Learning Outcomes based Curriculum

Preamble

The goal of the M. Tech. in Food Engineering and Technology programme is to develop an overarching framework for developing skilled human resources for the food sector. Furthermore, the course emphasizes boosting creativity and utilizing one's expertise of food engineering and technology for the welfare of society.

This M. Tech. course is a combination of professional courses, basic food science courses as well as advance courses that will help the student to find their role in the contemporary era for food technology and engineering. Furthermore, in these competitive times, the course will assist them in developing independence and self-reliance.

1. Introduction

Our civilization is currently undergoing changes at a rate higher than ever before. Information and knowledge double every 5–10 years. The global human population is still growing. As a result of the growing population, the consumption of resources is increasing faster as well. Among the most significant challenges for the future are the provision of reasonably priced and sustainable supply, storage and transport of energy, clean freshwater, and adequate food for all human beings. Food Engineering and Technology is involved in all three of these main challenges, directly or indirectly. Alternative energy sources are based on agricultural products, resulting in a new competition for farmland use for food production. Many accepted facts indicate that food will run short in the future and, therefore, food prices will increase. Global food production must increase by 70–100 % by 2050 to feed the global population. Keeping in mind the decreasing amount of arable farmland and the growing human population, new concepts will be required to feed the world and meet future consumer demands for food. Therefore, there is a need to design the course which will give the insight and full understanding on the present situation of food process engineering and technology. The M. Tech. in Food Engineering and Technology programme is structured in such a way that all of the aforementioned elements can be addressed. The course will provide basic and advances in the field food process engineering, food packaging, and food science technology. In addition to that the curriculum enhances the research and innovations approaches of student in the field of food process engineering, food science and technology, and food packaging. Graduates of Food Engineering and Technology will be prepared to work in the food sector areas such as quality control, plant and equipment design,

instrumentation, production, research and development, and to become a successful entrepreneur.

2. Qualification descriptors for the graduates

The qualification descriptors for a Master degree with in food engineering and technology include the following:

2.1 Graduates Knowledge & Understanding

Demonstrate (i) a systematic, general and comprehensible knowledge and understanding in the field of food engineering and technology, (ii) procedural knowledge that creates different types of professionals related to the varied scope in food processing, and (iii) professional skills in varied areas, including a critical understanding of the latest developments in the area of specialization, and an ability to use established techniques of analysis and enquiry within the area of specialization.

2.2 Graduates Skills & Techniques

Demonstrate skills in identifying information needs, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources, analysis and interpretation of data using methodologies as appropriate to the subject of food engineering and technology for formulating evidence-based solutions and arguments.

2.3 Competence

Demonstrate comprehensive knowledge about materials, including current research, scholarly, and/or professional literature, relating to essential and advanced learning areas pertaining to food processing and engineering field of study, and techniques and skills required for identifying related problems and issues.

3. Graduates Attributes

The graduate attributes for the post-graduate students pursuing food engineering and technology programme include capabilities that help them to strengthen their abilities for widening current knowledge base and skills, gaining new knowledge and skills in the areas of food processing and engineering. Graduate attributes are fostered through meaningful learning experiences made available through the updated curriculum, the total university experiences, and a process of critical and reflective thinking. The characteristics attributes of graduates of food engineering and technology programme include:

- Disciplinary knowledge and skills: Capable in demonstrating basic theoretical and practical knowledge and understanding in food engineering and technology.
- Effective communicator: Ability to communicate precisely, confidently and with clarity among the rural and urban communities to understand their food problem as well as various educational topics for creating awareness and making better lives.
- Critical thinking: Analytical reasoning and Problem solving: Ability to employ critical thinking in identifying the problem, developing analytical skills and capabilities to resolve the problems efficiently related to food science and technology.
- Research and scientific reasoning: Skills in undertaking small researches by way of paper, case studies, field visits, laboratory experiments etc. on the related topics/problems of the discipline and arrive at the results based on the scientific reasoning wherever applicable.
- Cooperation/ Team Work: Capability of working enthusiastically and united with the working teams in organizing events in the Department/ Faculty/ University/

Community, and accomplishing group work/ assignments / tasks by willing cooperation of all and well-coordinated group living through during educational visits.

4. Program Outcomes

1. Graduate has gained thorough understanding of the subject of Food Engineering and Technology as collated in the curriculum and developed the capability of self-learning so as to continue the search for knowledge.
2. Graduate has gained skills to apply knowledge in the Food laboratories/ Industries/ or to the challenges of local, regional or global dimensions aligned with the economy and sustainability of food industries.
3. Graduate has gained research acumen and developed critical thinking to carry out research in the domain, and continue learning
4. Graduate has gained enough exposure and articulation to disseminate the knowledge in formal or informal settings of Food sector.
5. Graduate has acquired competency in running or implementing a new project.

5. Programme structure

Total Credits: 71

Structure of the curriculum

Course category	No of courses	Credits per course	Total Credits
I. Core courses			
FT 511: Research Methodology		3	
FT 512: Transport Phenomena in Food Processing		4	
FT513: Engineering Properties of Biological materials	10	3	50
FT516: Emerging Food Processing Technologies		3	
FT517: Food Equipment and Plant Design		3	
FT 518: Recent Trends in Food Product Development and Packaging		3	
FT 519: Food Process Modelling and Simulation		3	
FT 571: Seminar		1	
FT 681: Project Work & Dissertation Part-I		12	
FT 682: Project Work & Dissertation Part-I		12	
II. Elective courses			
Elective I		3	15
Elective II	05	3	
Elective III		3	
Elective IV		3	
Elective V		3	
III. Open Elective courses			
Open Elective I	01	3	
Open Elective II		3	6
Total credits			**71**

6. SEMESTER-WISE SCHEDULE

SEMESTER I

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact	Credits
Core	FT 511: Research Methodology	2	0	1	4	3
	FT 512: Transport Phenomena in Food Processing	3	0	1	5	4
	FT 513: Engineering Properties of Biological materials	2	0	1	4	3
Elective	Elective-I	3	0	0	3	3
	Elective-II	3	0	0	3	3
	Elective-III	3	0	0	3	3
	Open Elective I	3	0	0	3	3

SEMESTER II

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	FT 516: Emerging Food Processing Technologies	3	0	0	3	3
	FT 517: Food Equipment and Plant Design	3	0	0	3	3
	FT 518: Recent Trends in Food Product Development and Packaging	2	0	1	4	3
	FT 519: Food Process Modelling and Simulation	2	0	1	4	3
	FT 571: Seminar	0	0	1	2	1
Elective	Elective-IV	3	0	0	3	3
	Elective-V	3	0	0	3	3
	Open Elective-II	3	0	0	3	3

SEMESTER III

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact	Credits
Core	FT 681: Project Work & Dissertation part-I	0	0	12	24	12

SEMESTER IV

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact	Credits
Core	FT 682: Project Work & Dissertation part-II	0	0	12	24	12

List of Elective courses:

FT 541: Recent Trends in Plant Products Technology

FT 542: Recent Trends in Animal Products Technology

FT 543: Recent Trend in Baking and Confectionary

FT 544: Extrusion Technology

FT 545: Traditional Indian Food; Case Studies

FT 546: Powder Technology

FT 547: Recent Trends in Biochemical Engineering

FT 548: Nano Technology in Food Applications

FT 549: Recent Trends in Fermentation Technology

FT 550: Recent Trend in Enzyme technology

FT 551: Valorization of Food Byproduct

FT 552: Recent Trend in Drying and Dehydration

FT 553: Food Microstructure and Texture

FT 554: Novel Separation Process

FT 555: Food Supply Chain Management Case Study

FT 556: Chemistry of Food Processes

7. Mapping of course with program outcomes (POs)

Course title	PO1	PO2	PO3	PO4	PO5
FT 511: Research Methodology	x	-	x	-	-
FT 512: Transport Phenomena in Food Processing	x	x	-	x	-
FT 513: Engineering Properties of Biological Materials	x	x	-	-	-
FT516: Emerging Food Processing Technologies	x		x	x	-
FT 517: Food Equipment and Plant Design	x	x	x	x	x
FT 518: Recent trends in Food Product Development and Packaging	x	x	-	x	x
FT 519: Food Process Modelling and Simulation	x	x	x	x	-
FT571: Seminar	-	-	x	-	-
FT 681: Project Work & Dissertation Part-I	x	x	x	x	x
FT 682: Project Work & Dissertation Part-II	x	x	x	x	x
Elective Courses					
FT 541: Recent Trends in Plant Products Technology	x	-	-	x	-
FT 542: Recent Trends in Animal Products Technology	x	-	-	x	-
FT 543: Recent Trend in Baking and Confectionary	x	-	-	x	-
FT 544: Extrusion Technology	x	-	-	x	-
FT 545: Traditional Indian Food; Case Studies	x	-	-	x	-
FT 546: Powder Technology	x	-	x	x	-
FT 547: Recent trends in Biochemical engineering	x	-	x	x	-
FT 548: Nano Technology in Food Applications	x	-	x	-	-
FT 549: Recent Trends in Fermentation Technology	x	-	x	x	-
FT 550: Recent trend in Enzyme technology	x	-	x	-	-
FT 551: Valorization of food byproduct	x	-	x	-	-
FT 552: Recent Trend in Drying and Dehydration	x	-	x	-	-
FT 553: Food Microstructure and Texture	x	-	x	-	-
FT 554: Novel Separation Process	x	-	x	-	-
FT 555: Food Supply Chain Management Case Study	x	x	-	x	x
FT 556: Chemistry of Food Processes	x	-	x	x	-

8. Evaluation Plan

The performance of students is evaluated using a continuous evaluation approach in accordance with Tezpur University's Annexure 41 and 42 guidelines. Evaluation plan for M.Tech Food Engineering and Technology is given in Table below

	Test-I * (Written)		**Test-II (Mid Term) (Written)**		**Test-III** Written type (including objective type), assignment, Quiz, Seminar, Field visit etc		**Test-IV (End Term) (Written)**	
	Marks	**Duration**	**Marks**	**Duration**	**Marks**	**Duration**	**Marks**	**Duration**
Credit ≤ 2	20	30 min	30	60 min	20	30 min	50	2 hrs
Credit ≥ 3	25	45 min	40	75 min	25	45 min	60	2 hrs
Time in the semester	Within Fifth Week		Within 10th week		Within 14th week		10 working days	
Spring	Within 3rd week of February		Within 3rd week of March		Within 3rd week of April		From 16th May	
Autumn	Within 1st week of September		Within 1st week of October		Within 1st week of November		From1st December	

8.1 Practical :For practical courses [say (0-0-1),(0-0-2)-etc.], the continuous evaluation on practical is as follows:

(a) P_Test-I (to be completed before Test-II of theory): Viva, total experiments performed by the student and report submission; **Marks-20**

(b) P_Test-II(to be completed before Test-IV of theory) : Practical examination, viva on the syllabus covered from beginning, Report etc.; **Marks-30**

(c) For practical courses [say **3-0-1),(2-1-1)** etc.]:There will be only one End term examination (Practical examination, viva,report etc.): **Marks-50**

A course instructor may add more components in the evaluation systems if desired.

8.2 Course coverage of theory syllabus shall be as follows:

i) Test I : From beginning till Test-I

ii) Test II (Mid Term) : From beginning till Test-II

iii) Test-III : From Test-II till Test-III

iv) Test IV (End Term) : From Test-II till Test IV and the course instructor may include some units of the syllabus covered under Test-I and Test-II

8.3. Test II and Test-IV will be conducted centrally as per existing TU guidelines. The course instructors shall submit the question papers of the Mid-term test to the Head of the FET Department and those of the End term test to the Dean of the School of Engineering at least one week before the test.

8.4. A course instructor will submit the lesson plan to the DAC prior to the beginning of the session / commencement of classes and the DAC will approve it with any modification, if necessary.

8.5. Tests other than No. II (Mid- Term) and No. IV (End- Term) will be conducted by the course instructor with the help from the research scholars of the department. Test II (Mid- Term) and Test IV (End- Term) will be conducted centrally under the Chairmanship of the Dean of School of Engineering.

8.6. The DAC of the FET department shall work out the detailed schedule of tests prior to the beginning of the semester and the schedule shall be required to be reflected in the lesson plans. The schedule of Test II (Mid-Term) will be announced by the office of the Dean, School of Engineering. The schedule of exams for Test IV (End- Term) will be announced by the office of Controller of Examinations.

8.7 Within 2 days of expiry of the “”Last Date” of each test, Head of the FET department shall send a compliance report on the conduct of tests to the Controller of Examinations by email.

8.8 There will not be any class on the days of Test II (Mid- Term).

8.9. The Monitoring Mechanism

a) The DAC shall approve the Lesson Plan along with the Evaluation Plan submitted by the course instructor at the beginning of the semester. The DAC shall ensure conformity to the Evaluation Plan stated above. Further, the Head of the FET Department shall ensure the display of marks of each test within a week after the completion of each test by the course instructors. The records of marks will be made available to the University when required.

b) In case any deviation is noticed, the HoD shall instruct the concerned instructor in writing to submit the same within 24 hours with a copy endorsed to the Dean of the School of Engineering. The Dean in turn shall forward to the Controller of Examinations in case such violations are observed.

c) The Dean of the School of engineering shall also monitor the progress of the continuous evaluation in regular intervals after every four weeks from the date of commencement of classes.

d) The Chairperson of the DAC shall take necessary steps for moderation of the question papers of the Major I and Major II from by involving the faculty.

8.10. Absence of students in examinations:

a) If a student opts to forgo the Major II (End Term), his/her final evaluation shall be as per his/her performance in the earlier evaluation components, provided such student takes at least three earlier **tests** including the Mid-term test. In such a case the total mark shall remain as decided earlier and the concerned student shall be awarded '0' mark for the Term End and his/her grades shall be awarded accordingly.

b) The student who might not be able to appear in the Term End due to any of the reasons as stated in clause 3.08 of the Regulations on Academic Matters, he/she shall be awarded an 'I' grade and he/she shall be treated as per the existing provisions of the regulations.

c) If a student misses out any other components of the examinations due to genuine reasons stated in clause 3.08 of the Regulations on Academic Matters the DAC may make necessary arrangements to make-up such losses by allowing him/her to take not more than two extra tests for the whole semester. Such student shall be required to submit documentary evidence and necessary clearance from the DAC for obtaining permission to take the examinations.

9. DETAILED SYLLABUS

FT 511: Research Methodology

L 2 T0 P1 CR3

Course outcomes:

CO1: Ability to design a research problem by applying appropriate experimental design.
CO2: Ability to statistically analyze the collected data.
CO3: Ability to explain the ethics in research and plagiarism.
CO4: Ability to write research papers, reports and research proposals.

Course content:

Testing of hypothesis: Introduction - Large sample tests based on normal distribution - Test for single mean, difference between means - proportion, difference between proportion - standard deviation, difference between standard deviation -Chi-square test for goodness of fit - Independence of attributes.

Analysis of variance: Small sample tests based on t and F distribution-Test for, single mean, difference between means, Paired t-test, test for equality of variances. ANOVA one -way classification, Two-way classification

Design of Experiments: Objectives, strategies, Experimental design, Factorial design, Central composite design, Fractional factorial design, Taguchi's approach to design ofexperiments.

Model development: Empirical model development, Validity of predicted equation, Graphic analysis, Adjusted coefficient of determination, F test for lack of fit.

Statistical quality control: Introduction-Process control-control charts for variables-X and R, X and s charts control charts for attributes: p chart, np chart, c chart

Research: Types, Research process and steps in it, Hypothesis, Research proposals and aspects; Research Design: Need, Problem Definition, variables, research design concepts, Literature survey and review, Research design process, Errors in research; Research Modeling : Types of Models, Model building and stages, Data consideration and testing, Heuristic and Simulation modeling. Report Writing: Pre writing considerations, Thesis writing, Formats of report writing, Formats of publications in Research journals. Ethical issues, ethical committees Commercialization, Copy right, royalty, Intellectual property rights and patent law, Trade Related aspects of Intellectual Property Rights, Reproduction of published material, Plagiarism, Citation and acknowledgement, Reproducibility and accountability.

Textbooks:

- Montgomery, D. C. *Design and Analysis of Experiments*, Wiley India, 2007.
- Montgomery, D.C. and Runger, G.C. *Applied Statistics & Probability for Engineers*, Wiley India, 2007.

Suggested readings:

- Kothari, C.K. Research Methodology Methods and Techniques, New Age International, 2004.
- Gupta S.C. & Kapoor V.K., "*Fundamentals of Mathematical Statistics"*, Sultan Chand and Sons, New Delhi, 11th edition, 2007.
- Ewans W. & Grant G., "*Statistical Methods in Bio informatics – An Introduction"*, Springer, 2nd edition, 2005.

FT512: Transport Phenomena in Food Processing

L 3 T0 P1 CR4

Course outcomes:

CO1: Ability to identify the transport processes in food processing and their mechanism.
CO2: Ability to calculate heat transfer, mass transfer, momentum analysis for food processing unit operations.
CO3: Ability to formulate and solve the problems related to transport processes and apply in food engineering.

Course content:

Transport processes and flux equations: Overall mass balance, energy balance, special mass balance, momentum balance, diffusive and convective transport, equations for fluxes, equation of continuity and equation of motion.

Momentum Transport: Viscosity and the mechanisms of momentum transport, shell momentum balances and velocity distributions in laminar flow for Newtonian and non Newtonian fluids, velocity distributions with more than one independent variable. Fluid flow through porous beds, permeability and Darcy's law, Kozeny- Karman equation, fluidization.

Diffusive heat transfer and mass transfer: Diffusive heat/mass transfer in steady/unsteady and one/multiple dimensions, mass transfer with chemical reaction, moving boundary problems, simultaneous heat and mass transfer, analytical solutions to problems of diffusive transport viz. heating, drying, freezing.

Convective heat transfer and mass transfer: Flow inside ducts, dispersion, laminar boundary layers, mass transfer with chemical reactions, simultaneous momentum, heat and mass Transfer, natural convection.

Multicomponent transport: Binary systems, multi-component flux equations, mass transport in food processing operations such as osmotic dehydration, dimensional analysis.

Analytical and Approximate Methods in Transport Phenomena: Governing equations and boundary conditions in Transport processes, application of methods of (i) separation of variable (ii) variation of parameters and (iii) Laplace transform to solve transport problems in food processing.

Textbooks:

- Geankoplis, C. J. *Transport processes and separation process principles*, Prentice Hall of India, New Delhi, 2003.
- Datta, A. K. *Transport Phenomena in Food Processing Engineering*, Himalaya Publishing House, 2001.

Suggested readings:

- Rao, M. A., Rizvi, S. S. H. and Datta A.K. *Engineering Properties of Foods*, CRC Press, 2005.

FT 513: Engineering Properties of Biological materials

L 2 T0 P1 CR3

Course outcomes:

CO1: Ability to describe the basic properties of food materials.
CO2: Ability to correlate the engineering properties of food and biological material to process design and quality control during processing.
CO3: Ability to identify and predict the physical changes in food during processing and storage.
CO4: Ability to apply the knowledge of food engineering properties on process design, food processing machine design on the pilot and industrial scale.

Course content:

Physical characteristics of different seeds and grain and other food products-shape and size-description of shape and size - volume and density, porosity, surface area. Particle Size Distribution.

Rheological Properties of Foods: Introduction to Rheology; Flow of Material; Newton's Law of Viscosity; Viscous; Newtonian Fluids; Non- Newtonian Fluids; ideal and non-ideal Plastic Fluids;ideal and non- ideal viscous Fluids; ideal and non-ideal solids. Measurement of rheological properties: different Viscosity Measurement & viscometers; Vibrational (Oscillation) Viscometer; Bostwick Consistometer. Deformation of Materia, Viscoelastic

Behavior; Extensional Flow. Mechanical Models. Texture of Foods Dough Testing Instruments

Contact stresses between bodies: Hertz problems-firmness and hardness-mechanical damage-impact damage and dead load damage-vibration damage-friction-effect to load, sliding velocity, temperature, water film and surface roughness-friction in agricultural materials-rolling resistance-angle of internal friction, angle of repose

Flow of bulk granular materials - aero dynamics of agricultural materials and food products - drag coefficients - terminal velocity.

Thermal properties: specific heat-thermal conductivity thermal diffusivity-methods of determination-steady state and transient heat flow. Electromagnetic Properties: Color & Color Order Systems; Dielectric Properties of Foods; method of determination - energy absorption from high-frequency electric field. Water Activity and Sorption Properties of Foods. Surface Properties of foods.

Textbooks:

- M.A. Rao, Syed S.H. Rizvi, Ashim K. Datta, Jasim Ahmed , *Engineering Properties of Foods*, CRC Press 4th Ed 2014
- Sahin S. and Sumnu, S. G., *Physical Properties of Foods by Springer*, NewYork, 2010

Suggested readings:

- Ignacio Arana, *Physical Properties of Foods: Novel Measurement Techniques and Applications*, CRC Press, 2012
- M J Lewis Woodhead, *Physical Properties of Foods and Food Processing Systems*, Publishing Limited, 2010
- Ludger Figura, Arthur A. Teixeira, *Food Physics: Physical Properties - Measurement and Applications*, Springer2007

FT 516: Emerging Food Processing Technologies

L 3 T 0 P0 CR3

Course outcomes:

CO1: Ability to explain various novel and emerging technologies that can be applied to food processing for quality improvement of the processed foods.
CO2: Ability to explain the advantages and limitations of the emerging food processing technologies and methods to overcome the limitations.
CO2: Ability to develop ideas for research and development using the emerging food processing technologies.

Course content:

High Pressure Processing: Principles of high pressure processing, use of high pressure to improve food safety and stability. Effects of high pressure on food quality: Pressure effects on microorganisms, enzyme, texture and nutrients of food. Modelling HP processes. Other applications of high pressure processing.

Pulsed electric fields processing: Historical background, PEF treatment systems, main processing parameters. Mechanisms of action: mechanisms of microbial and enzyme inactivation. PEF for processing of liquid foods and beverages, PEF Processing for solid foods. Food safety aspects of pulsed electric fields. Pulsed electric field and high pressure processing.

Osmotic dehydration: mechanism of osmotic dehydration, effect of process parameters on mass transfer, determination of moisture and solid diffusion coefficient, application of osmotic dehydration.

Athermal membrane concentration of liquid foods and colours: osmotic membrane distillation, direct osmosis, membrane modules, Applications of membrane concentration.

Processing by radio frequency electric fields: radio frequency electric fields equipments, RFEF non-thermal inactivation of yeasts, bacteria and spores, electrical costs.

Ultrasound processing: fundamentals of ultrasound, ultrasound as a food preservation and processing aid, effects of ultrasound on food properties.

Alternate thermal processing: Microwave heating: dielectric properties of foods, heat and mass transfer in microwave processing, application of microwave processing for foods;

Radiofrequency processing: dielectric heating, material properties, radio-frequency heating and drying applications; Ohmic heating: Fundamentals of ohmic heating, electrical conductivity, modeling, treatment of products.

Hybrid drying technologies: combined microwave vacuum drying, combining microwave vacuum drying with other processes, equipment for microwave vacuum drying, product quality degradation during dehydration.

Textbooks:

- Sun, D. *Emerging Technologies for Food Processing*, Academic Press, 2005.
- Barbosa-Canovas, G. V., Tapia, M.S. and Cano, M.P. *Novel Food Processing Technologies*, CRC Press, 2004.

Suggested readings:

- Ohlsson, T. and Bengtsson, N. *Minimal Processing technologies in the food industry*, Woodhead Publishing Limited, 2002.

FT 517: Food Equipment and Plant Design

L 3 T0 P0 CR3

Course Outcomes:

CO1: Ability to determine prerequisites for site selection, plant layout, and design consideration for food processing plant.
CO2: Ability to recognize the unit operations and selection of equipment's required for food processing operations.
CO3: Ability to demonstrate skills for determining equipment design and fabrication methods and testing procedures.

Course content:

Design and selection of food processing equipment, heat transfer equipment, food evaporation equipment, refrigeration and freezing equipment, thermal process equipment, mass transfer equipment, equipment for novel processing.

Introduction to plant design-special features of food processing industry-plant location–location factors-site selection-location theory and models-layout-objectives-classical and practical layout–preparation of layout- fruit juice processing plant, reduction unit, evaporation plant, drying plant, bake ovens and frying plant, thermal processing plant, refrigeration and air conditioning plant, packaging plant–ancillary equipment's - building materials–water supply and drainage-illumination–ventilation-estimation of services-peak and critical load –electrical installations –installation, operation and maintenance for food processing industry.

Textbooks:

- Ahmad, T. *Dairy Plant Engineering and Management*, Kitab Mahal, 2009.
- George D. Saravacos, Athanasios E. Kostaropoulos. *Handbook of Food Processing Equipment*, Springer.

Suggested readings:

- Biegler,L., Grossmann,I.E. and Westeberg, A.W. *Systematic Methods of Chemical Engineering and Process Designs*, Prentice Hall of India, 1997.
- Turton, R., Bailie, R.C. and Whiting, W.B. Analysis, *Synthesis and Design of Chemical Processes*, Prentice Hall of India, 2008.

FT518: Recent Trends in Food Product Development and Packaging

L 2 T0 P1 CR3

Course Outcomes:

CO1: Ability to generate new ideas and develop innovative food product.
CO2: Ability to evaluate the acceptability of develop product through consumer feedback.

CO3: Ability to apply effective active and intelligent packaging system for quality improvement of food products.
CO4: Ability to implement novel modified atmosphere packaging system for fresh-prepared produce.

Course content:

Innovation product development: Concept, generation of ideas. Desk Research. Screening/appraisal of initial ideas. Detailed study of product, process and market, Planning and developmental activities and evaluating them. Development of prototype product and its testing for acceptance. Development of process and planning for production trials. Planning the test market. Evaluation of test results. Launching of the product. Advertising and marketing plans. Introduction to Consumer Survey, market Survey. Detailed feasibility analysis.

Novel Food Packaging: Active and intelligent packaging: An introduction; Oxygen, ethylene and other scavengers; Antimicrobial food packaging; Non-migratory bioactive polymers (NMBP) in food packaging; Time-temperature indicators (TTIs); The use of freshness indicators in packaging; Packaging-flavour interactions; Moisture regulation.

Developments in modified atmosphere packaging (MAP): Novel MAP applications for fresh-prepared produce; MAP, product safety and nutritional quality; Reducing pathogen risks in MAP-prepared produce; Detecting leaks in modified atmosphere packaging.

Optimizing packaging; Legislative issues relating to active and intelligent packaging; Recycling packaging materials; Green plastics for food packaging; Integrating intelligent packaging, storage and distribution; Testing consumer responses to new packaging concepts.

Textbooks:

- Ahvenainen, R. *Novel food packaging techniques*, Elsevier, 2003.
- Hu,R. *Food Product Design A Computer-Aided Statistical Approach*, Technomic Publishers, 2005.

Suggested readings:

- Moskowitz, H.R., Saguy,S. and Straus,T. *An Integrated Approach to New Food Product Development*, CRC Press, 2006.

FT519: Food Process Modelling and Simulation

L 2 T0 P1 CR3

Course outcomes:

- CO1: Ability to identify the design, operating and performance parameters in food processing operations.
- CO2: Ability to develop mechanistic process models for unit operations in food processing.
- CO3: Ability to use up-to-date approach of computation for solving model equation.
- CO4: Ability to solve and validate the model equations and analyze for sensitivity.
- CO5: Ability to develop and validate phenomenological models for food processing operations.

Course content:

Introduction to Process Modeling: Balance equations and rate equations, mathematical models, empirical models and linear regression, systematic modelling approach, general property balance models in food processing, analytical solutions to ordinary differential equations, Laplace transformations and numerical methods in mathematical modeling.

Transport Phenomena Models: Equation of continuity, equation of energy, equation of motion, ODE models in food processing, transport phenomena models involving PDE, chart solutions to unsteady state transport problem, interfacial mass transfer, and rheological modeling.

Kinetic Modeling : Kinetics and food processing, the rate expression, temperature effects on the reaction rates, enzyme catalyzed reaction kinetics, metabolic process engineering, microbial kinetics, kinetics of microbial death, model of ideal reactors, modeling batch and continuous thermal processing operations of foods.

Mathematical Modeling in Food Engineering Operations: Moving boundary and other transport phenomena models for processes involving phase change, unit operation models: drying, baking, frying, evaporation, distillation, extraction, crystallization.

Model Solution and Simulation tools: MATLAB/SCILAB/SIMULINK as tools for solving mathematical models and for simulation. Solution strategies for lumped parameter models and distributed parameter models. Simulation of food manufacturing processes.

Text Books:

- Hangos, K. M. and Cameron, I. T. *Process Modelling and Model Analysis*, Academic Press, 2001.
- Ozilgen, M. *Food process modelling and control: chemical engineering applications*, Gordon and Breach Science Publishers, 1998.

Suggested readings:

- Ozilgen, M. *Hand book of food process modelling and statistical quality control: with extensive MATLAB applications*, CRC Press, 2011.
- Das, H. *Food processing operations analysis*. Asian books private limited, 2005.
- Tijskens, L.M., Hertog, M.L., Nicolaï, B.M., *Food process modelling*, Woodhead Publishing, 2001.

FT 571 Seminar

Elective -I

FT 541: Recent Trends in Plant Products Technology

L 2 T0 P1 CR3

Course outcomes:

CO1: Ability to develop cost effective fortification techniques for plant-based food products.
CO2: Ability to utilize novel techniques for plant based new product development.
CO3: Ability to utilize novel techniques for the preservation and value addition of plant-based product.
CO4: Ability to explain the physicochemical and engineering properties of plant-based products.
CO5: Ability to apply skills to demonstrate in plant-based industries or in research and development sector.

Course content:

Introduction to foods of plant origin: Fruits and nuts; cereal grains; legumes; Foods from leaves, stem and roots; spices and herbs; Beverages: both alcoholic and non-alcoholic; vegetable oils and fats; gums, gels and resins. Their processing and preservation.

Improvement of quality of crops and plant foods: Organic farming; fortification of foods of plant origin, their nutritional value and economic aspects.

Application of novel techniques of food processing to plant foods: Application of pulsed electric field assisted extraction of juice from food plants, application of PEF to orange juice products; Use of high pressure to processing and preservation of plant foods; use of ultra-violet light, ultra sound, microwave an ohmic-heating technology for processing of plant foods; extraction of essential oils by super-critical fluid extraction; application of non-thermal techniques for plant food processing.

Innovation in plant products: Role of modification of ingredients in improving the quality of spices, fruits and vegetable based products, gum, gels, resin etc. Engineering properties of

raw and semi- finished products for product development. Equipment recently used for production of plant products.

Application of biotechnology to foods of plant origin: Transgenic plants; biotechnology for the improvement of nutritional quality of foods from plants; genetic modification of plant seed storage protein for food production; chemistry, biosynthesis and engineering of starches and other carbohydrates for food application; chemistry and engineering of vegetable oils and fats; plant cell and tissue culture for production of food ingredients; Plant pigments, their characteristics, biosynthesis is and gene regulation and application as food additives; Regulation and risk of genetically modified foods and transgenic plants.

Textbooks:

- D. K. Salunkhe and S. S. Deshpande, *Foods of Plant Origin: Production, Technology, and Human Nutrition*, Van Nostrand Reinhold, 1991.
- Anthony Uyekpen Osagie, Offiong Udo Eka and Victor Ogieva Igodan, *Nutritional Quality of Plant Foods*, Post-Harvest Research Unit, Dept. of Biochemistry, University of Benin, 1998.

Suggested readings:

- Octavio Paredes-Lopez, *Molecular Biotechnology for Plant Food Production*, CRC Press, 1999

FT 542: Recent Trends in Animal Products Technology

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to apply advance methods for processing and preservation of meat, poultry and fish.
CO2: Ability to analyze the quality of fresh and package food through use of novel methods.
CO3: Ability to examine the utilization process of waste and by product of meat, poultry and fish for value addition through advance processing methods.
CO4: Ability to implement new technologies for milk processing and increasing shelf life of dairy products.

Course content:

Meat: Automation for the modern slaughter house, hot-boning of meat, new spectroscopic techniques for online monitoring of meat quality, real-time PCR for the detection of pathogens in meat, new developments in decontaminating raw meat, automated meat processing, developments in chilling and freezing of meat, high pressure processing of meat, approaches for the development of functional meat products, new techniques for analyzing

raw meat, modified atmosphere packaging, perspectives for the active packaging of meat products

Poultry : Breeding and quality of poultry, stunning and slaughter of poultry, processing and packaging of poultry, new techniques of preservation of poultry, production of turkeys, geese, ducks and game birds, microbial hazards in poultry production and processing, latest trends in measuring quality of poultry and poultry products, treatment and disposal of poultry processing waste.

Fish and sea food: Fresh fish handling and chill storage, modified atmospheric packaging of sea foods, fish odours and flavours, assessment of freshness of fish and sea foods, traditional dried and salted fish products, proteolysed fish products, minced fish technology, retort pouch processing technology, irradiation and microwave in fish handling and processing, advanced freezing technology for fish storage, high pressure processing of sea foods, value addition of fresh water and aquaculture fish products, application of enzymes in fish processing and quality control, toxins, pollutants and contaminants in fish and sea foods.

Milk: Physical, chemical and nutritional properties of milk components, improvements in the pasteurization and sterilization of milk. Flavour generation in dairy products, controlling texture of fermented dairy products, functional dairy products, on-line measurement of product quality in dairy processing, high pressure processing of milk products, novels separation technologies to produce dairy ingredients, new technologies to increase shelf- life of dairy products, genetic engineering of milk proteins, production and utilization of functional milk proteins, methods of improving nutritional quality of milk, significance of milk fat in dairy products, chromatographic, spectrometric, ultrasound and other techniques for analysis of milk lipids.

Textbooks:

- Leo M. L. Nollet, Fidel Toldnl, *Advanced Technologies for Meat Processing*, CRC Press, 2006.
- D. P. Sen, *Advances in fish processing Technology*, Allied Publishers

Suggested readings:

- R.K.Robinson, Modern dairy technology. Advances in milk processing, Vol.I, Elsevier
- R. K. Robinson *Modern dairy technology. Vol.2, Advances in milk products*, Elsevier.
- G.C. Mead, *Poultry Meat Processing and Quality*, Net Library, Inc, Woodhead Publishing, 2004.
- Vazhiyil Venugopal, *Seafood Processing: Adding Value Through Quick Freezing, Retortable Packaging, and Cookchilling*, CRC Press, 2006.

FT 543: Recent Trend in Baking and Confectionary

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to apply new ingredients in bakery products for functional properties.
CO2: Ability to identify the new equipment used in bakery and confectionery.
CO3: Ability to identify the new technologies for confectionery products.
CO4: Ability to describe the quality of bakery and confectionery products using modified ingredients.

Course content:

Current status, growth rate, and economic importance of Bakery and Confectionary Industry in India. Product types, nutritional and safety of products.

Bakery Products: Role of modification of ingredients for improving the quality of breads, biscuits, cookies & crackers, cakes & pastries; doughnuts; rusks; other baked products. Engineering properties of batter and dough for the preparation of bakery products; equipment recently used in bakery industries; product quality characteristics, faults and corrective measures for above bakery products. Product technology of innovative bakery products.

Confectionary Products: Role of modification of ingredients for improving the quality of hard-boiled candies, toffees, fruit drops, chocolates and other confections; Engineering properties of cocoa butter, cocoa liquor etc. equipment recently used in confectionery industries; processes, product quality parameters, faults and corrective measures. Product technology of innovative confectionery products

Textbooks:

- Matz, S. A. *Bakery Technology and Engineering*, CBS Publications, 2003.
- Minifie, B. W. *Chocolate, Cocoa and Confectionery*, CBS Publications, 1997.

Suggested readings:

- Stanley P. Cauvain and Linda S. Young, Technology of Bread Making, second edition, Springer publication.
- Stanley P. Cauvain and Linda S, Bakery Food Manufacture and quality, Blackwell Science Publisher.

FT 544: Extrusion Technology

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to identify the extrusion process mechanisms and effect on nutritional quality
CO2: Ability to select appropriate extruder for the specific food product
CO3: Ability to solve the process related problem during extrusion.
CO4: Ability to develop new food product with various ingredients.

Course content:

Equipment: Single Screw Extruders- constructional and operational characteristics; Twin Screw Extruders- constructional and operational characteristics of co-rotating twin screw extruder; and Ancillary Equipment, Operating characteristics of extruders; Model and strategies for computer control of a twin screw extruder.

Characteristics of various extruded food products: Rheological properties, textural properties. Sensory characteristics and nutritional value;

Application: Cold extrusion; extrusion cooking, New extrusion technology for confectionery product; Breakfast cereal products.

Design Aspect of extruder: Extruder components, extrusion models, extrusion measurement and experimentation

Textbooks:

- R Guy, *Extrusion Cooking: Technologies and Applications*, Woodhead Publishing.
- Frame, N.D., *The Technology of Extrusion Cooking*, Springer.

Suggested readings:

- Leszek Moscicki, *Extrusion-Cooking Techniques: Applications, Theory and Sustainability*, Wiley.

FT 545: Traditional Indian Food; Case Studies

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to classify the various types of traditional food product of India
CO2: Ability to explain the invention and processing aspect related to food product.
CO3: Ability to support the entrepreneur of traditional Indian food.

Course content:

Introduction to traditional foods of India, composition and nutritive values, microbial and biochemical diversity, quality and food safety challenges.

Processing & Preservation methods of Sweets & Desserts: Kulfi, Falooda, Kheer, khurchan, khoa/mawa, Rabri, jalebi, imarti, Gulabjamun, Peda, petha, rewdi, gajak, milk cake, balushahi, balmithai, singoni, Ras-malayi, Gulqand, ghevar, rasgolla, chamcham, sonhalwa, sonpapri, several varieties of halwa, laddu, barfi & rasgolla.

Traditional fermented foods: Idli, dosa, Vada, khamman dhokla, Dahi (Curd), Srikhand.

Processing & Preservation methods of Snacks: Gujiya, kachauri, samosa, mirchibada, kofta, potato chips, banana-chips, mathri, bhujiya, fried dhals, bhujia, shakarpara, pakora, vada.

Processing & Preservation methods of Baked Products: Biscuits, Toast, Candies, Cookies, Breads, Roti, Naan, Tandoori Roti, parantha, kulcha, puri, bhatura.

Processing & Preservation methods of Preserves & Beverages: Murabba, sharbat, pana, aampapad, sharbat, coconut water, tea, milk (khas, rose), Alcoholic Beverages

Industrialization, Socioeconomic Conditions and Sustainability of Traditional Foods.

Textbooks:

- K.H. Steinkrus, *Handbook of Indigenous Fermented Foods*. *2nd Edition*, Marcel Dekkar Inc. 1998.
- Sukumar De, *Outlines of Dairy Technology*, *1st Edition*, Oxford University Press, (PB), 2009.

Suggested readings:

- P. Wickramasinghe, and C. Selva Rajah, *The Food of India 1st Edition*, Oberoi Group, Periplus, 2001.
- Aneja, B.N. Mathur, R.C. Chandan, and A.K. Banerjee, *Technology of Indian Milk Products.* R.P. Dairy India Year Book, 2009.
- Rakesh Mangal, *Fundamentals of Indian Cooking 2nd Edition*, Subling Publication, 2003.

Elective -II

FT 546: Powder Technology

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to interpret the microstructure of the different powders.
CO2: Ability to develop different food powders of having high storage stability, using advance techniques.
CO3: Ability to determine the storage behavior of the food powders in different storage environment.
CO4: Ability to evaluate the different flow patterns, mass flow in storage vessel.

Course content:

Introduction to food powders*:* Crystalline and amorphous microstructure of powders, cohesive forces in powders, adhesive forces and surface energies, stickiness of powders during the or formation and handling, surface structure of powders, fluidity of powders, compressibility of powders, mixing property of powders, segregation of powder particles, dust formation and explosion risk, hydration property of powders

Powder production*:* spray drying, freeze drying, roller and drum drying, grinding of food powder production.

Agglomeration/granulation in food powder production: powder characteristics, physicochemical reactivity of food powders, agglomeration processes and mechanisms, wet controlled growth agglomeration technologies, wet agglomeration mechanisms and powder reactivity.

Fluidization in food powder production: principles of fluidization, techniques and equipment, applications of fluidization in the production of food powders, limitations, future trends.

Handling of food powders: flow patterns and storage design: basic flow patterns in storage vessels, storage vessel design, mass-flow operation, the Jenike silo design method, the flow-no flow criterion, silo design worked example.

Risk of dust explosion: dust explosion hazards, laboratory testing to assess explosion characteristics of dust clouds, safety from dust cloud explosion hazards, specific unit operations.

Powder properties in food production systems: sampling, moisture content and chemical composition, particle properties, bulk properties of powders.

Techniques to analyze particle size of food powders: collection of data, presentation of data, powder sampling and techniques for particle size analysis, particle size analysis by direct methods, classification methods and secondary methods, in-line measurements

Surface composition of food powders: microscopy and spectroscopy techniques for analysing the surface of food powder, factors affecting food powder surface composition, impact of powder surface composition on powder functionality.

Food powder rehydration: principles of powder rehydration-wettability and sinkability, dispersibility, solubility, improvement of rehydration properties.

Shelf- life of food powders: water absorption and desorption of food powders, crystallization of amorphous powder, oxidative changes, effect of Maillard reaction, survival of dried probiotic bacteria.

Textbooks:

- Bhandari BS, Bansal N, Zang M, Schuck P., *Handbook of food powders-process and properties*, Woodhead publishing ,2013
- Yasuo Araim, *Chemistry of powder production,* Chapman & Hall Publishing, Tokyo, 1996.

Suggested readings:

- Rhodes, M. J. *Principles of powder technology*, 1990.
- Masuda, H., Higashitani, K., & Yoshida, H. *Powder technology: fundamentals of particles, powder beds, and particle generation.* CRC Press, 2006.

FT 547: Recent trends in Biochemical Engineering

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to analyze the developments in enzyme engineering, genetic engineering etc., for industrial application.
CO2: Ability to explain the new fermentation processes and developments in the types of fermenters and bioreactors.
CO3: Ability to develop new methods for immobilization of enzymes.
CO4: Ability to apply the knowledge of computer application for operation and quality control of biochemical processes.

Course content:

Advances in enzyme engineering; Recent advances in sterilization practice; Novel sources of carbon, nitrogen and other nutrients. Application of computers in biochemical engineering; Modelling and Simulation in Biochemical Engineering,; Advances in genetic engineering;

Production of secondary metabolites; Advances in continuous fermentation; Advances in enzyme immobilization; Advances in downstream processing

Textbooks:

- Ghose, T. K., Fiechter, A., & Blakebrough, N. *Advances in biochemical engineering*, v. 1-9. Springer-Verlag (1978).
- Dwevedi, A. *Enzyme Immobilization: Advances in Industry, Agriculture, Medicine, and the Environment*. Springer, 2016.

Suggested readings:

- Najafpour, G. *Biochemical engineering and biotechnology*. Elsevier, 2015.
- Gupta,V.K., Schmoll, M., Maki,M., Tuohy, M., & Mazutti, M.A. *Applications of microbial engineering*, CRC Press, 2013.
- Svendsen, A., *Enzyme Functionality: Design: Engineering, and Screening*, CRC Press, 2003.
- Yoo,Y.J., Feng,Y., Kim, Y.H., & Yagonia, C. .Fundamentals of Enzyme Engineering, Springer, 2017
- Bailey,J.E.,& Ollis,D.F. *Biochemical engineering fundamentals.* Chemical Engineering Education, 1976.
- John Villadsen, Sang Yup Lee, Jens Nielsen, Gregory Stephanopoulos, *Fundamental Bioengineering*, John Wiley & Sons, 2016.

FT 548: Nano Technology in Food Applications

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to understand the physical chemical and optical properties of nanomaterials and their safety aspects.
CO2: Ability to interpret application the new functional nanomaterial, nano-emulsions or nano-capsules in food technology.
CO3: Ability to apply new technology for the determination of adulteration or spoilage in food using nanomaterials.

Course content:

Nano materials: method of synthesis of nanomaterials for food application; Characterization techniques of synthesized nanomaterials; physical chemical and optical properties of nanomaterials; safety and efficacy of nanomaterials in food products; regulatory issues of nanomaterials in food product.

Application of nanotechnology to food products: application of nanomaterial, nano-encapsulation, nano-emulsion to food and nutrients; micro and nanotechnologies for process control and quality assessment, application of nanotechnology in detection of adulteration in food; application in food packaging; to judge the spoilage of food products.

Textbooks:

- Grumezescu, A. *Novel Approaches of Nanotechnology in Food (Vol.1).* Academic Press, 2016.
- Hernández-Sánchez, H., & Gutiérrez-López, G. F. *Food Nanoscience and Nanotechnology*. Springer, 2015.

Suggested readings:

- Chaudhry, Q., Castle, L., & Watkins, R. *Nanotechnologies in food* (No. 14). Royal Society of Chemistry, 2010.

FT 549: Recent Trends in Fermentation Technology

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to determine the preservation aspects of microbial cultures using recent advanced techniques.
CO2: Interpret working principles of various sophisticated techniques like high pressure processing, ohmic heating, etc., in processing of fermented foods.
CO3: Identify and design effective extraction process and use of functional molecules generated during fermentation.
CO4: Interpret the health benefit effect of consumption of fermented foods.
CO5: Acquire/display knowledge of utilization of food wastes and generating valuable components from it.

Course content:

History of Fermentation, Relevance of Fermented Food Products, Novel Preservation Techniques for Microbial Cultures: *Freeze-Drying, Spray Drying, Fluid Bed Drying*, cryoprotectants, Novel Emerging Preservation Technologies: novel immobilization techniques (microencapsulation of cultures including yeasts), Electrospinning and Electrospraying, Biotechnological interventions to increase the viability during cell preservation.

High pressure processing for fermented food products (meat, dairy products, alcoholic and non-alcoholic beverages, etc.)

Pulsed electric field technology in Wine Production, Application of ultra sound and irradiation treatments in food fermentation, Ohmic heating and fermentation.

Novel fermented dairy products, meat products, grains based products, fruits and vegetables based products, etc. Bioactive compounds from fermented food products and their health promoting potentialities.

Probiotics, Prebiotic and Synbiotic Foods: Important features of probiotic microorganisms - Health effects of probiotics including mechanism of action- Probiotics in various foods: fermented products, Quality assurance of probiotics and safety–Side effects and risks, effects of prebiotics on human health and potential applications in risk reduction of diseases - Perspective for food applications for the following - Non-digestible CHO / Oligosaccharides - Dietary fibre, resistant starch, gums.

Functional and health benefits aspects of consumption of fermented foods.

Modern trends in microbial production of Single Cell Protein (SCP); bioethanol from sugar, molasses, starch and cellulosic materials, etc.

Textbooks:

- Shikha Ojha K and Tiwari BK. *Novel Food Fermentation Technologies*,Springer.
- E. M. T. El-Mansi, C. F. A. Bryce, Arnold L. Demain, A. R. Allman. *Fermentation Microbiology and Biotechnology*, Second Edition.

Suggested readings:

- P F Stanbury, A Whitaker, S Hall, *Principles of Fermentation Technology*

FT 550: Recent Trend in Enzyme Technology

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to apply fundamentals of enzyme properties, nomenclatures, characteristics, mechanisms and biochemical calculation for enzyme kinetics.
CO2: Ability to apply methods for purification, characterization and immobilization of enzymes and understanding various applications of enzymes that can benefit human life.
CO3: Ability to understand current and future trends of applying enzyme technology for commercialization purpose of biotechnological products.
CO4: Ability to compare and contrast the historical uses of enzyme technology with contemporary application of enzyme technology in diverse range of food industries.

Course content:

Introduction: Criteria of purity of enzymes- Specific activity. Enzyme units-Katal and IU. Enzyme activity- chemical nature of enzymes. Protein nature of enzymes and Non protein

enzymes. Coenzymes and Cofactors Classification of coenzymes. Isozymes, Abzymes, Synzyme

Enzyme Catalysis and Inhibition: Lock and key, Induced fit and Transition state Hypotheses. Mechanism of enzyme catalysis- Acid-base catalysis, covalent catalysis, Metal ion catalysis, Proximity and orientation effects etc. Reversible Inhibition- Competitive, Non Competitive, Uncompetitive, Mixed, Substrate, Allosteric and Product Inhibition.

Enzyme Kinetics: Factors affecting the enzyme activity-Concentration, pH and temperature. Kinetics of a single- substrate enzyme catalysed reaction, Michealis-Menten Equation, Km, Vmax, L.B Plot, Turn over number, Kcat. Kinetics of Enzyme Inhibition. Kinetics Allosteric enzymes.

Industrial uses of Enzymes: Industrial Enzymes-Thermophilic enzymes, amylases, lipases, proteolytic enzymes in meat and leather industry, enzymes used in various fermentation processes, cellulose degrading enzymes, Metal degrading enzymes.

Stability of Enzymes: Enzymes stabilization by selection and genetic Engineering, protein engineering. Reaction Environment rebuilding, Chemical modification, intra-molecular cross linking, immobilization. Application of enzymes in industry, analytical purpose and medical therapy

Textbooks:

- Nicholas Price & Lewis Stevens. *Fundamentals of Enzymology*
- Trevor Palmer. *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*.

Suggested readings:

- Stryer, Voet and Lehninger. *Biochemistry text books*, Relevant Chapters.
- Palmer, T. and Bonner, P.L. *Enzymes: Biochemistry. Biotechnology and Clinical Chemistry*, Horwood Publishing Limited, 2007.

FT 551: Valorization of Food By-product

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to explain the type of by-products generated from food processing industries.
CO2: Ability to recall the functional properties of the valorized by-products.
CO3: Ability to assess the valorized products obtained from by-products from plant and animals processing units for quality parameters.
CO4: Ability to develop valorized products from processing by-products.

Course content:

Overview of food processing industries, current scenario of food processing by-products, regulatory issues and concerns of valorization of food processing by-products.

Biochemical and nutritional aspects of food processing by-products, microbiology of food processing by- products, fermentation of food processing by-products, enzyme technologies for bioconversion of food processing by-products

Valorization of by-products from plant-based food processing industries, cereals, oilseeds, roots and tubers, sugarcane, plantation products, fruits and vegetables, bakery and confectionery, fermented and non-fermented beverages.

Valorization of by-products from plant-based food processing industries, dairy by-products, seafoods, meats, poultry, and eggs

Environmental concerns, future prospects of valorization of food processing by-products

Textbooks:

- Waldron, K.W. *Hand book of waste management and co-product recovery in food processing.* Elsevier, 2009.
- Chandrasekaran, M. *Valorization of food processing by-products*. CRC Press, 2012.

Suggested readings:

- Oreopoulou, V., & Russ, W. *Utilization of by-products and treatment of waste in the food industry*. New York, NY, USA, Springer. 2007.
- Arvanitoyannis, I. S. (2010). *Waste management for the food industries*. Academic Press, 2010.
- Wang, L.K., Hung, Y.T., Lo, H.H., & Yapijakis, C. *Waste treatment in the food processing industry.* CRC Press, 2005.

FT 552: Recent Trend in Drying and Dehydration

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to employ the selection of suitable drying technology for a specific food.
CO2: Ability to demonstrate the advanced drying technology for good quality of food products and energy efficient.
CO3: Ability to design and propose the concept of hybrid drying to solve a specific drying problem in industry.
CO4: Ability to model and simulate the simple drying process for food.

Course content:

Drying fundamentals: Theories of drying, drying rate characteristic curve, heat and mass transfer mechanisms in drying, models for prediction of sorption isotherms, thermodynamics of sorption isotherms.

Need for advanced drying technologies, classification and selection criteria- conventional versus novel technologies, Innovation and trends in drying technologies, Impinging steam drying: basic features, hydrodynamics and heat transfer Pulsed fluid bed drying: principles and examples

Low pressure superheated steam drying: Basic principle of LPSSD, LPSSD of food and biomaterials, mathematical modeling of LPSSD, Airless drying, drying in mobilized beds, vacuum jet drying, Refractance window drying, Acoustic drying, RF- vacuum drying,

Contact sorption drying: mechanism, characteristics of sorbents/carriers, technology of sontact sorption drying Heat pump assisted drying: Classification of heat pump dryers, fundamentals of heat pump dryers, heat and mass transfer mechanisms, optimum use of heat pump in drying systems, innovative heat pump design systems.

Sonic drying: basic characteristics of sound, sound generation, mechanism of sonic drying, drying kinetics, sound assisted dryers.

Pulse combustion drying: principle, combustors design and construction, types of combustors,

Hybrid drying technologies: microwave-convective drying with cogeneration, microwave vacuum drying, filter mat drying, spray fluid bed vibrated fluid bed dryer,

Food dryer process controls: need of process control, control parameters, control strategy, control philosophy, fundamental control methods, and advanced control.

Textbooks:

- Kudra T & Mujumdar AS, *Advanced Drying Technologies*, CRC Press,2009
- Barbosa-Canovas GV, Vega-Mercado HV. *Dehydration of foods*, International Thomson publishing, 1996.

Suggested readings:

- Ratti, C. *Advances in food dehydration*. CRC Press, 2008.
- Kudra, T. *Energy aspects in food dehydration. Advances in food dehydration*, 2009.

FT 553: Food Microstructure and Texture

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to explain the microstructural approach how it connects the most properties and phenomena in foods.
CO2: Ability to understand structure-property relationships in food materials to derive appropriate functional models.
CO3: Ability to explain the rheological properties of the food and will be able to apply the rheological properties for the development of new food product.
CO4: Ability to analyze flow behavior different kind of semi-finished material for product development.

Course content:

Food Structuring: Introduction, food structure, factor affecting texture, Approaches to Food Structuring, effect of Extrusion, drying, High pressure, and other process on food structure, Structure and Stability, Gels, Gelation.

Mechanisms, Mixed Gels, The Microstructure of Gels, Structure-Property Relations in Gels

Microstructural elements and their interactions: Polysaccharides, Proteins, fat, water, Ingredient interactions in complex foods.

Novel methods to study food microstructure: History of Food Microstructure Studies, Light Microscopy, Transmission Electron Microscopy, Scanning Electron Microscopy, Other Instrumentation and Techniques.

Food rheology and structure: stress and strain tensors, viscometric properties, shear stress-shear rate relationships, units in rheological measurements, types of fluid flow behaviour, apparent viscosity, intrinsic viscosity, stress- strain behaviour of solid foods, linear viscoelasticity, phase transitions in foods.

Flowandfunctionalmodelsforrheologicalpropertiesoffluidfoods:Time independent flow behaviour, Apparent viscosity- shear rate relationships of shear- thinning foods, models for time dependent flow behaviour, role of solids fraction in rheology of dispersions, effect of temperature on viscosity, treatment of rheological data using models.

Textbooks:

- D. Julian Mc Clements, *Understanding and controlling the microstructure of complex foods*, CRC Press
- Steff, J. F. *Rheological Methods in Food Process Engineering*, Freeman Press,1996.

Suggested readings:

- V.J. Morris and K. Groves, *Food Microstructures, Microscopy, Measurement and Modelling*, Woodhead Publishing.

FT 554: Novel Separation Process

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to identify the various separation process for food application.
CO2: Ability to recommend the various extraction and separation processing aspect of food processing.
CO3: Ability to evaluate the mechanism of various extraction and separation process in food processing.
CO4: Ability to calculate the design parameters of separation process in food processing.

Course content:

Introduction: Separation process in chemical and Biochemical industries, Categorization of separation process, equilibrium and rate governed processes. Introduction to various new separation techniques e.g. Membrane separation, Ion-exchange foam separation, supercritical extraction, liquid membrane, PSA & Freeze drying.

Membrane based separation technique (MBSTs): Historical background, physical and chemical properties of membranes, Techniques of membrane preparation, membrane characterization, various types of membranes and modules. Osmosis and osmotic pressure. Working principle, operation and design of reverse osmosis, ultrafiltration, microfiltration, electrodialysis and pervaporation. Gaseous separation by membrances.

Ion Exchange: History, basic principle and mechanism of separation, Ion exchange resins, regeneration and exchange capacity. Exchange equilibrium, affinity, selectivity and kinetics of ion exchange. Design of ion exchange systems and their uses in removal of ionic impurities from effluents.

Introduction to foam separation, micellar separation, supercritical fluid extraction, liquid membrane permeation and chromatographic separation.

Textbooks:

- King, C. J. *Separation Processes*, Tata McGraw-Hill, 1980.
- Sourirajan, S. and Matsura, T. *Reverse Osmosis and Ultra-filtration – Process Principles*, NRC Publication, 1985.

Suggested readings:

- Henry, J. D. and Li, N. N. *New Separation Techniques*, AICHE, 1975.
- Hatton, T.A., Scamehorn, J.F. and Harvell, J.H. *Surfactant Based Separation Processes*, Marcel Dekker Inc., 1989.

FT 555: Food Supply Chain Management Case Study

L 3 T0 P0 CR3

Course outcomes:

CO1: Ability to identify the effective food supply chain management requirements.
CO2: Ability to analyze the effect of food production, manufacturing, retailing and logistics on food supply chain.
CO3: Ability to apply effective sourcing and purchasing models to improve supply chain operations.
CO4: Ability to estimate the risk in supply chain and apply effective traceability system.
CO5: Ability to apply the skills for developing supply chain system for food industries.

Course content:

Introduction: Introduction to supply chains in India, Types of food Chain, Factors Influencing Food Supply Chains, Case studies in food supply chain.

Food Production: Entities in agriculture supply chain, Agriculture and poverty alleviation, barriers in development of agri-industry, future steps for agriculture industry. Case studies on farmer empowerment by Industry.

Food Manufacturing: Importance of food processing, market conditions, food processing and packaging, Inventory management, food safety, procurement, Case studies

Food retailing: The retail environment, Online retailing of food, Future challenges in food retailing

Food Logistics: movement of Food, Trends in food logistics, packaging in logistics, temperature controlled in supply chains, Case studies.

Challenges in International food supply chains: International food supply chains, Factor affecting international food supply, International politics and food, Case studies

Food Sourcing and Procurement: sourcing, sourcing models, purchasing models, supplier segmentation, supplier development, strategic sourcing, sustainable procurement, case example

Risk Management: Risk management and uncertainty, Risks in the supply chain, Risks in the food supply chain, managing supply chain risks, managing risks in food supply chains, Case examples

Trends in Food Supply Chains: Traceability and use of technology, food production, food processing in a technological context, food packaging in a technological context, food logistics

Food regulation, safety and quality: Attributes to consider when designing food supply chains, food regulation and its effect on safety, food laws and regulation, reference standards,

compatibility standards, private food standards, other initiatives within the food supply chains, case examples.

Sustainability challenges in food supply chain: Introduction to sustainability, sustainable supply chains, sustainable food supply chains, measuring sustainability, developing sustainability within food supply chains, case studies.

Textbooks:

- Samir Dani, Kogan Page. *Food Supply Chain Management and Logistics From Farm to fork.*
- Michael A. Bourlakis, Paul W. H. Weightman, *Food Supply Chain Management*. Wiley-Blackwell.

Suggested readings:

- Preston W. Blevins, *Food Safety Regulatory Compliance: Catalyst for a Lean and Sustainable Food Supply Chain*

FT 556: Chemistry of Food Processes

L 2 T0 P1 CR3

Course outcomes:

CO1: Ability to identify the chemical constituents present in different types of food
CO2: Ability to understand the interactions between the various chemicals present within the food during processing and storage
CO3: Ability to apply the knowledge for processing and fortification of food products.
CO4: Ability to estimate quantities of different chemicals that may be present in the food

Course Content

Water: Physical properties, types of water, water activity and shelf life of food Distribution of water in various foods and moisture determination.

Carbohydrates: Nomenclature and classification, structure and chemical properties of carbohydrates-monosaccharide, disaccharides and polysaccharides; changes in carbohydrates during processing. Carbohydrates determination methods. Enzymic and non-enzymic browning.

Proteins: Classification, structure and properties of proteins, Proteins from plant and animal sources. Changes in protein during processing, protein determination methods.

Lipids: Classification, structure, physical and chemical properties of fatty acids and fats. Lipids-simple and derived. Different types of fats, uses in food processing, food emulsions, fat replacers. Changes during food processing.

Minerals: Classification, minerals in meat, milk, plants and their interaction with other components, losses of minerals during processing, metal uptake in canned foods.

Vitamins : Role of vitamins in food industry, effect of various processing treatments and fortification of foods. Food sources, effects of deficiency.

Pigments: Their roles in food industry, Bitter substance and tannins.

Additives: Direct, indirect additives, Functions, Types, Safety concern and legal regulations.

Enzymes: Enzymes: properties, classification, coenzymes and cofactors, enzyme kinetics, regulatory enzymes, iso-enzymes, enzyme inhibition and kinetics of enzyme inhibition, enzyme purification;

Practicals:

1. Preparation of standard solutions for the chemical analysis i.e. HCl, H_2SO_4, $KmnO_4$, Sodium Thiosulphate and Iodine.
2. Determination of moisture content.
3. Reducing and non-reducing sugar
4. Determination of fiber content of different food material.
5. Detection of amino acid, containing aromatic ring, by Xanthoproteic test.
6. Determination of protein by Kjeldal method.
7. Determination of Ash content.
8. Detection of presence of starch by Iodine test.
9. Determination of water activity of different food materials.
10. To distinguish between mono-saccharides and di-saccharides of barfoed test.
11. Determination of minerals: calcium, phosphorous and iron;
12. Estimation of vitamins: ascorbic acid, carotene and thiamine.
13. Estimation of fats & Oils i.e. Free fatty acid, Peroxide value, Saponification value, RM Number, TBA test, Iodine value,

Text Book:

- Principles of Food Chemistry, John M, Deman, Chapman and Hall, 3rd Edition, 1999.
- Food Chemistry, Fennema Owen R., Food Science & Technology series, CRC press, New York, 4th edition, 2007.

References:

- Food chemistry, Lillian Hoagland Meyer, CBS publication, New Delhi, 2nd Edition, 2006.
- Food Science Chemistry & Experimental Foods, Dr. M. Swaminathan, Bappco Ltd 2nd Edition, 2001.
- Food chemistry, S. Yadav, Anmol Publications 1st Edition, 1997.