- Routine practical as per the schedule
- Visit to the relevant industry or laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- Be able to manufacture various varieties of cheeses using cheese specific startercultures.
- To have knowledge on Bacteriophages of cheese starters.
- Be able to develop different fermented milk products, particularly traditional fermented milk products.
- To develop the probiotic cheese using probiotic cultures.

X. Suggested Reading:

- Speranza B, Bevilacqua A, Corbo MR and Sinigagli M. 2017. *Starter Cultures in Food Production.* Wiley Black Well, John Wiley and Sons, Ltd, UK.
- FatihYildiz. 2009 *Development and Manufacture of Yogurt and Other Functional Dairy Products*, CRC Press, USA.
- El-Mansi EMT, Bryce CFA, Arnold L. Demain and Allman AR. (Edited). 2012. *Fermentation Microbiology and Biotechnology*, Third Edition CRC.
- McSweeney P, Fox P, Cotter P and Everett D. (Eds.) 2017. *Cheese -Chemistry, Physics and Microbiology*, 4th Edn. Academic Press.
- Puniya AK. 2015. *Fermented Milk and Dairy Products*; CRC Press/ Taylor and Francis(ISBN 9781466577978).
- Hutkins RW. 2019. *Microbiology and Technology of Fermented Foods*, 2nd Ed,

Wiley Blackwell, New Jersey, USA.
- Wood BJ and Warner PJ. (Eds.). 2003. *Genetics of Lactic Acid Bacteria*. Springer Verlag.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Evolution and classification of cheeses and fermented Dairy foods; Introduction, classification and types of cheeses and fermented dairy foods. Market share and recent market trends.	4
2	**Unit II** Microbiology of cheese, Cheese starter cultures involved in the manufacture, their types, roles, Current classification and metabolic pathways. Rennet, rennet substitutes; Microbial and recombinant rennet used in cheese preparation. Bacteriophages of cheese starters. Microbes associated with spoilage, defects, causative organisms and preventive measures. Health aspects of cheese	6
3	**Unit III** Microbiology of cheese ripening Microbiological changes, Factors Influencing Growth of Microorganisms, Flavourdevelopment, Role of starter flora and supplementary flora in cheese ripening. Accelerated cheese ripening through biotechnological approaches, Cheese with high linoleic acid content, Enzyme-modified cheese, GMO, Microbiological and biochemical aspects of major cheese varieties - Cheddar, Swiss- Type Cheeses - Emmental, Very hard cheese - Parmesan, Dutch cheese varieties - Edam, Gouda, Pasta Filata/Pizza Cheese - Mozzarella, Unripened cheese - Cottage, Internal mould ripened cheese - Roquefort, Surface mould ripened cheese - Camembert, Bacterial surface ripened cheese- Limburger; Microbiology of processed cheese.	12
4	**Unit IV** Microbiology of Fermented dairy foods; Dahi, lassi, yoghurt, Kefir, Koumiss, functional fermented dairy based beverages, fermented whey drinks, and dairy based fermented cereal foods, fortified fermented dairy foods - Microbes associated with spoilage and preventive measures. Safety and standards of fermented foods.	6
5	**Unit V** Functional cheeses, Cheese as matrix for probiotic delivery. Health aspects of cheese and fermented foods: nutritional value, and therapeuticbenefits.	4
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Preparation and evaluation of ethnic fermented dairy products	3
2	Preparation of cheese with mesophilic dairy starter cultures and different microbial rennets	3
3	Preparation of functional/probiotic cheese	3
4	Microbial analysis of cheeses	2
5	Identification and characterization of specific starter cultures from different varieties of cheeses (*Leuconostoc* for Dutch type cheese, *Propioni bacterium* for Swiss type cheese)	2
6	Determination of ß-galactosidase activity of microorganisms	1
7	Accelerated cheese ripening using different interventions	2
	Total	**16**

I. Course Title : Probiotics and Prebiotics

II. Course Code : DM 524

III. Credit Hours : 3=2+1

IV. Why this course?

Probiotics are live microorganisms intended to provide health benefits when consumed, generally by improving or restoring the gut flora. This study covers Gut microbiota and its role in human health, mechanism of action of probiotics/prebiotics, safety and regulations on probiotics or probiotic food products.

V. Aim of the course

To understand the concept of probiotics and prebiotics in relation to food formulations and health effects.

VI. Theory:

Unit I

Probiotics, Prebiotics and Synbiotics: Concepts, definitions and history. Gut microbiota and its role in human health and disease.

Unit II

Identification of probiotic strains isolated from different niches by polyphasic approach using phenotypic, biochemical and genotypic tools/techniques. Characterization and selection of candidate probiotic strains on the basis of FAO/ WHO or ICMR/DBT guidelines.

Unit III

Mechanism of action of probiotics: Colonization in the gut; Adhesion to intestinal mucosal surface – role of surface proteins; Antimicrobial/antagonistic activity of probiotics, Pathogen exclusion; Immuno-modulatory action; Impact on gut, homeostasis; Host microbe interaction and their cross talk; Role of biomarkers for probiotic functionality.

Unit IV

Mechanism of action of prebiotics and synbiotics: Selective stimulation of beneficial bacteria in the gut microbiota; Effect on gastric emptying and intestinal transit rate; Production of short chain fatty acids (SCFA); Effect of SCFA on host metabolism and immunomodulation; Anti-adhesive prebiotics. Synbiotics and their action through improved viability of probiotic microorganisms and provision of specific health benefits.

Unit V

Dairy based foods as carrier of probiotics: Dairy based products as delivery vehicles –Stability towards manufacturing conditions, enhancing stability through encapsulation or drying strategies for lyophilized formulations etc., co-culture compatibility with starters, minimum effective dose, and large-scale production of probiotic biomass through fermentation for application in foods and as drugs/ supplements.

Unit VI

Designer probiotics: Genetically modified probiotics as oral vaccines, enhanced adhesion properties and health promoting functions.

Unit VII

Safety, human trials and regulatory guidelines: *In vitro* and *in vivo* safety assessment of probiotics; designing human trials; regulatory guidelines - US, Canada, Europe and India.

VII. Practical:

- Isolation of probiotic organisms from human milk and faecal samples.
- Tentative identification by microscopic examination, catalase and biochemical tests.
- Identification of isolates by genus and species-specific PCR.
- Evaluation of bacterial isolates for probiotic properties.
- Acid tolerance; Bile tolerance; Hydrophobicity; Antimicrobial activity.
- Specific utilization of prebiotics by probiotic bacteria.
- Survival of probiotic culture in fermented dairy products.
- Microencapsulation of probiotic bacteria.

VIII. Teaching Methods/ Activities:

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- Have knowledge on the Gut microbiota and its role in human health
- To have knowledge on identification, characterization and selection of probiotic strains using phenotypic, biochemical and genotypic tools/techniques.
- To know about the different mechanism of action of probiotics/prebiotics establishing through in vitro and in vivo studies.
- To have any idea about the safety and regulations on probiotics or probiotic food products.

X. Suggested Reading:

- Sungsoo C and Finocchiaro ET. 2010. *Handbook of prebiotics and probiotics ingredients: health benefits and food applications*. Boca Raton: Taylor and Francis.
- Ipek G, Vijay JK and Mohamed A. 2006. *Probiotics in Food Safety and Human Health*.
- Huffnagle GB. 2008. *The Probiotics Revolution: The Definitive Guide to Safe, NaturalHealth Solutions Using Probiotic and Prebiotic Foods and Supplements*.

Bantam,USA.
- Venema K. 2015. *Probiotics and Prebiotics: Current Research and Future Trends*.
- Min-TzeLiong. 2011. *Probiotics: Biology, Genetics and Health Aspects*. Springer.
- Prajapati JB and Behare PV. 2018. *Textbook of Dairy Microbiology:* Directorate of Knowledge Management in Agriculture, ICAR, ISBN: 978-81-7164-182-6.
- Di Gioia, Diana. -Biavati, Bruno. 2018. *Probiotics and Prebiotics in Animal Health and Food Safety*
- Wallace RK and Wallace S. 2017. *Gut Crisis: How Diet, Probiotics, and Friendly Bacteria Help You Lose Weight and Heal Your Body and Mind*. Dharma Publication, Fairfield, USA.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Probiotics, Prebiotics and Synbiotics: Concepts, definitions and history. Gut microbiota and its role in human health and disease.	4
2	**Unit II** Identification of probiotic strains isolated from different niches by polyphasic approach using phenotypic, biochemical and genotypic tools/techniques. Characterization and selection of candidate probiotic strains on the basis of FAO/ WHO or ICMR/DBT guidelines.	4
3	**Unit III** Mechanism of action of probiotics: Colonization in the gut; Adhesion to intestinalmucosal surface – role of surface proteins; Antimicrobial/antagonistic activity of probiotics, Pathogen exclusion; Immuno-modulatory action; Impact on gut homeostasis; Host microbe interaction and their cross talk; Role of biomarkers for probiotic functionality.	6
4	**Unit IV** Mechanism of action of prebiotics and synbiotics: Selective stimulation of beneficial bacteria in the gut microbiota; Effect on gastric emptying and intestinal transit rate; Production of short chain fatty acids (SCFA); Effect of SCFA on host metabolism and immunomodulation; Anti-adhesive prebiotics. Synbiotics and their action through improved viability of probiotic microorganisms and provision of specific health benefits.	6

5	**Unit V** Dairy based foods as carrier of probiotics: Dairy based products as delivery vehicles – Stability towards manufacturing conditions, enhancing stability through encapsulation or drying strategies for lyophilized formulations etc., co-culture compatibility with starters, minimum effective dose, and large-scale production of probiotic biomass through fermentation for application in foods and as drugs/supplements.	4
6	**Unit VI** Designer probiotics: Genetically modified probiotics as oral vaccines, enhanced adhesion properties and health promoting functions.	4
7	**Unit VI** Safety, human trials and regulatory guidelines: *In vitro* and *in vivo* safety assessment of probiotics; designing human trials; regulatory guidelines - US, Canada, Europe and India.	4
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Isolation of probiotic organisms from human milk and faecal samples	2
2	Tentative identification by microscopic examination, catalase and biochemical tests	2
3	Identification of isolates by genus and species-specific PCR	2
4	Evaluation of bacterial isolates for probiotic properties	2
5	Acid tolerance; Bile tolerance; Hydrophobicity; Antimicrobial activity	2
6	Specific utilization of prebiotics by probiotic bacteria	2
7	Survival of probiotic culture in fermented dairy products	2
8	Microencapsulation of probiotic bacteria	2
	Total	**16**

I. Course Title : Research Techniques

II. Course Code : DM-525

III. Credit Hours : 3=2+1

IV. Why this course?

Research techniques are required to study the tools and techniques that are used in quantitative and qualitative methods. This study covers microscopic analysis of different types of bacteria, activities of enzyme using spectrophotometric based assays, identification and characterization of microorganisms by PCR etc.

V. Aim of the course

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

VI. Theory:

Unit I

Microscopy: Principles, design and application of bright field, dark field, phase contrast, fluorescence, atomic force, confocal laser and electron microscopes.

Unit II

Cell fractionation: Physical and chemical methods of microbial cell lysis: Ultrasonication, glass bead lysis, micro-fluidization, enzymatic and solvent induced techniques.

Unit III

Molecular separation: Ultrafiltration, crystallography, isoelectric focusing, chromatography, SDS-PAGE, micro and ultracentrifugation.

Unit IV

Assay methods: Spectrophotometric methods, ELISA, protein and enzyme assays, microbiological assay, and microbial receptor assay.

Unit V

Studying nutritional and therapeutic attributes of microorganisms and fermented dairy foods - Use of cell culture and small animal models.

VII. Practical:

- Familiarization with the construction and design of a compound microscope; use of light microscope accessories; microscopic analysis of different types of bacteriaby bright field, dark field, phase contrast and fluorescence microscopes.
- Disruption of bacterial cells by ultra-sonification.
- Demonstration of chromatographic techniques and SDS-PAGE.
- Demonstration of aerobic and anaerobic culturing techniques.
- Demonstration of use of animal models in toXicity studies.
- Identification and characterization of microorganisms by PCR.

VIII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation

- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- Be able to do the microscopic analysis of different types of bacteria.
- To measure the activities of enzyme using spectrophotometric based assays..
- To know about the identification and characterization of microorganisms by PCR.

X. Suggested Reading:

- Murphy DB. 2001. *Fundamentals of Light Microscopy and Electronic Imaging*, Wiley-Liss, Inc., USA.
- Harisha S. 2010. *Biotechnology Procedures and Experiments Handbook*. Infinity science press LLC, Hingham, MA 02043, USA.
- Hofmann A and Clokie S. (Eds.). 2018. *Wilson and Walker's principles and techniques of biochemistry and molecular biology*. Cambridge University Press.
- Spencer JFT & Ragout AL, Nollet LML and Toldra F. 2013. *Food analysis* HPLC, Third edition, CRC press, Taylor and Francis group, Florida, USA.
- Nollet LML and Toldra F. 2013. *Food analysis* HPLC, Third edition, CRC press, Taylor and Francis group, Florida, USA.
- Nasser Hajibagheri MA.1999. *Electron Microscopy Methods and Protocols, Methods in Molecular Biology Series*, # 117.Humana Press Inc., Totowa, New Jersey, USA.
- Singer S. 2001. *Experiments in Applied Microbiology*, Academic Press, New York, USA.

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Microscopy: Principles, design and application of bright field, dark field, phase contrast, fluorescence, atomic force, confocal laser and electron microscopes.	6
2	**Unit II** Cell fractionation: Physical and chemical methods of microbial cell lysis: Ultrasonication, glass bead lysis, micro-fluidization, enzymatic and solvent induced techniques.	6
3	**Unit III** Molecular separation: Ultrafiltration, crystallography, isoelectric focusing, chromatography, SDS-PAGE, micro and	6

	ultracentrifugation.	
4	**Unit IV** Assay methods: Spectrophotometric methods, ELISA, protein and enzyme assays, microbiological assay, and microbial receptor assay.	8
5	**Unit V** Studying nutritional and therapeutic attributes of microorganisms and fermented dairy foods – Use of cell culture and small animal models.	6
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Familiarization with the construction and design of a compound microscope; use of light microscope accessories	2
2	Microscopic analysis of different types of bacteriaby bright field, dark field, phase contrast and fluorescence microscopes	2
3	Disruption of bacterial cells by ultra-sonification	2
4	Demonstration of chromatographic techniques and SDS-PAGE	3
5	Demonstration of aerobic and anaerobic culturing techniques	2
6	Demonstration of use of animal models in toxicity studies	2
7	Identification and characterization of microorganisms by PCR	3
	Total	**16**

I. Course Title : Microbial Fermentation Technology

II. Course Code : DM-526

III. Credit Hours : 3=2+1

IV. Why this course?

Fermentation technology is the use of organisms to produce food, pharmaceuticals and alcoholic beverages on a large scale industrial basis. The basic principle involved in the industrial fermentation technology is that organisms are grown under suitable conditions, by providing raw materials meeting all the necessary requirements such as carbon, nitrogen, salts, trace elements and vitamins in a suitably designed bioreactor.

V. Aim of the course:

To disseminate recent information on basic and applied aspects of fermentation technology and its industrial application to the students.

VI. Theory:

Unit I

Fermentation for enhancing shelf life of foods, types of fermentation-submerged/solid state and semi-solid.

Unit II

Microbial growth, metabolism, death, membrane transport, fermentation kinetics and fermentation modelling, batch, fed batch, continuous culture systems.

Unit III

Bioreactor design, measurement and control in fermentation. Different types of fermenters, scaling up of fermentation, sterilization, agitation; pH, Eh, temperature measurement and control, downstream processing and product recovery, immobilization in fermentation.

Unit IV

Biosensors in fermentation applications: Biosensors, basic principles; application in detection of sugars, alcohol, amino acids.

Unit V

Industrial production of microbial cell biomass, organic acids, enzymes, antibiotics, micro-nutrients, amino acids, vitamins, ethanol, SCP and alcoholic beverages.

VII. Practical:

- Bacterial growth in batch culture.
- Different methods of microbial cultivation.
- Fermenter operation and measurement.
- Production of antimicrobial substances/ bacteriocins
- Production of microbial enzymes
- Production of baker yeast, SCP/microbial biomass.
- Production of alcohol, lactic acid.
- Production of alcoholic beverages and whey beverage.

VIII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Routine Practical as per the schedule
- Visit to the relevant industry or Laboratory

IX. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the Bioreactor design, measurement and control in fermentation.
- Be able to produce the microbial cell biomass, organic acids, enzymes, antibioticsetc. using fermenter.
- To have an idea about the construction, design and application of biosensor.
- Be able to produce alcoholic and whey beverages.

X. Suggested Reading:

- Kulandaivelu S and Janarthanan S. 2012. *Practical Manual on Fermentation Technology*.I K International Publishing House Pvt. Ltd.
- PF Stanbury Dr Whitaker. 2008. *Principles of Fermentation Technology*, Elsevier; 2editions.
- Okafor N, Okeke BC. 2017. *Modern Industrial Microbiology and Biotechnology* (Text Book), Second Edition published by CRC press, USA.
- ArindamKuila and Vinay Sharma. 2019. *Principles and Applications of Fermentation Technology* John Wiley and Sons.
- Hutkins RW. 2019. *Microbiology and Technology of Fermented Foods*, 2nd Ed, Wiley Blackwell, New Jersey, USA.
- Gabriel V, Ouwehand A, Salminen S and Wright AV. 2019. *Lactic acid Bacteria: Microbiological and Functional Aspects*. CRC Press.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Fermentation for enhancing shelf life of foods, types of fermentation - submerged/solid state and semi-solid.	6
2	**Unit II** Microbial growth, metabolism, death, membrane transport, fermentation kinetics and fermentation modelling, batch, fed	6

	batch, continuous culture systems.	
3	**Unit III** Bioreactor design, measurement and control in fermentation. Different types of fermenters, scaling up of fermentation, sterilization, agitation; pH, Eh, temperature measurement and control, downstream processing and product recovery, immobilization in fermentation.	8
4	**Unit IV** Biosensors in fermentation applications: Biosensors, basic principles; application in detection of sugars, alcohol, amino acids.	6
5	**Unit V** Industrial production of microbial cell biomass, organic acids, enzymes, antibiotics, micro-nutrients, amino acids, vitamins, ethanol, SCP and alcoholic beverages.	6
	Total	**32**

Practical:

Sr. No.	Topic	No. of Practical (s)
1	Bacterial growth in batch culture	2
2	Different methods of microbial cultivation	2
3	Fermenter operation and measurement	2
4	Production of antimicrobial substances/ bacteriocins	2
5	Production of microbial enzymes	2
6	Production of baker yeast, SCP/microbial biomass	2
7	Production of alcohol, lactic acid	2
8	Production of alcoholic beverages and whey beverage	2
	Total	**16**

Course Syllabus and Contents
Ph.D. (Agri) in Dairy Science

I. Course Title : Advances in Lipid Technology

II. Course Code : DS 611

III. Credit Hours : 3=3+0

IV. Why this course?

Fats have multifarious effect on human beings. These are source of saturated fats, unsaturated fats, sterols (including cholesterol), phospholipids, etc. The essential fatty acids have a significant role in human health. There are however, some relations between certain type of fats (i.e. cholesterol, certain saturated fats and trans-fats) and cardiovascular disease in humans. There are several technological means to modify fat such as inter-esterification, fractionation of fat, hydrogenation, bleaching, refining, etc. Repeated frying of fat can lead to formation of toxic substances, unfit for consumption. Consumers have started accepting the modified fats for health reasons.

V. Aim of the course

To study the physico-chemical and nutritional characteristics of fats and oils, their processing and application in food products.

VI. Theory:

Unit I

Current trends in the fats and oil industry in India and abroad: Sources and classification of commercial edible fats and oils from animal, vegetable and marine origin; Non-conventional fats/oils for edible purpose – rice bran oil, microbial lipids, etc.

Unit II

Structural aspects of fats and oils in relation to their processing, properties and utilization; Polymorphism and polytypism, crystallization kinetics.

Unit III

PUFA, MUFA, CLA, Medium Chain Triglycerides (MCTs), Omega fatty acids, Transfatty acids: Nutritional and technological interventions; Phytosterols and their significance.

Unit IV

Advances in extraction and refining of oils and fats; Application of membrane techniques in oil refining.

Unit V

Physical, chemical and enzymatic modification approaches to tailor-made fats. Cholesterol reducing treatments; structured lipids; Fat replacers; Isolation of emulsifiers.

Unit VI

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.

Unit VII

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; Cocoa butter substitutes.

VII. Learning outcome

After undergoing this course, the students are expected to deliver the following:

- Able to recommend the type of fat suitable for given application (i.e. for frying).
- Prepare modified fats with reduced cholesterol, reduced long chain saturated fats, etc.
- Make the food processor understand the principle of polymorphic transformation of fat for texture development in fatty food system.
- Can modify the fat to suit physiological needs of the people.

VIII. Suggested Reading

- Garti, N.andSato, K. (Eds.). 2001.Hartel, R.W., and Kaylegian, K.E. Chapter 11. Advancesin milk fat fractionation – Technology and applications. In: *Crystallization processes in fats and lipid systems*, 1stEdn,Boca Raton: Taylor and Francis Group (eBook ISBN9781482270884).
- Hartel, R. W., and Kaylegian, K. E. 2001. Advances in milk fat fractionation – Technology and applications. In: *Crystallization Processes in Fats and Lipid Systems*. Garti, N., and Sato, K. (Eds.), Chapter 11, Taylor and Francis Group.
- Rajah, K.K. (Ed.). 2014. *Fats in food technology*. John Wiley and Sons Ltd., UK **(ISBN:** 9781405195423)
- Tamime, A.Y. (Ed.). 2009. *Dairy fats and related products*. Oxford, UK: Blackwell Publishing Ltd., pp. 1-315.

Websites

- AOCS Lipid Library- http://lipidlibrary.aocs.org/human-nutrition/trans-fat-replacementsin-foods-(pg2)
- Fats and Cholesterol - USDA-https://nal.usda.gov/fnic/fats-and-cholesterol
- Fats and Fatty Acids in Human Nutrition-http://fao.org/3/a-i1953e.pdf
- Dietary Guidelines Advisory Committee-http://www.usda.gov/cnpp/Pubs/DG2000/Full%20Report.pdf.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1.	**Unit I** Current trends in the fats and oil industry in India and abroad. Sources and classification of commercial edible fats and oils from animal, vegetable and marine origin. Non-conventional fats/oils for edible purpose – rice bran oil, microbial lipids,etc.	**9**
2.	**Unit II**	**6**

	Structural aspects of fats and oils in relation to their processing, properties and utilization. Polymorphism and polytypism, crystallization kinetics.	
3.	**Unit III** Nutritional and technological interventions in PUFA, MUFA, CLA, Medium Chain Triglycerides (MCTs), Omega fatty acids, Transfattyacids. Phytosterols and their significance.	**6**
4.	**Unit IV** Advances in extraction and refining of oils and fats. Application of membrane techniques in oil refining.	**5**
5.	**Unit V** Physical, chemical and enzymatic modification approaches to tailor-made fats. Cholesterol reducing treatments; structured lipids; Fat replacers; Isolation of emulsifiers.	**6**
6.	**Unit VI** 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.	**7**
7.	**Unit VII** 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. Cocoa butter substitutes.	**9**
	Total	**48**

I. Course Title : Advances in Protein Technology

II. Course Code : DS 612

III. Credit Hours : 3=3+0

IV. Why this course?

Protein is an essential major nutrient in the diets. Essential amino acids play an important role. Cheaper sources of protein are being constantly unearthed possibly from several sources, viz. plants, animals, microbes and mushrooms. Protein malnutrition, especially in children is being tackled today. Use of membrane processing (especially ultrafiltration) and food texturization technologies has led to the development of newer type of high protein food ingredients and products. The state of protein – un-denatured and denatured can play a role in functionality of resultant food as well as in digestion of the nutrient. Protein hydrolysates have their own application even in pharmaceuticals.

V. Aim of the course:

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

VI. Theory:

Unit I

Characteristics, functional properties and applications of proteins from plant, animal, microbial and non-conventional sources.

Unit II

Denaturation of proteins: effect of processing parameters on denaturation; effect of denaturation on the physico-chemical and biological properties of proteins in food systems.

Unit III

Structure-functional relationship of food proteins; Protein interactions with food constituents and their significance: protein-protein interactions. Protein--lipid interactions, protein-polysaccharide interactions, protein-ion interactions.

Unit IV

Nutritional aspects of dietary proteins: Protein nutrition and digestion; protein quality evaluation methods; effect of processing on nu-tritive value of proteins.

Unit V

Food protein concentrates and isolates: types, production, characterization and applications Protein hydrolysates: production and processing; de-bittering; bioactive peptides: classification, production and properties.

Unit VI

Texturization of proteins; Selection of ingredients and processes; Microstructure of texturized foods, Protein based fat substitutes; Protein engineering; Protein genetic polymorphism.

VII. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- Tackle the problem of protein malnutrition.
- Adopt some recent technological means to produce high protein food ingredients such as WPC, WPI, MPC, Micellar casein powder, etc.

- Modify the native protein (i.e. protein hydrolysate) to have specific applications in composite food products

VIII. Suggested Reading:

- Boland M, Singh H and Thompson A. (Eds.). 2014. Milk proteins: From expression to food. Academic Press.
- Consultation FE. 2011. Dietary protein quality evaluation in human nutrition. FAO Food Nutrition Papers, 92, 1-66.
- Damodaran S. 1997. Food proteins and their applications. CRC Press. Restructured and Revised Syllabi of Post-graduate Programmes Vol. 4 36
- Fox Patrick F and McSweeney PLH. (Eds.) 2013. Advanced Dairy Chemistry: Volume 1: Proteins, Parts A&B, New York: SpringerScience+Business Media.
- Hayes M. 2018. Food Proteins and Bioactive Peptides: New and Novel Sources, Characterisation Strategies and Applications. Foods, 7(3):E38. (doi: 10.3390/foods7030038).
- Hettiarachchy NS, Sato K, Marshall MR and Kannan A. (Eds.). 2012. Food proteins and peptides: Chemistry, functionality, interactions and commercialization. CRC Press.
- Maskan M and Altan A. 2016. Advances in Food Extrusion Technology. CRC press.
- Phillips GO and Williams PA. (Eds.). 2011. Handbook of Food Proteins. Elsevier Pub.
- Sims S. (Ed.). 2019. Protein Hydrolysates: Uses, Properties and Health Effects. Nova Publishers.
- Yada RY. (Ed.). 2017. Proteins in Food Processing. Woodhead Publishing.

Websites:

- Protein energy malnutrition-FAO http://fao.org/DOCREP/W0073e/w0073e05.htm
- Dietary Protein EU Science Hub European Commission- https://ec.europa.eu/jrc/en/healthknowledge-gateway/promotion-prevention/nutrition/protein
- High and Low Biological Value Protein Foods: (EUFIC)- https://www.eufic.org/en/whats-infood/article/the-basics-proteins

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Characteristics, functional properties and applications of proteins from plant, animal, microbial and non-conventional sources.	8
2	**Unit II** Denaturation of proteins: effect of processing parameters on denaturation; effect of denaturation on the physico-chemical and biological properties of proteins in food systems.	8

3	**Unit III** Structure-functional relationship of food proteins; Protein interactions with food constituents and their significance: protein-protein interactions. Protein--lipid interactions, protein-polysaccharide interactions, protein-ion interactions.	**8**
4	**Unit IV** Nutritional aspects of dietary proteins: Protein nutrition and digestion; protein quality evaluation methods; effect of processing on nu-tritive value of proteins	**8**
5	**Unit V** Food protein concentrates and isolates: types, production, characterization and applications Protein hydrolysates: production and processing; de-bittering; bioactive peptides: classification, production and properties.	**8**
6	**Unit VI** Texturization of proteins; Selection of ingredients and processes; Microstructure of texturized foods, Protein based fat substitutes; Protein engineering; Protein genetic polymorphism.	**8**
	Total	**48**

I. Course Title : Product Monitoring and Process Control

II. Course Code : DS 621

III. Credit Hours : 3=3+0

IV. Why this course?

Whatever food products are processed at the food plant needs to be monitored for product quality and safety. Recent developments in advanced control techniques have opened up novel possibilities for food process control. Food processes have been particularly difficult to automate and control owing to non-uniformity and variability in raw-materials, and lack of sensors for real-time monitoring of key process variables and quality attributes. Model-based control, distributed control systems together with field communication protocols, and other computer-aided advanced control strategies have proven themselves in selected food processing applications. The benefits of advanced control techniques include reduced costs, increased quality and improved food safety.

V. Aim of the course

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

VI. Theory:

Unit I

The concept of Product-Process Monitoring in dairy and food industries; Definition of 'quality', optimization paradigm, quality-prediction model based on quality kinetics and process state equations, simulation modelling; Process/Product Optimization: optimization procedures – search methods, Response surface, differentiation and programming methods; neural networks, optimization software.

Unit II

Process Control: objectives, control loop, loop elements and their functions; Modes of process control; Control techniques; Control equipment.

Unit III

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

Unit IV

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

Unit V

Formation of flavour compounds in milk and milk products during heat processing (including UHT processing, caramelization and extrusion cooking), fermentation and ripening (cultured products and cheese flavour, with special reference to bitterness) and storage (Maillard browning); Aroma losses/retention during the drying process (in rela-tion 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: Application of analytical techniques (Differential Thermal Analysis, Differential Scanning Calorimetry, X-ray crystallography, circular dichroismspectroscopy, dynamic light scattering, laser diffraction, image analysis and Nuclear Magnetic Resonance) to monitor the effect of processing and storage on structure of foods.

Unit VII

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

Unit VIII

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.

VII. Learning outcome

After undergoing this course, the students are expected to deliver the following:

- Prepare a protocol for specific food industry in which all critical processes are to be monitored
- Avoid chances of occurrence of structure defect in food product through monitoring of the food structure using latest methodologies (i.e. DSC, NMR, etc.)
- Improve and stabilize the color of the food system through color characterization methods
- Elucidate the development of flavor for flavor rich foods (i.e. cheese, Enzyme modified cheese, fermented dairy products, etc.)

VIII. Suggested Reading

- Acree TE and Teranishi R. 1993. Flavour Science: Sensible Principles and Techniques. Washington: Amer. Chem. Soc.
- Bartlett PN, Elliott JM and Gardner JW. 1997. Electronic noses and their application in the food industry. Food Technology, 51(12), 44-48.
- Kress-Rogers E and Brimelow CJB. (Eds.). 2001. Instrumentation and Sensors for the Food Industry. CRC Press, Woodhead Pub. Ltd.
- Nollet LML. (Ed.) 2020. Mass Spectrometry Imaging in Food Analysis, CRC Press. • Pomeranz Y. (Ed.). 2013. Food analysis: Theory and Practice. Springer Science and Business Media.
- Schaertel BJ and Firstenberg-Eden R. 1988. Biosensors in the food industry: present and future. Journal of Food Protection, 51(10), 811-820.

Websites :

- Quality Management Tools-Including TQM, Six Sigma, Cost of Quality and EFQMhttps://cgma.org/resources/tools/essential-tools/quality-management-tools.html Process Control Solutions: Berthhold Technologies-https://berthold.com/en/pc/home?gclid=EAIaIQobChMIl-uQ4—K4gIVQyUrCh0P_gqvEAMYASAAEgJfcPD_BwE
- Laboratory Quality Management System – World Health Organization-https://who.int/ihr/ publications/lqms_en.pdf
- Real Time Process Monitoring in Food and Beverage Manufacturing-https://manufacturing.net/article/2016/02/real-time-process-monitoring-food-and-beveragemanufacturing.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1.	**Unit I** The concept of Product-Process Monitoring in dairy and food industries. Definition of 'quality', optimization paradigm, quality-prediction model based on quality kinetics and process state equations, simulation modeling. Process/Product Optimization: optimization procedures – search methods, Response surface, differentiation and programming methods; neural networks, optimization software.	**7**
2.	**Unit II** Process Control: objectives, control loop, loop elements and their functions. Modes of process control; Control techniques; Control equipment.	**4**
3.	**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 and full-history indicators. Commercial devices; Applications and limitations; E-Nose and E-Tongue – Simulation of natural organs, components and their functions, applications	**9**
4.	**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.	**3**
5.	**Unit V** Formation of flavour compounds in milk and milk products during heat processing (including UHT processing, caramelization and extrusion cooking), fermentation and ripening (cultured products and cheese flavour, with special reference to bitterness) and storage (Maillard browning). Aroma losses/retention during the drying	**6**

	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.	
6.	**Unit VI** Monitoring of food structure: Application of analytical techniques (Differential Thermal Analysis, Differential Scanning Calorimetry, X-ray crystallography, circular dichroismspectroscopy, dynamic light scattering, laser diffraction, image analysis and Nuclear Magnetic Resonance) to monitor the effect of processing and storage on structure of foods.	**4**
7.	**Unit VII** Emerging spectroscopic techniques in assessment of foods: Raman Spectroscopy and Electron Spin Spectroscopy – working principles and applications; Monitoring of irradiated foods, detection of lipid auto-oxidation, etc. Microwave and NIR absorption/reflection methods for Compositional analyses, Automated milk analysers, Proximate principles in cheese and milk powder	**10**
8.	**Unit VIII** 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.	**5**
	Total	**48**

I. Course Title : R&D Management in Dairy Industry
II. Course Code : DS 622
III. Credit Hours : 3=3+0

IV. Why this course?

Several dairy industries have separate R and D cell to carry out product innovation or to bring in more returns to the organization. Managing the R&D in a planned manner helps to deliver the goods to reap its benefit. Once patenting procedure is known, those research findings of extreme utility in dairy industry can be filed for patenting. The researches that have far reaching impact value should be taken for transfer of technologies within the limited time frame.

V. Aim of the course

To provide in-depth knowledge to students about selection and management of research projects and in patenting and transfer of technology processes.6

VI. Theory:

Unit I

Global scenario of R&D efforts in dairy processing; Determinants of Consumer Preferences; Competitive positioning and value chain configuration in global market.

Unit II

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

Unit III

Skill requirements of an R and D manager; New product development: strategies, models and life cycle analysis.Food innovation dynamics; innovation opportunities; innovations in traditional and functional foods; consumer driven food innovation; implementation of latest technology and assessment.

Unit IV

Management of R&D functions: Criterion for selection of R&D projects; Technology development process, Techniques for monitoring R and D functions.

Unit V

Patenting Laws; Indian Patenting Act/International Protocols for technology transfer; Transfer of technology from Lab to Plant, ISO 9001, ISO 14001, ISO 22000, ISO 50001, OHSAS; Laboratory Quality Management System- ISO 17025, Retailer Standards -BRC Food and BRC/IoP Standards, International Food Standard (IFS), SQF 1000 and SQF 2000, Global GAP and India GAP., Six-Sigma concept.

Unit VI

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

VII. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- Identify whether the researches carried out are suitable for patenting
- Help in selecting proper R and D projects for the benefit of the industry as well as for the consumers

- Can write Project proposals to bring in Research funding from external agencies for mutual benefit

VIII. Suggested Reading:

- Basu CR. 2017. *Business Organization and Management*. Tata-McGraw Hill Publication.
- Early R, Early M and Anderson A. 2009. *Food Product Development*. Woodhead PublishingLtd.
- Robbins SP, Judhe, TA and Vorha N. 2013. *Organization Behaviour*. 15th Edn, Pearson Education Publishing Inc.
- Tetra Pak Dairy Processing Handbook. 2015. www.dairyprocessinghandbook.com.

Websites:

- World Intellectual Property Organization-https//wipo.int
- IPR and Patents CEN CENELEC-https://cencenelec.eu/ipr/Pages/default.aspx
- ISO-International Standardization for Organization-https://iso.org/home.html ISO-45001 Occupational Health and Safety-https://iso.org/iso-45001-occupational-healthand-safety.html

Teaching Schedule:

Theory

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Global scenario of R&D efforts in dairy processing; Determinants of Consumer Preferences; Competitive positioning and value chain configuration in global market.	6
2	**Unit II** Management of human resources in dairy Industry: Structure and design of Research and Development organization; Analysis of organization behaviour – Transactional analysis; Personnel management – Typology analysis, individual and the organization, team building, human behaviour at work, motivation.	10
3	**Unit III** Skill requirements of an R and D manager; New product development: strategies, models and life cycle analysis.Food innovation dynamics; innovation opportunities; innovations in traditional and functional foods; consumer driven food innovation; implementation of latest technology and assessment.	8
4	**Unit IV**	8

	Management of R&D functions: Criterion for selection of R&D projects; Technology development process, Techniques for monitoring R and D functions.	
5	**Unit V** Patenting Laws; Indian Patenting Act/International Protocols for technology trans fer; Transfer of technology from Lab to Plant, ISO 9001, ISO 14001, ISO 22000, ISO 50001, OHSAS; Laboratory Quality Management System- ISO 17025, Retailer Standards -BRC Food and BRC/IoP Standards, International Food Standard (IFS), SQF 1000 and SQF 2000, Global GAP and India GAP., Six-Sigma concept.	**10**
6	**Unit VI** Project proposal writing for research funding, Development of feasibility and technical report for dairy plant establishment, Report writing of projects and its evaluation	**6**
	Total	**48**

I. Course Title : Advances in Carbohydrate Technology
II. Course Code : DT 623
III. Credit Hours : 3=3+0

IV. Why this course?

Besides proteins and fats, carbohydrates are other important nutrients. The flavour, Restructured and Revised Syllabi of Post-graduate Programmes Vol. 4**40** colour and structure of food product also depend on the type and amount of carbohydrates present and their reactivity with other constituents during processing .Modified starches have been the recent addition to the list of stabilizers available for the food industry. Lactose – the carbohydrate of milk origin has a special role to play in dairy and food industry. Modifications of carbohydrates such as inversion ,enzymic hydrolysis, maillard reaction can lead to value-addition in some food products.

V. Aim of the course

To study the physico-chemical and nutritional characteristics of carbohydrates, and their applications in food processing and health

VI. Theory

Unit I

Introduction to Carbohydrates: Classification, Sources of carbohydrates, Structure of major groups, Non-conventional sources of carbohydrates.

Unit II

Characterization and functional properties of Carbohydrates; Various classes of sweeteners; Production technologies for Corn Syrup Solids (CSS), High fructose corn syrup (HFCS); Maltodextrins; Phenomenon of retrogradation of starch and interventions in foods and methods to control it.

Unit III

Milk Carbohydrates: Manufacturing technologies and their functional, nutritional and technological properties; Lactose hydrolysed dairy products.

Unit IV

Nutritional and therapeutic aspects of carbohydrates: Role in dental caries, obesity, cardiovascular diseases (CVD), colon health, diabetes; resistant starches, Prebiotics, Non-digestible carbohydrates (NDC) and their health benefits.

Unit V

Modified starches: Technologies for starch modification; Properties, applications, safety and toxicity. Carbohydrate based edible packaging films.

Unit VI

Hydrocolloids: Classification, structures, functional properties, and applications.

Unit VII

Cyclodextrins; Carbohydrates as fat replacers/fat substitutes; microencapsulating agents; Techniques for production of protein-polysaccharide conjugates and their applications.

VII. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- Unravel the unconventional sources of carbohydrate for human nutrition

- To produce dairy foods free of allergenicity i.e. lactose-free for lactose intolerant persons
- Able to ameliorate defects in food product through knowledge about interaction of carbohydrates with other constituents in food during processing and/or storage
- To recommend reducing calorie in food (formulate dietetic food) through use of carbohydrate source to mimic properties of fat.

VIII. Suggested Reading

- Eliasson AC. 2006. *Carbohydrates in Food*, 2nd Edn, CRC Press, Taylor and Francis group.
- Biliaderis CG and Izydorczyk MS. 2007. *Functional Food Carbohydrates.* CRC Press, Taylor and Francis group.
- Mc Sweeney PLH and Fox PF. 2009. *Advanced Dairy Chemistry*. Volume 3, Lactose, water, salts and minor constituents. USA: Springer Science and Business Media.
- Paques M and Lindner C. (Eds.). 2019. Lactose: Evolutionary Role, Health Effects, and Applications. Academic press.
- Steve W Cui. 2005. *Food Carbohydrates: Chemistry, Physical Properties and Applications.* CRC Press, Taylor and Francis group.

Websites:

- Effect of Food Processing on Dietary Carbohydrates- http://fao.org/3/W8079E/w8079e0j.htm
- Carbohydrates: Uses, health benefits, and risks – Medical News Today-https:// www.medicalnewstoday.com/articles/161547.php

Teaching Schedule:

Theory

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Introduction to Carbohydrates: Classification, Sources of carbohydrates, Structure of major groups, Non-conventional sources of carbohydrates.	6
2	**Unit II** Characterization and functional properties of Carbohydrates; Various classes of sweeteners; Production technologies for Corn Syrup Solids (CSS), High fructosecorn syrup (HFCS); Maltodextrins; Phenomenon of retrogradation of starch and interventions in foods and methods to control it.	8
3	**Unit III** Milk Carbohydrates: Manufacturing technologies and their functional, nutritionaland technological properties; Lactose hydrolysed dairy products	8

4	**Unit IV** Nutritional and therapeutic aspects of carbohydrates: Role in dental caries, obesity, cardiovascular diseases (CVD), colon health, diabetes; resistant starches, Prebiotics, Non-digestible carbohydrates (NDC) and their health benefits.	**8**
5	**Unit V** Modified starches: Technologies for starch modification; Properties, applications, safety and toxicity. Carbohydrate based edible packaging films.	**6**
6	**Unit VI** Hydrocolloids: Classification, structures, functional properties, and applications.	**4**
7	**Unit VII** Cyclodextrins; Carbohydrates as fat replacers/fat substitutes; microencapsulating agents; Techniques for production of protein-polysaccharide conjugates and their applications.	**8**
	Total	**48**

Course Syllabus and Contents
Ph.D. (Agri) in Dairy Chemistry

I. Course Title : Advances in Chemistry of Milk Proteins
II. Course No. : DC-611
III. Credit Hours : 3=3+0

IV. Why this course?

To gain insights in the underlying structure-function aspects of milk proteins, biological role of bioactive milk proteins, properties of bioactive peptides and allergy aspects of milk proteins.

V. Aim of the course:

To understand the advances in area of functionality of milk proteins.

VI. Theory:

Unit I: Biosynthesis of milk proteins

Biosynthesis of milk proteins, milk fat globule membrane (MFGM) proteins.

Unit II: Structure of milk protein with respect to function

Primary structure of casein, structural properties of casein and whey proteins and their structure-functional relationship.

Unit III: Modification of milk proteins with respect to function

Physical, chemical and enzymatic modification of milk proteins and their functional Characteristics.

Unit IV: Antimicrobial protein in milk

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

Unit V: Significance of bioactive peptides

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

Unit VI: Nutritive and therapeutic aspects of milk proteins

Nutritive and therapeutic aspects of milk proteins and peptides; Milk protein allergy: mechanism and method of their reduction in dairy products.

VII. Teaching Methods/ Activities:

- Lecture
- Student's Book/Publication Review
- Group Work
- Assignment (Reading/Writing)
- Student presentation
- Guest Lectures

VIII. Learning outcome:

After successful completion of this course, the students are expected to be able to:

- Understand the basic mechanism on functionality of major milk proteins and bioactive milk proteins

- Understand the aspects on biosynthesis of milk proteins, bioactive peptides and nutritive properties of milk proteins

IX. Suggested Reading:

- Damodaran S and Paraf A. 1997. *Food Proteins and their Applications*. Marcel Dekker.
- Gigli I. (Ed.). 2016. *Milk Proteins: From Structure to Biological Properties and Health Aspects*. BoD–Books on Demand.
- Hettiarachchy NS, Sato K, Maurice R, Marshall MR and Kannan A. 2016. *Bioactive Food Proteins and Peptides: Applications in Human Health*. CRC Press.
- Deeth HC and Bansal N. 2018. *Whey Proteins from Milk to Medicine*. 1st Edition, Academic Press
- McSweeney PLH, O'Mahony and James A. 2013. *Advanced Dairy Chemistry Volume 1A:Proteins: Applied Aspects*. Springer-Verlag, New York.
- McSweeney PLH, O'Mahony and James A. 2016. *Advanced Dairy Chemistry Volume 1B:Proteins: Applied Aspects.* Springer-Verlag, New York.
- Popay AI and Prosser CG.1997. *Biotech in Agric*. Series No. 18, CABI.
- Visser Hans. 1992. *Protein - Interactions*. VCS.
- Welch RAS, Burns DJW and Davis SR. 1997. *Milk Composition, Production and Biotechnology*. CABI.

Teaching Schedule:

Theory:

Sr. No.	Units	No. of Lecture (s)
1	**Unit I: Biosynthesis of milk proteins** Biosynthesis of milk proteins, milk fat globule membrane (MFGM) proteins.	8
2	**Unit II: Structure of milk protein with respect to function** Primary structure of casein, structural properties of casein and whey proteins and their structure-functional relationship.	8
3	**Unit III: Modification of milk proteins with respect to function** Physical, chemical and enzymatic modification of milk proteins and their functional characteristics.	8
4	**Unit IV: Antimicrobial protein in milk** Mechanism of action and biological role of specific and non-specific antimicrobial factors in milk- immunoglobulins, lactoferrin, lactoperoxidase and lysozyme.	8
5	**Unit V: Significance of bioactive peptides** Milk protein derived bioactive peptides – their properties; significance and application; bitter peptides in cheese; growth factors in milk.	8
6	**Unit VI: Nutritive and therapeutic aspects of milk proteins** Nutritive and therapeutic aspects of milk proteins and peptides; Milk protein allergy: mechanism and method of their reduction in dairy products	8
	Total	**48**

I. Course Title : Advances in Chemistry of Milk Lipids

II. Course No. : DC-612

III. Credit Hours : 3=3+0

IV. Why this course?

This is an advanced course for in-depth understanding of milk fat including recent research work in the area of milk fat. This course is going to cover all these aspects.

V. Aim of the course:

To impart the students with the in-depth understanding of various facets of milk fat including synthesis, changes during processing, various constituents of milk fat including minor components. The course also gives the opportunity to learn the recent research work being done in the area of milk fat.

VI. Theory:

Unit I: Origin, composition, structure and physical chemistry of milk fat globule membrane

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, and camel. Changes in milk fat globule membrane during processing and its effect on digestion.

Unit II: Lipolytic enzymes in milk of different species

Lipolytic enzymes in milk of different species including human; Bile salt stimulated lipase and esterases, induced and spontaneous lipolysis in milk. Assay for lipase activity; Biosynthesis of fatty acids, glycerol, neutral lipids, phospholipids, sphingolipids and cholesterol.

Unit III: Fatty acids and other components in milk fat

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

Unit IV: Deterioration of milk fat due to oxidization and heating

Chemistry of oxygen in relation to autoxidation of milk fat including effect of milk components and environmental factors; Types of oxidations; Thermal oxidation; Chemical and biological properties of heated and oxidized fats.

Unit V: Significance of milk fat in human health

Significance of milk lipids in human health. Role of milk lipids in consumer acceptance of dairy products. Polymorphism and milk fat crystallization.

VII. Teaching Methods/ Activities:

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work
- Guest Lectures

VIII. Learning outcome:

After successful completion of this course, the students are expected to be able to:

- Have in-depth understanding of milk fat including its origin in mammary gland, Lipolytic enzyme in milk of various species including lipolysis, Types of minor milk components and their structure
- Deterioration of milk fat due to oxidation and Significance of milk fat in human health.

X. Suggested Reading:

- Fox PF. 1995. *Advanced Dairy Chemistry.* Vol. II. *Lipids.* 2nd Ed. Chapman and Hall.
- Fox PF and McSweeney PLH. 2006. *Advanced Dairy Chemistry Volume 2: Lipids*. Springer-US.
- Fox PF, Uniacke-Lowe T, McSweeney PLH and O'Mahony JA. 2015. *Dairy Chemistry and Biochemistry*. 2nd Edition. Springer.
- Jensen RG. 2018. The lipids of human milk. CRC Press.
- Nollet LML and Toldra F. 2009. *Handbook of Dairy Foods Analysis*. CRC Press. Taylor and Francis Group.
- Truong T, Palmer M, Bansal N and Bhandari B. 2016. *Effect of Milk Fat Globule Size on the Physical Functionality of Dairy Products*. Springer International Publishing.
- Truong T, Lopez C, Bhandari B and Prakash S. 2020. *Dairy Fat Products and Functionality*.
- Walstra P and Jenness R. 1984. *Dairy Chemistry and Physics*. John Wiley and Sons.
- Wong NP, Jenness R, Keeney M and Elmer HM. 1988. *Fundamental of Dairy Chemistry*. 3rd Ed. Van Nostrand Reinhold Co.

Teaching Schedule:

Theory:

Sr. No.	Units	No. of Lecture (s)
1	**Unit I: Origin, composition, structure and physical chemistry of milk fat globule membrane** 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, and camel. Changes in milk fat globule membrane during processing and its effect on digestion.	**10**
2	**Unit II: Lipolytic enzymes in milk of different species** Lipolytic enzymes in milk of different species including human; Bile salt stimulated lipase and esterases, induced and spontaneous lipolysis in milk. Assay for lipase activity; Biosynthesis of fatty acids, glycerol, neutral lipids, phospholipids, sphingolipids and cholesterol.	**11**
3	**Unit III: Fatty acids and other components in milk fat**	**9**

	Essential fatty acids, prostaglandins and flavour compounds. Conjugated linoleic acids – different isomers, factors affecting their levels in dairy products and their significance.	
4	**Unit IV: Deterioration of milk fat due to oxidization and heating** Chemistry of oxygen in relation to autoxidation of milk fat including effect of milk components and environmental factors; Types of oxidations; Thermal oxidation; Chemical and biological properties of heated and oxidized fats.	**9**
5	**Unit V: Significance of milk fat in human health** Significance of milk lipids in human health. Role of milk lipids in consumer acceptance of dairy products. Polymorphism and milk fat crystallization	**9**
	Total	**48**

I. Course Title : Advances in Chemistry of Dairy Processing

II. Course No. : DC-621

III. Credit Hours : 3=3+0

IV. Why this course?

This course covers the physicochemical changes during processing of milk and chemistry of different additives and ingredients with respect to their effect on functional properties of dairy foods. This course is going to cover all these aspects.

V. Aim of the course

To highlight the impact of processing parameters on the milk constituents with special reference to chemical changes involved and also to impart the basic knowledge on the chemistry and significance of bio active compounds and additives.

VI. Theory:

Unit I: Heat induced changes and interactions

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

Unit II: Physical changes in the fat globules after homogenisation

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

Unit III: Specific and non-specific enzymatic coagulation of milk

Specific and non-specific enzymatic coagulation of milk.

Unit IV: High Pressure Processing of milk

Physico-chemical and structural changes occurring in milk constituents during high pressure processing of milk.

Unit V: Encapsulation of bioactive compounds

Chemistry involved in encapsulation of bioactive compounds and factors affecting their stability during processing.

Unit VI: Micronutrients, Stability of sweeteners and Milk fat replacers

Chemistry involved in the fortification of milk with vitamins, minerals and nutraceuticals. Stability of high intensity sweeteners during processing of milk and milk products. Milk fat replacers.

VII. Teaching Methods/ Activities:

- Lecture
- Student's Book/Publication Review
- Group Work
- Assignment (Reading/Writing)
- Student presentation
- Guest Lectures

VIII. Learning outcome:

After successful completion of this course, the students are expected to be able to:

- Understand the effect of processing on milk constituents
- Analyse the stability of different additives including micronutrients added to milk as affected by different processing treatments

IX. Suggested Reading:

- Shortt C and Brien JO. 2004. *Handbook of Functional Dairy Products*. CRC Press.
- Deeth HC and Lewis MJ. 2017. *High Temperature Processing of Milk and Milk Products*. Wiley-Blackwell.

- Fox PF and McSweeney PLH. 1998. *Dairy Chemistry and Biochemistry*.Blackie Academic Professional, Chapman and Hall.
- IDF. 1995. Special issue. *Heat Induced Changes in Milk*. Intern. Dairy Fed.,Brussels.
- Koca, N. (Ed.). 2018. Technological Approaches for Novel Applications in Dairy Processing. BoD–Books on Demand.
- Leo ML Nollet. 2004. Intense Sweeteners. Handbook of Food Analysis. 2ndEd. Marcel Dekker.
- Minj, J., Sudhakaran, A. and Kumari, A. 2020. Dairy Processing: Advanced Research to Applications. Springer Singapore.
- Walstra P, Walstra P, Wouters JTM and Geurts TJ. 2005. Dairy Science and Technology. CRC Press

Teaching Schedule:
Theory:

Sr. No.	Units	No. of Lecture (s)
1	**Unit I: Heat induced changes and interactions** Heat induced changes and interactions between protein, lipids, carbohydrates and minerals during processing of milk. Effect of heat on the proteins of concentrated milk systems. Inactivation of indigenous milk enzymes during processing.	**8**
2	**Unit II: Physical changes in the fat globules after homogenisation** Physical changes in the fat globules in unhomogenized and homogenized milk; cold agglutination – its mechanisms and role.	**8**
3	**Unit III: Specific and non-specific enzymatic coagulation of milk** Specific and non-specific enzymatic coagulation of milk.	**8**
4	**Unit IV: High Pressure Processing of milk** Physico-chemical and structural changes occurring in milk constituents during high pressure processing of milk.	**8**
5	**Unit V: Encapsulation of bioactive compounds** Chemistry involved in encapsulation of bioactive compounds and factors affecting their stability during processing.	**8**
6	**Unit VI: Micronutrients, Stability of sweeteners and Milk fat replacers** Chemistry involved in the fortification of milk with vitamins, minerals and nutraceuticals. Stability of high intensity sweeteners during processing of milk and milk products. Milk fat replacers.	**8**
	Total	**48**

I. Course Title : Advances in Analytical Techniques in Dairy Chemistry
II. Course No. : DC-622
III. Credit Hours : 3=3+0

IV. Why this course?

To gain insights in the underlying principle of newer instrumental techniques and their application in the dairy science research. This course is going to cover all these aspects.

V. Aim of the course

To highlight the application of advance analytical techniques used for analysis of milk and milk products.

VI. Theory:

Unit I: Isoelectric focusing, 2-D gel electrophoresis, Immuno assays

Electrophoresis: Isoelectric focusing and 2-D polyacrylamide gel electrophoresis; Capillary zone electrophoresis, Enzyme linked immune-sorbentassay, blotting techniques.

Unit II: High performance liquid chromatography

High performance liquid chromatography; Theory, instrumentation and application in analysis of dairy foods.

Unit III: Mass spectroscopy

Mass spectroscopy: Principle, instrumentation and application in milk proteins/ milk fat analysis.

Unit IV: Protein sequencing

Protein sequencing; Chemical reactions involved in analysis of primary structure of proteins.

Unit V: X-ray crystallography

Circular dichroism spectroscopy; Theory and application for determination of secondary structure of proteins.

Unit VI: Circular Dichroism Spectroscopy

X-ray crystallography; Theory and application for determination of tertiary structure of milk proteins.

Unit VII: Atomic spectroscopy

AAS (Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy, ICPS (Inductively coupled plasma spectroscopy); Principle and application in analysis of milk and milk products.

Unit VIII: Infrared, Fluorescence

Infrared Spectroscopy, Fluorescence Spectroscopy: principle and application.

Unit IX: Differential scanning calorimetry, NMR and FTIR

Differential scanning calorimetry: principle and application for milk fat and protein analysis. NMR (Nuclear Magnetic Resonance), FTIR (Fourier Transform Infrared). Principle, application for quality analysis of milk and milk products.

VII. Teaching Methods/ Activities:

- Lecture
- Student's Book/Publication Review
- Group Work
- Assignment (Reading/Writing)
- Student presentation
- Guest Lectures

VIII. Learning outcome:

After successful completion of this course, the students are expected to be able to:

- Understand the basic principle on advance analytical techniques for quality assessment of milk and milk products
- Understand the aspects on structure determination of milk proteins

X. Suggested Reading:

- Blundell TL and Johnson LN. 1976. *Protein Crystallography*. Academic Press.
- Calter P. 2004. *Methods in Molecular Biology*. Vol. 244 2nd Ed. *Protein Purification Protocols*. Humana Press.
- FL Creighton T. 1998. *Protein Structure*. 2nd Ed. Portland Press.
- Nielsen SS. 1994. *Introduction to Chemical Analysis of Foods*. Part IV.Jones and Bertlett Publ.
- Leo ML and Toldra NF. *Handbook of Dairy Foods Analysis*. 1st Ed. CRC Press.
- Wilson K and Walker J. 2000. *Practical Biochemistry: Principles and Techniques*. Cambridge University Press.
- Christian GD, Dasgupta PS, Schug K. 2014. Analytical Chemistry, 7th Edition Wiley Global Education.
- Nollet, L. M. (Ed.). 2020. *Mass Spectrometry Imaging in Food Analysis*. CRC Press.
- Nordén, B., Rodger, A., and Dafforn, T. 2019. *Linear Dichroism and Circular Dichroism: A Textbook on Polarized-Light Spectroscopy*. Royal Society of Chemistry.
- Singh, D. B., and Tripathi, T. 2020. *Frontiers in Protein Structure, Function, and Dynamics*.

Teaching Schedule:

Theory:

Sr. No.	Units	No. of Lecture (s)
1	**Unit I: Isoelectric focusing, 2-D gel electrophoresis, Immuno assays** Electrophoresis: Isoelectric focusing and 2-D polyacrylamide gel electrophoresis; Capillary zone electrophoresis, Enzyme linked immune-sorbentassay, blotting techniques.	**6**
2	**Unit II: High performance liquid chromatography** High performance liquid chromatography; Theory, instrumentation and application in analysis of dairy foods.	**6**
3	**Unit III: Mass spectroscopy** Mass spectroscopy: Principle, instrumentation and application in milk proteins/ milk fat analysis.	**6**
4	**Unit IV: Protein sequencing** Protein sequencing; Chemical reactions involved in analysis of primary structure of proteins.	**6**
5	**Unit V: X-ray crystallography**	**6**

	Circular dichroism spectroscopy; Theory and application for determination of secondary structure of proteins.	
6	**Unit VI: Circular Dichroism Spectroscopy** X-ray crystallography; Theory and application for determination of tertiary structure of milk proteins.	**6**
7	**Unit VII: Atomic spectroscopy** AAS (Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy, ICPS (Inductively coupled plasma spectroscopy); Principle and application in analysis of milk and milk products.	**6**
8	**Unit VIII: Infrared, Fluorescence** Infrared Spectroscopy, Fluorescence Spectroscopy: principle and application.	**6**
9	**Unit IX: Differential scanning calorimetry, NMR and FTIR** Differential scanning calorimetry: principle and application for milk fat and protein analysis. NMR (Nuclear Magnetic Resonance), FTIR (Fourier Transform Infrared). Principle, application for quality analysis of milk and milk products.	**6**
	Total	**48**

Course Syllabus and Contents
Ph.D. (Agri) in Dairy Microbiology

I. Course Title : Advances in Microbial Physiology

II. Course Code : DM 611

III. Credit Hours : 3=3+0

IV. Why this course?

Microbial physiology deals with metabolism and energy provision; reproduction and death; and regulation of vital activity on the intracellular level and on the level of microbe-microbial interactions and interactions of microorganisms with plants, animals, and man. This study covers growth kinetics of microorganisms, genetical changes during endospore formation, interactions of bacterial communities and diversity in natural eco-systems.

V. Aim of the course:

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

VI. Theory:

Unit I

Microbial growth and stress response; Mathematics and kinetics of bacterial growth, Continuous culture system (chemostat and turbidostat), DiauXic and synchronous growth, Unrestricted versus nutrient-limited growth; Advances in growth measurement, counting viable but non-culturable microbes, Growth in natural environments and limitations. Osmotic stress and osmoregulation, high and low osmolality, osmotic control of gene eXpression, Aerobic to anaerobic transitions, oXidative stress, regulation of the oXidative stress response,pH stress and acid tolerance,Thermal stress and heat shock response, Nutrient stress and starvation stress response, starvation protecting proteins.

Unit II

Peptidoglycans of bacterial cell walls; peptidoglycan hydrolases and synthesis; teichoic and lipo-teichoic acids, Outer membranes of Gram-negative bacteria; lipo-polysaccharide biosynthesis; Outer membranes of Gram-negative bacteria, Bacterial flagella; ChemotaXis; Swarming motility; motility in spirochetes, Endospore formation in bacillus; molecular design of a spore; Stages, physiological changes and genetic aspects of sporulation; Sporulating genes; initiation, transition, forespore development and final stages of sporulation; spore corteX and coat synthesis; Biochemical changes during sporulation, heat resistance in spores; Activation, germination, and outgrowth of bacterial endospores.

Unit III

Energy generation and transport of metabolites: Substrate-level and oXidative phosphorylation; Measurement of proton motive force; Electron transport systems; Anaerobic respiration; Conversion of proton motive force to energy;

Structure of F1F0 and the ATP operon; Energy yield; Generating ATP in alkalophiles; Energetics of chemolithotrophs; Metabolite transport; Facilitated diffusion; Mechanosensitive channels; ATP-binding cassette transporter family; Chemiosmotic-driven transport; Establishing ion gradients; New insight into Respiration and fermentation mechanism in Lactic Acid bacteria, specific transport systems; ATP-linked ion motive pumps, the histidine permease, iron, phosphotransferase system. Sugartransport in Lactic Acid bacteria.

Unit IV

Metabolic Pathways: Alternate pathways of carbohydrate metabolism; Fructose bisphosphatealdolase pathway; Alternate pathways of glucose utilization; Entner-doudoroff or ketogluconate pathway; phosphoketolase pathway; oxidative pentose phosphate cycle; Gluconeogenesis, regulation, glycogen synthesis, tricarboxylic acid cycle, glyoXylate cycle. Utilization of sugars other than glucose, lactose, galactose; maltose, mannitol, fucose and rhamnose, melibiose, raffinose, stachyose; Cellulose degradation; metabolism of starch and glycogen.

Unit V

Microbial (bacterial, archaeal, fungal and viral) diversity, Bacterial communities and diversity in natural eco-systems with special reference to Lactic Acid bacteria. EXtremophiles: hyperthermophiles, eXtreme acidophiles, psychrophiles, barophiles halophiles, alkaliphiles, oligotrophs, radiation-resistant microorganisms, eXtremophiles habitats and microorganisms, Biochemistry and physiology of adaptation, biotechnology of eXtremophiles.

VII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/ Writing)
- Student's Book/ Journal Articles
- Student presentation
- Group Work
- Visit to the relevant industry or Laboratory

VIII. Learning outcome:

After undergoing this course, the students are eXpected to deliver the following:

- To have knowledge on the growth kinetics of microorganisms.
- To have an idea about the genetical changes during endospore formation.
- To know about the energy generation using electron transport chains.
- To have idea on interaction of bacterial communities and diversity in natural eco-systems.

IX. Suggested Reading:

- Cowan MK. 2012. *Microbiology: A Systems Approach*, 3rd Edn. The McGraw Hill Companies, New York, USA.
- Madigan MT, Martinko JM and Parker J. 2012. *Brock Biology of Microorganisms*, 13th Edn. Prentice Hall, London, UK. Edition, Prentice Hall, London, UK.

- Moat AG, Foster JW and Spector MP. 2004. *Microbial Physiology*. 4th Ed. John Wiley and Sons, USA.
- Ogunseitan O. 2005. *Microbial Diversity: Form and Function in Prokaryotes* Blackwell Publishing, Malden, USA.
- Xie *et al*. 2011. *Bacterial Flagellum as a Propeller and as a Rudder for Efficient Chemotaxis*. PNAS108 (6): 2246-51.

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Microbial growth and stress response; Mathematics and kinetics of bacterial growth, Continuous culture system (chemostat and turbidostat), Diauxic and synchronous growth, Unrestricted versus nutrient-limited growth; Advances in growth measurement, counting viable but non-culturable microbes, Growth in natural environments and limitations. Osmotic stress and osmoregulation, high and low osmolality, osmotic control of gene expression, Aerobic to anaerobic transitions, oxidative stress, regulation of the oxidative stress response,pH stress and acid tolerance, Thermal stress and heat shock response, Nutrient stress and starvation stress response, starvation protecting proteins.	8
2	**Unit II** Peptidoglycans of bacterial cell walls; peptidoglycan hydrolases and synthesis;teichoic and lipo-teichoic acids, Outer membranes of Gram-negative bacteria; lipo-polysaccharide biosynthesis; Outer membranes of Gram-negative bacteria, Bacterial flagella; Chemotaxis; Swarming motility; motility in spirochetes, Endospore formation in bacillus; molecular design of a spore; stages, physiological changes and genetic aspects of sporulation; Sporulating genes; initiation, transition, forespore development and final stages of sporulation; spore cortex and coat synthesis; Biochemical changes during sporulation, heat resistance in spores; Activation, germination, and outgrowth of bacterial endospores.	10
3	**Unit III** Energy generation and transport of metabolites: Substrate-level and oxidative phosphorylation; Measurement of proton motive force; Electron transport systems Anaerobic respiration; Conversion of proton motive force to energy; Structure of F1F0 and the ATP operon; Energy yield; Generating ATP in alkalophiles; Energetics of chemolithotrophs; Metabolite transport; Facilitated diffusion; Mechanosensitive channels; ATP-binding cassette transporter family; Chemiosmotic-driven transport; Establishing ion gradients; New insight into Respiration and fermentation mechanism in Lactic Acid bacteria, specific transport systems; ATP-linked ion motive pumps, the	10

	histidine permease, iron, phosphotransferase system. Sugar transport in Lactic Acid bacteria.	
4	**Unit IV** Metabolic Pathways: Alternate pathways of carbohydrate metabolism; Fructose bisphosphatealdolase pathway; Alternate pathways of glucose utilization; Entner- doudoroff or ketogluconate pathway; phosphoketolase pathway; oxidative pentose phosphate cycle; Gluconeogenesis, regulation, glycogen synthesis, tricarboxylic acid cycle, glyoXylate cycle. Utilization of sugars other than glucose, lactose, galactose; maltose, mannitol, fucose and rhamnose, melibiose, raffinose, stachyose; Cellulose degradation; metabolism of starch and glycogen.	10
5	**Unit V** Microbial (bacterial, archaeal, fungal and viral) diversity, Bacterial communitiesand diversity in natural eco-systems with special reference to Lactic Acid bacteria. Extremophiles: hyperthermophiles, eXtreme acidophiles, psychrophiles, barophiles halophiles, alkaliphiles, oligotrophs, radiation-resistant microorganisms, extremophiles habitats and microorganisms, Biochemistry and physiology of adaptation, biotechnology of extremophiles.	10
	Total	**48**

I. Course Title : Advances in Microbial Genetics
II. Course Code : DM 612
III. Credit Hours : 3=3+0

IV. Why this course?

Microbial genetics is the study of inheritance in microorganisms, including bacteria and fungi. This study covers the advancement of genetic expression and regulation in Prokaryotic system, genetic engineering/recombinant DNA technology, mutations, gene editing using advanced tools, etc. The course will also highlight applications of genetic tools.

V. Aim of the course:

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

VI. Theory:

Unit I

Nucleic Acids: Structure of DNA – A, B and Z and triplex DNA, Function of DNA, RNA, DNA Replication models, Protein-Nucleic acid Interactions and helix-turn- helix (HTH) motif, 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, Photoreactivation, Excision repair, mismatch repair, post replication repair and SOS repair. Site Directed Mutagenesis, Directed evolution, Targeted Genome Editing and CRISPR/Cas9.

Unit III

Prokaryotic Transcription; Promoters- Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Transcriptional regulation-positive and negative; Operon models, - Lac, Gal and Trp. Translation: Translation machinery, translation process, Initiation, elongation, termination, factors of Protein Synthesis, peptide bond formation and translocation, Regulation of prokaryotic translation.

Unit IV

Plasmid - Structure and replication, types of plasmids, moveable genetic elements: Transposons, IS and Tn elements, molecular mechanism of transposition, Recombination in bacteria, homologous and non-homologous, 'illegitimate' recombination, and site-specific recombination; Transformation and competence factors, Transduction and Conjugation, structure of F plasmids, Hfr, Recombination methods as a tool for Gene mapping.

Unit V

Genetic Engineering/ rDNA–Restriction Enzymes – Types, Mode of action and application as a tool for gene manipulation, Vectors – Cloning and expression vectors, Construction of genomic and cDNA library, construction of full length cDNA, Microarray, Gene Silencing, Gene knock out.

Unit VI

Intracellular Signaling in microorganisms, cell-cell communication (quorum sensing), Signal transduction mechanism or pathways.

Unit VII

Pyrosequencing, Illumina, Ion torrent, Nanopore sequencing technologies for whole genome and metagenome sequencing.

VII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Visit to the relevant industry or Laboratory

VIII. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the biological significance of DNA and RNA
- To have an idea about the genetic expression and regulation in Prokaryotic system
- To know about the recent advancements in genetic engineering/recombinant DNA technology.
- To have exposure on gene editing using advanced tools.

IX. Suggested Reading:

- Dyson MR and Durocher Y. 2007. *Expression Systems*. Scion Publ.
- Hartl D, Jones L and Elizabeth W. 2000. *Genetic Analysis of Genes and Genomes*. Jones Bartkett Publ.
- Watson JD, Tania AB, Stephen PB, Alexander G, Michael L and Richard L. 2017. *Molecular Biology of the Gene*. Pearson.
- Keuzer H and Massey A. 2001. *Recombinant DNA and Biotechnology*. 2nd Ed. ASM Press.
- Russell Peter J. 2014. *IGenetics: a molecular approach*. Pearson
- Streips UN and Yasbin RE. 2002. *Modern Microbial Genetics*. 2nd Ed. John Wiley and Sons.
- Synder L and Champness W. 2003. *Molecular Genetics of Bacteria*. 2nd Ed. ASM Publ.

Teaching Schedule:

Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Nucleic Acids: Structure of DNA – A, B and Z and triplex DNA, Function of DNA, RNA, DNA Replication models, Protein-Nucleic acid Interactions and helix-turn- helix (HTH) motif, Genetic Code.	6

2	**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, Photoreactivation, Excision repair, mismatch repair, post replication repair and SOS repair. Site Directed Mutagenesis, Directed evolution, Targeted Genome Editing and CRISPR/Cas9.	8
3	**Unit III** Prokaryotic Transcription; Promoters- Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Transcriptional regulation-positive and negative; Operon models, - Lac, Gal and Trp. Translation: Translation machinery, translation process, Initiation, elongation, termination, factors of Protein Synthesis, peptide bond formation and translocation, Regulation of prokaryotic translation.	10
4	**Unit IV** Plasmid - Structure and replication, types of plasmids, moveable genetic elements: Transposons, IS and Tn elements, molecular mechanism of transposition, Recombination in bacteria, homologous and non-homologous, 'illegitimate' recombination, and site-specific recombination; Transformation and competence factors, Transduction and Conjugation, structure of F plasmids, Hfr, Recombination methods as a tool for Gene mapping.	8
5	**Unit V** Genetic Engineering/ rDNA–Restriction Enzymes – Types, Mode of action and application as a tool for gene manipulation, Vectors – Cloning and expression vectors, Construction of genomic and cDNA library, construction of full length cDNA, Microarray, Gene Silencing, Gene knock out.	8
6	**Unit VI** Intracellular Signaling in microorganisms, cell-cell communication (quorum sensing), Signal transduction mechanism or pathways.	4
7	**Unit VII** Pyrosequencing, Illumina, Ion torrent, Nanopore sequencing technologies for whole genome and metagenome sequencing.	4
	Total	**48**

I. Course Title : Advances in Dairy and Food Microbiology

II. Course Code : DM 621

III. Credit Hours : 3=3+0

IV. Why this course?

Functional foods have potentially positive effects on health beyond basic nutrition and promote optimal health and help to reduce the risk of life style diseases. This course covers biochemical pathways of Lactic acid bacteria for carbohydrate metabolisms or protein metabolisms, bacteriocins and their application as biopreservatives, encapsulation of microorganisms and enzymes for the delivery tothe target site etc.

V. Aim of the course:

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

VI. Theory:

Unit I

Lactic acid bacteria in food fermentations, Important metabolic pathways of microorganisms, Current status of metabolism of starters cultures; Antibiotic resistance in lactic acid bacteria, Current trends in lactic starter for industrial applications and functional foods, Special additional cultures, Biofilm and their remedies, Future aspects in research and development of LAB.

Unit II

Current concepts in starter technology, Novel starter preservation techniques, DVS, Improving starter cultures for food fermentation by genetic manipulation/metabolic engineering, Development/formulation of new products based on dairy by-products, Bioactive metabolites and biogenic amines, Designer milk, Modern concepts in cheese ripening, Nutraceuticals and functional foods, Genetically modified foods/ products, Safety aspects of genetic engineered foods.

Unit III

Bacteriocins of lactic acid bacteria, Structure, function, transport and mode of action, Application of bacteriocins in food bio preservation, Non-bacteriocin antimicrobial compounds- reuterin, antifungal compounds, milk and food derived bioactive peptides and other antimicrobial compounds, Protective cultures, Antimicrobial packaging system, active packaging.

Unit IV

Newly emerging pathogens, Concepts in food toxicology, Food borne toxins, Rapid methods for detection in food borne pathogens, Current concepts in food quality and safety management, Control of food borne pathogens, Pasteurization, dehydration, freezing, fermentation, irradiation and chemical additives, microwave processing, microfiltration, bactofugation, Hurdle technology, modified atmosphere packaging and storage, novel technology in control of food based pathogens, Use of non-thermal technologies (ultra-high voltage electric fields, thermosonication hydrostatic pressure technology, cold plasma etc.) alternate-thermal technologies (ohmic heating, dielectric

heating, infrared and induction heating etc.), Biological technologies (antibacterial enzymes, proteins and peptides) in food processing.

Unit V

Encapsulation as a means for delivery of bacteria and functional ingredients-microencapsulation and nanoencapsulation, nanotechnology, Immobilization of cell and enzymes and their use in dairy and food industry.

VII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Visit to the relevant industry or Laboratory

VIII. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- Have knowledge on the functional dairy foods.
- To have an idea about biochemical pathways of Lactic acid bacteria for carbohydrate metabolisms or protein metabolisms.
- To know about the Bacteriocins and their application as biopreservatives.
- To have any idea about the encapsulation of microorganisms and enzymes for the delivery to the target site.

IX. Suggested Reading:

- Ozer B and Evrendilek GA. 2014. *Dairy Microbiology and Biochemistry: Recent Developments.* CRC Press
- Bagchi D, Lau FC and Ghosh DK. 2010. *Biotechnology in Functional Foods and Nutraceuticals* (1st Edition, 2010) CRC Press, USA.
- Kwak HS. 2015. *Nano- and Microencapsulation for Foods*. Wiley Publishing
- Erkmen O and Bozoglu TF. 2016. *Food Microbiology: Principles into Practice*, 2 Volume Set. Wiley Publishing.
- Suvendu Bhattacharya. 2014. *Conventional and Advanced Food Processing Technologies.* Wiley Publishing.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Lactic acid bacteria in food fermentations, Important metabolic pathways of microorganisms, Current status of metabolism of starters cultures; Antibiotic resistance in lactic acid bacteria, Current trends in lactic starter for industrial applications and functional foods, Special additional cultures, Biofilm and their remedies, Future aspects in research and development of LAB	8

2	**Unit II** Current concepts in starter technology, Novel starter preservation techniques, DVS, Improving starter cultures for food fermentation by genetic manipulation/metabolic engineering, Development/formulation of new products based on dairy by-products, Bioactive metabolites and biogenic amines, Designer milk, Modern concepts in cheese ripening, Nutraceuticals and functional foods, Genetically modified foods/ products, Safety aspects of genetic engineered foods	10
3	**Unit III** Bacteriocins of lactic acid bacteria, Structure, function, transport and mode of action, Application of bacteriocins in food bio preservation, Non-bacteriocin antimicrobial compounds- reuterin, antifungal compounds, milk and food derived bioactive peptides and other antimicrobial compounds, Protective cultures, Antimicrobial packaging system, active packaging	10
4	**Unit IV** Newly emerging pathogens, Concepts in food toXicology, Food borne toXins, Rapid methods for detection in food borne pathogens, Current concepts in food quality and safety management, Control of food borne pathogens, Pasteurization, dehydration, freezing, fermentation, irradiation and chemical additives, microwave processing, microfiltration, bactofugation, Hurdle technology, modified atmosphere packaging and storage, novel technology in control of food based pathogens, Use of non-thermal technologies (ultra-high voltage electric fields, thermosonication hydrostatic pressure technology, cold plasma etc.) alternate-thermal technologies (ohmic heating, dielectric heating, infrared and induction heating etc.), Biological technologies (antibacterial enzymes, proteins and peptides) in food processing	12
5	**Unit V** Encapsulation as a means for delivery of bacteria and functional ingredients- microencapsulation and nanoencapsulation, nanotechnology, Immobilization of celland enzymes and their use in dairy and food industry	8
	Total	**48**

I. Course Title : Advances in Food Safety of Dairy Products

II. Course Code : DM 622

III. Credit Hours : 3=3+0

IV. Why this course?

Food safety is used as a scientific discipline describing handling, preparation, and storage of food in ways that prevent food-borne illness. This study covers principles of safety in advanced food microbiological laboratory, general mechanismof microbial pathogenesis, emerging food borne pathogens, antimicrobial resistance in bacteria etc.

V. Aim of the course:

To develop knowledge, understanding and application of foodborne pathogens at an advanced level to ensure safety of dairy products.

VI. Theory:

Unit I

Milk borne diseases, public health concern and epidemiology Trends in food borne disease and implication; Methods of diseases transmission; Changing patterns in epidemiology of milk borne diseases; Impact of agricultural and modern food manufacturing practices in transmission of food borne diseases. Public health concern associated with milk and milk products; type of microbial spoilage, defects and control measures.

Unit II

General mechanism of microbial pathogenesis: Food borne infection by colonizationand adhesion factors like Pilli or fimbriae, adhesion proteins, Food borne infectionby biofilm formation; invasion and intracellular residence factors; Food borne infection by phagocytosis, invasion mediated induced phagocytosis; Food borne infection by iron acquisition; motility and chemotaXis; Food borne infection by invasion of immune system; IntoXication; ToXi-infection. Structure and function of eXotoXins and endotoXin; Genetic regulation and secretary system for virulence factors.

Unit III

Growth, survival characteristics, virulence and infectivity of dairy pathogens; Growth and survival characteristics of *E. coli*, *Enterobacter sakazaki*, Salmonella, Shigella, *Yersinia enterocolitica*, Streptococcus sp., *L. monocytogenes*, *Mycobacterium avium* subsp. *paratuberculosis*, *Brucella* sp., *Campylobacter jejuni*, *Staph.aureus*, *B. cereus*, *Clostridium perfringens*, toXigenic fungi and viruses in milk and milk products, their pathology of illness, mode of transmission, incidence of illness, virulence and infectivity.

Unit IV

Microbiological risk assessment of dairy foods: Risk analysis principle and concept; Hazard identification and characterization; Exposer assessment; Risk characterization in dairy products; Risk assessment models (dose response/ exposer assessment models);Risk factors affecting microbial safety of raw and processed dairy foods; Risk profiling of pathogens in milk and milk products; Risk management issues and control strategies for dairy products.

Unit V

Antimicrobial resistance in dairy animals and public health concern: Global and national perspective of AMR in dairy sector; WHO priority list/ guidelines on AMR bacteria; National action plan on AMR. Surveillance/ Incidence of AMR bacteria in dairy food chain and public health concern Mechanisms of resistance development in AMR bacteria; Conventional and rapid diagnostics for detection of AMR bacteria in dairy foods.

VII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/ Writing)
- Student's Book/ Journal Articles
- Student presentation
- Group Work
- Visit to the relevant industry or Laboratory

VIII. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on principles of safety in advanced food microbiological laboratory.
- To have an idea about the general mechanism of microbial pathogenesis.
- To know about the emerging food borne pathogens.
- To have knowledge on antimicrobial resistance in bacteria.

IX. Suggested Reading:

- Schwarz S, Cavaco LM, Shen J and Aarestrup FM. 2018. *Antimicrobial Resistance in Bacteria from Livestock and Companion Animals* ASM Press.
- Haas CN, Rose JB and Gerba CP. *Quantitative Microbial Risk Assessment*. John Wiley and Sons.
- Kudva IT and Nicholson T. 2016. *Virulence Mechanisms of Bacterial Pathogens.* ASM Press.
- McVey DS, Kennedy M and Chengappa MM. 2013. *Veterinary Microbiology* John Wiley and Sons.
- Yoe C. 2016. *Principles of Risk Analysis: Decision Making Under Uncertainty*. Publisher - Technology and Engineering.
- Bhunia AK. 2019. *Foodborne Microbial Pathogens: Mechanisms and pathogenesis.* Springer-Verlag New York.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Milk borne diseases, public health concern and epidemiology Trends in food borne disease and implication; Methods of diseases transmission; Changing patterns in epidemiology of milk borne diseases; Impact of agricultural and modern food manufacturing practices in transmission of food borne diseases. Public health concern associated with milk and milk products; type of microbial spoilage, defects and control measures.	8
2	**Unit II** General mechanism of microbial pathogenesis: Food borne infection by colonization and adhesion factors like Pilli or fimbriae, adhesion proteins, Food borne infection by biofilm formation; invasion and intracellular residence factors; Food borne infection by phagocytosis, invasion mediated induced phagocytosis; Food borne infection by iron acquisition; motility and chemotaxis; Food borne infection by invasion of immune system; Intoxication; Toxi-infection. Structure and function of exotoxins and endotoxin; Genetic regulation and secretary system for virulence factors.	10
3	**Unit III** Growth, survival characteristics, virulence and infectivity of dairy pathogens; Growth and survival characteristics of *E. coli*, *Enterobacter sakazaki*, Salmonella, Shigella, *Yersinia enterocolitica*, Streptococcus sp., *L. monocytogenes*, *Mycobacterium avium* subsp. *paratuberculosis*, *Brucella* sp., *Campylobacter jejuni*, *Staph.aureus*, *B. cereus*, *Clostridium perfringens*, toxigenic fungi and viruses in milk and milk products, their pathology of illness, mode of transmission, incidence of illness, virulence and infectivity.	10
4	**Unit IV** Microbiological risk assessment of dairy foods: Risk analysis principle and concept; Hazard identification and characterization; Exposer assessment; Risk characterization in dairy products; Risk assessment models (dose response/ exposer assessment models);Risk factors affecting microbial safety of raw and processed dairy foods; Risk profiling of pathogens in milk and milk products; Risk management issues and control strategies for dairy products.	12
5	**Unit V** Antimicrobial resistance in dairy animals and public health concern: Global and national perspective of AMR in dairy sector; WHO priority list/ guidelines on AMR bacteria; National action plan on AMR. Surveillance/ Incidence of AMR bacteria indairy food chain and public health concern Mechanisms of resistance developmentin AMR bacteria; Conventional and rapid diagnostics for detection of AMR bacteriain dairy foods.	8

	Total	**48**

I. Course Title : Advances in Probiotics and Functional Foods

II. Course Code : DM 623

III. Credit Hours : 3=3+0

IV. Why this course?

Probiotics are live microbial food supplements that provide several health benefits, as they help in maintaining excellent stability and composition of the intestinal microbiota and boost the resistance against infection by pathogens. The requirement for probiotic functional foods is rapidly and progressively because of increased awareness of the public regarding the impact of food on health. This study covers prebiotics, synbiotics and postbiotics, functional food ingredients and their role in human health and nutrition, different mechanism of action of probiotics establishing through in vitro and in vivo studies, scientific assessment of probiotics/functional foods, next generation probiotics etc.

V. Aim of the course:

To familiarize the student with the advancements in probiotics and functional foods

VI. Theory:

Unit I

Probiotics: Characteristics of probiotics for selection, Stability during storage and passage to gastrointestinal tract.

Unit II

Probiotic mode of action and disease control: Homeostasis of disturbed commensal microbial flora in the gut, pathogen exclusion, production of antimicrobial substances, modulation of immune system, alteration of intestinal bacterial metabolite action, alteration of microecology of healthy humans and patients.

Unit III

Prebiotics, synbiotics and postbiotics: Concept and definitions, criteria, types and sources of prebiotics, prebiotics and gut microbiota.

Unit IV

Functional foods; Nutraceuticals, medical/health foods, functional foods ingredients and their role in human health and nutrition.

Unit V

Dairy based functional foods: Dahi, lassi, yoghurt, kefir, cheese, koumiss, functional fermented dairy beverages, and dairy based cereal foods, fortified fermented dairy foods.

Unit VI

Cereals, soya, plant based and other functional foods; Miso, Kimchi, Sauerkraut, Sake, Ogi, Gundruk, Natto, Doenjang, Tempeh, Douchi, Cheonggukjang, and Soy milk based fermented foods: (yoghurt, dahi, beverages and cheese), fermented meat products.

Unit VII

Microbial production of Bioactive compounds: Bacteriocins, Bioactive peptides, Conjugated Linoleic Acids, gamma-Aminobutyric acid, Vitamins (Folate, Riboflavin, Vitamin B12), Low calorie sugars (Xylitol, Sorbitol, Mannitol, Trehalose), Micronutrients (Selenium, Zinc).

Unit VIII

Health benefits of probiotics/functional foods: Gastrointestinal disorders, metabolic syndrome including cardiovascular diseases, diabetes and obesity, Brain health, Immunological disorders, cancer, health and wellbeing in Ageing, alcoholic and non-alcoholic liver disease, Reproductive and Hormonal disorders, mental health.

Unit IX

Scientific Assessment of probiotics/functional foods: Role of Biomarkers, Application of Proteomics, Metabolomics, Nutrigenetics and Nutrigenomics in establishing scientific evidence of functional foods for imparting health benefits.

Unit X

Regulations and Future prospects of probiotics and functional foods: Legal statusof probiotics, safety and regulatory aspects and Future prospects.

Unit XI

Next generation probiotics (Designer probiotics): Robust probiotic strains with stress survival systems, enhanced adhesion ability and surface markers etc. and for mucosal delivery of vaccines.

VII. Teaching Methods/ Activities:

- Lectures
- Assignment (Reading/Writing)
- Student's Book/Journal Articles
- Student presentation
- Group Work
- Visit to the relevant industry or Laboratory

VIII. Learning outcome:

After undergoing this course, the students are expected to deliver the following:

- To have knowledge on the Prebiotics, synbiotics and postbiotics.
- To have knowledge on functional food ingredients and their role in human health and nutrition
- To know about the different mechanism of action of probiotics establishing through *in vitro* and *in vivo* studies.
- To have any idea about the Scientific Assessment of probiotics/functional foods.

IX. Suggested Reading:

- Huffnagle GB. 2008. *The Probiotics Revolution: The Definitive Guide to Safe*, Natural Health Solutions Using Probiotic and Prebiotic Foods and Supplements. Bantam, USA.
- Robert Keith Wallace (Author) and Samantha Wallace. 2017. *Gut Crisis: How Diet, Probiotics, and Friendly Bacteria Help You Lose Weight and Heal Your Body and Mind*. Dharma Publication, Fairfield, USA.
- Hae-Soo Kwak. 2015. *Nano- and Microencapsulation for Foods*. Wiley Publishing Edward R. (Ted) Farnworth. 2008. *Handbook of Fermented Functional Foods*. CRC Press
- Prajapati JB and Behare PV. 2018. *Textbook of Dairy Microbiology*. Directorate of Knowledge Management in Agriculture, ICAR, ISBN: 978-81-7164-182-6.
- Puniya AK. 2015. *Fermented Milk and Dairy Products*; CRC Press/ Taylor and Francis(ISBN 9781466577978)
- Frias J, Villaluenga CM and Peñas E. (Ed.). 2016. *Fermented Foods in Health and Disease Prevention*. Elsevier Inc.
- Sungsoo C, and Finocchiaro ET. 2010. *Handbook of prebiotics and probiotics*

ingredients: health benefits and food applications. Boca Raton: Taylor and Francis.

- Owen Judith A and Janis Kuby. 2013. *Kuby immunology*. New York: W.H. Freeman.
- Tamang Jyoti Prakash. 2020. *Ethnic fermented foods and beverages of India: science history and culture*. Singapore: Springer.

Teaching Schedule:
Theory:

Sr. No.	Topic	No. of Lecture (s)
1	**Unit I** Probiotics: Characteristics of probiotics for selection, Stability during storage and passage to gastrointestinal tract	2
2	**Unit II** Probiotic mode of action and disease control: Homeostasis of disturbed commensal microbial flora in the gut, pathogen exclusion, production of antimicrobial substances, modulation of immune system, alteration of intestinal bacterial metabolite action, alteration of microecology of healthy humans and patients	4
3	**Unit III** Prebiotics, synbiotics and postbiotics: Concept and definitions, criteria, types and sources of prebiotics, prebiotics and gut microbiota	4
4	**Unit IV** Functional foods; Nutraceuticals, medical/health foods, functional foods ingredients and their role in human health and nutrition	4
5	**Unit V** Dairy based functional foods: Dahi, lassi, yoghurt, kefir, cheese, koumiss, functional fermented dairy beverages, and dairy based cereal foods, fortified fermented dairy foods	4
6	**Unit VI** Cereals, soya, plant based and other functional foods; Miso, Kimchi, Sauerkraut, Sake, Ogi, Gundruk, Natto, Doenjang, Tempeh, Douchi, Cheonggukjang, and Soy milk based fermented foods:(yoghurt, dahi, beverages and cheese), fermented meat products	6
7	**Unit VII** Microbial production of Bioactive compounds: Bacteriocins, Bioactive peptides, Conjugated Linoleic Acids, gamma-Aminobutyric acid, Vitamins (Folate, Riboflavin, Vitamin B12), Low calorie sugars (Xylitol, Sorbitol, Mannitol, Trehalose), Micronutrients (Selenium, Zinc).	4
8	**Unit VIII** Health benefits of probiotics/functional foods: Gastrointestinal disorders, metabolic syndrome including cardiovascular diseases, diabetes and obesity, Brain health, Immunological disorders, cancer,	6

	health and wellbeing in Ageing, alcoholic and non-alcoholic liver disease, Reproductive and Hormonal disorders, mental health	
9	**Unit IX** Scientific Assessment of probiotics/functional foods: Role of Biomarkers, Application of Proteomics, Metabolomics, Nutrigenetics and Nutrigenomics in establishing scientific evidence of functional foods for imparting health benefits	6
10	**Unit X** Regulations and Future prospects of probiotics and functional foods: Legal statusof probiotics, safety and regulatory aspects and Future prospects	4
11	**Unit XI** Next generation probiotics (Designer probiotics): Robust probiotic strains with stress survival systems, enhanced adhesion ability and surface markers etc. and for mucosal delivery of vaccines	4
	Total	**48**

List of Journals and E-Resources

- *Indian Journal of Dairy Science*
- *International Dairy Journal*
- *International Journal of Dairy Technology*
- *Journal of Dairy Research*
- *Journal of Dairy Science*
- *Comprehensive Reviews in Food Science and Food Safety*
- *Critical Reviews in Food Science and Nutrition*
- *Food Additives and Contaminants: Part A and Part B*
- *Food Analytical Methods*
- *Food Hydrocolloids*
- *Food Chemistry*
- *Food Research International*
- *Food Reviews International*
- *Food Science and Technology - Lebensmittel-Wissenschaft and Tech*
- *Food Science and Technology International*
- *Food Science and Technology Research*
- *Food and Chemical Toxicology*
- *Indian Journal of Dairy Science*
- *International Journal of Food Properties*
- *International Journal of Food Science and Technology*
- *IDF Bulletins*
- *Journal of Agricultural and Food Chemistry*
- *Journal of Food Biochemistry (Journal of Food Lipids)*
- *Journal of Food Composition and Analysis*
- *Journal of Food Processing and Preservation*
- *Journal of Food Quality*
- *Journal of Food Safety*
- *Journal of Food Science*
- *Journal of Food Science and Technology*
- *Journal of Functional Foods*
- *Journal of the Science of Food and Agriculture*
- *Advances in Applied Microbiology*
- *Advances in Bioscience and Biotechnology*
- *Advances in Genetics*
- *Advances in Microbial Physiology*
- *Annals of Microbiology*

- *Annual Review of Microbiology*
- *Antonie van Leeuwenhoek*
- *Applied and Environmental Microbiology*
- *Applied Biochemistry and Microbiology*
- *Applied Microbiology and Biotechnology*
- *Archives of Animal Nutrition*
- *Archives of Microbiology*
- *Bioscience, Biotechnology and Biochemistry*
- *BMC Microbiology*
- *BMC Molecular Biology*
- *Brazilian Journal of Microbiology*
- *British Food Journal*
- *British Journal of Nutrition*
- *Canadian Journal of Microbiology*
- *Cellular Microbiology*
- *Clinical Microbiology*
- *Comparative Immunology Microbiology and Infectious Diseases*
- *Comprehensive Reviews in Food Science and Food Safety*
- *Critical Reviews in Environmental Science and Technology*
- *Critical Reviews in Food Science and Nutrition*
- *Critical Reviews in Microbiology*
- *Current Genetics*
- *Current Microbiology*
- *Current Opinion in Biotechnology*
- *Current Science*
- *Current Topics in Microbiology and Immunology*
- *Dairy Science and Technology (Le Lait)*
- *Environmental Microbiology*
- *Enzyme and Microbial Technology*
- *Eukaryotic Cell*
- *European Food Research and Technology*
- *European Journal of Clinical Microbiology and Infectious Diseases*
- *FEMS Microbiology Ecology*
- *FEMS Microbiology Letters*
- *FEMS Microbiology Reviews*
- *Food Analytical Methods*
- *Food and Function*
- *Food Bioscience*
- *Food Biotechnology*
- *Food Control*
- *Food Microbiology*

- *Food Microbiology and Food Safety*
- *Food Quality and Preference*
- *Food Research International*
- *Food Reviews International*
- *Food Science and Technology - Lebensmittel-Wissenschaft and Tech*
- *Food Science and Biotechnology*
- *Food Science and Technology International*
- *Food Technology and Biotechnology*
- *Foodborne Pathogens and Disease*
- *Frontiers in Cellular and Infection Microbiology*
- *Frontiers in Microbiology*
- *Frontiers in Molecular Biosciences*
- *Fungal Genetics and Biology*
- *Future Microbiology*
- *Gene*
- *Indian Journal of Animal Sciences*
- *Indian Journal of Dairy Science*
- *Indian Journal of Medical Microbiology*
- *Indian Journal of Microbiology*
- *Indian Journal of Veterinary Science*
- *Innovative Food Science and Emerging Technologies*
- *International Dairy Journal*
- *International Journal of Dairy Technology*
- *International Journal of Fermented Foods*
- *International Journal of Food Microbiology*
- *International Journal of Food Properties*
- *International Journal of Food Science and Nutrition*
- *International Journal of Food Science and Technology*
- *International Journal of General and Molecular Microbiology*
- *International Journal of Probiotics and Prebiotics*
- *Journal of Agricultural and Food Chemistry*
- *Journal of Animal and Feed Sciences*
- *Journal of Animal Science*
- *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 Dairy Research*
- *Journal of Dairy Science*

- *Journal of Food and Drug Analysis*
- *Journal of Food Biochemistry*
- *Journal of Food Composition and Analysis*
- *Journal of Food Processing and Preservation*
- *Journal of Food Protection*
- *Letters in Applied Microbiology*
- *Journal of Food Quality*
- *Journal of Food safety*
- *Journal of Food Science*
- *Journal of Food Science and Technology*
- *Journal of Functional Foods*
- *Journal of General and Applied Microbiology*
- *Journal of Industrial Microbiology and Biotechnology*
- *Journal of Industrial Microbiology and Biotechnology*
- *Journal of Medicinal Food*
- *Journal of Microbial Food Safety Standards*
- *Journal of Microbiology*
- *Journal of Microbiology and Biotechnology*
- *Journal of Microscopy*
- *Journal of Molecular Microbiology and Biotechnology*
- *Journal of Rapid Methods and Automation in Microbiology*
- *Journal of The Science of Food and Agriculture*
- *Journal of Virology*
- *Methods in Microbiology*
- *Microbial Ecology in Health and Disease*