Course Title with Credit Load
Ph.D. in Dairy Technology

Course Code	Course Title	Credit Hours
DT 611	Advances in Lipid Technology	3 (3+0)
DT 612**	Advances in Protein Technology	3 (3+0)
DT 621**	Product Monitoring and Process Control	3 (3+0)
DT 622	R and D Management in Dairy Industry	3 (3+0)
DT 623	Advances in Carbohydrates Technology	3 (3+0)
DT 691	Doctoral Seminar-I	1 (1+0)
DT 692	Doctoral Seminar-II	1 (1+0)
DT 699	Doctoral Research	75 (0+75)

Minor Courses

The courses will be selected from the allied disciplines of Dairy Engineering, Dairy Chemistry and Dairy Microbiology to meet the minimum credit requirements.

Supporting Courses

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

Common Courses

1. Library and Information Services 1
2. Technical Writing and Communications Skills 1
3. Intellectual Property and its Management in Agriculture 1
4. Basic Concepts in Laboratory Techniques 1
5. Agricultural Research, Research Ethics and Rural Development Programmes 1

*Core courses for Master's programme; **Core courses for Doctoral programme

Course Contents
Ph.D. in Dairy Technology

I. Course Title : Advances in Lipid Technology

II. Course Code : DT 611

III. Credit Hours : 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, Trans-fatty 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 VI

Frying process and systems; Changes in fats and oils during frying; Snack foods - Processing sys-tems; 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. Advances in milk fat fractionation – Technology and applications. In: *Crystallization processes in fats and lipid systems*, 1st Edn,Boca Raton: Taylor and Francis Group (eBook ISBN 9781482270884).
- 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-replacements-in-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

I. Course Code : DT 612

II. Course Title : Advances in Protein Technology

III. Credit Hours : 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 denatur-ation 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

IX. 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.

- 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/health-knowledge-gateway/promotion-prevention/nutrition/protein
- High and Low Biological Value Protein Foods: (EUFIC)-https://www.eufic.org/en/whats-in-food/article/the-basics-proteins

I. Course Title : Product Monitoring and Process Control

II. Course Code : DT 621

III. Credit Hours : 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.

IX. Websites

- Quality Management Tools-Including TQM, Six Sigma, Cost of Quality and EFQM-https://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-beverage-manufacturing

I. Course Title : R&D Management in Dairy Industry

II. Course Code : DT 622

III. Credit Hours : 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.

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 Publishing Ltd.
- 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-health-and-safety.html

I. Course Title : Advances in Carbohydrate Technology

II. Course Code : DT 623

III. Credit Hours : 3+0

IV. Why this course?

Besides proteins and fats, carbohydratesareother important nutrients. The flavour,

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

Potential Areas for Research

1. Active, intelligent and biodegradable packaging
2. Application of non-thermal processes for value-added dairy products
3. Bioactives from plant/plant bio-waste for human nutrition
4. By-products from agri-food industry: Recovery, utilization and revalorization
5. Composite dairy foods
6. Dairy based analogues
7. Dairy derived ingredients and their applications
8. Green technologies for dairy and food products
9. Health foods for conferring physiological benefits
10. Innovations in fermented dairy and food products
11. Nanotechnology in dairy and food applications
12. Non-bovine milk and milk products
13. Novel extruded food based on dairy and cereal/legume based solids.
14. Novel products utilizing membrane processed dairy solids.
15. Sensory characterization, technology standardization, value addition and shelf life extension of traditional Indian dairy products
16. Target delivery of nutraceuticals/active functional ingredients through dairy matrices
17. Technology of novel and exotic cheeses
18. Utilization of dairy by-products

List of Journals

1. *Australian Journal of Dairy Technology*
2. *British Food Journal*
3. *Cereal Chemistry*
4. *Cereal Foods World*
5. *Comprehensive Reviews in Food Science and Food Safety*
6. *Critical Reviews in Food Science and Nutrition*
7. *CyTA - Journal of Food (Ciencia Y TecnologiaAlimentaria)*
8. *Dairy Science and Technology (formerly Le Lait)*
9. *Drying Technology: An International Journal*
10. *Emirates Journal of Food and Agriculture*
11. *European Food Research and Technology*
12. *European Journal of Nutrition and Food Safety*

13. *Food and Bioprocess Technology*
14. *Food and Bioproducts Processing*
15. *Food and Function*
16. *Food Bioscience*
17. *Food Hydrocolloids*
18. *Food Quality and Preference*
19. *Food Research International*
20. *Food Reviews International*
21. *Indian Journal of Dairy Science*
22. *Innovative Food Science and Emerging Technologies*
23. *International Dairy Journal*
24. *International Journal of Dairy Technology*
25. *International Journal of Fermented Foods*
26. *International Journal of Food Properties*
27. *International Journal of Food Science and Technology*
28. *Irish Journal of Agricultural and Food Research*
29. *Journal of Dairy Research*
30. *Journal of Dairy Science*
31. *Journal of Food Measurement and Characterization*
32. *Journal of Food Processing and Preservation*
33. *Journal of Food Science and Technology*
34. *LWT - Food Science and Technology*