



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

Course work Subject Codes and Subject Names

S.No.	Sub Code	Subject Title	L	T	P	Credits	
2.	FT-10001	Recent Advances in Fruits & Vegetables Processing	4	0	-	4	
3.	FT-10002	Recent Advances in Cereals, Pulses & Oilseeds Processing	4	0	-	4	
4.	FT-10003	Recent Advances in Dairy Engineering & Technology	3	1	-	4	
5.	FT-10004	Recent Advances in Meat, Fish & Poultry Processing	4	0	-	4	
6.	FT-10005	Recent Advances in Food Engineering	3	1	-	4	
7.	FT-10006	Statistical Techniques	3	1	-	4	
8.	FT-10007	Advances in Food Biotechnology	4	0	-	4	
9.	FT-10008	Recent Advances in Bioprocess Engineering	3	1	-	4	
10.	FT-10009	Comprehensive Course in Food Engineering & Technology	Self-Study				

1. Students entering into the Ph.D. Programme at Food Engineering & Technology department, SLIET shall have to complete mandatory courses, RM-10000 "Research Methodology" & FT-10009, "Comprehensive Course in Food Engineering & Technology".
2. Subject code FT-10009, "Comprehensive Course in Food Engineering & Technology" will be based on the Oral Examination (after the II Semester) to the DRC (Departmental Research Committee).
3. FT-10009 is a self study mandatory course and the candidate will be awarded satisfactory or unsatisfactory grade depending upon the performance. In case, candidate does not secure satisfactory grade, will be given another chance after 3rd semester which shall be the last and final. Failing will result termination of the Ph.D. Registration of the candidate.
4. Student has to successfully pass 01 Elective Subject also in addition to the mandatory courses from the series of FT-8000, FT-9000 & FT-10000 (except the mandatory one).
5. Students entering into the Ph.D. Programme after completion of M.Tech. Degree shall have to opt the elective subject only from the FT-10000 series exclusively.



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

FT-10001: Recent Advances in Fruits and Vegetables Processing

L	T	P	Cr
4	0	0	4

M.M.: 100
Ex. Hrs.: 3

UNIT I

Physiology of development, ripening and senescence of fruits and vegetables, Harvesting and harvesting indices of fruits and vegetables, post harvest changes of fruits and vegetables, Technological advances in thermal processing of fruit and vegetable.

UNIT II

Minimal processed technology, Fresh-cut Produce, Quality Parameters of Fresh-cut Fruit and Vegetable Products, Safety Aspects of Fresh-cut Fruits and Vegetables, Enzymatic Effects on Flavor and Texture of Fresh-cut Fruits and Vegetables, Preservative Treatments for Fresh-cut Fruits and Vegetables, Application of Packaging and Modified Atmosphere to Fresh-cut Fruits and Vegetables, storage and handling of fresh produce.

UNIT III

Edible coatings for fruits, Selecting edible coatings, Gas permeation properties of edible coatings, Wettability and coating effectiveness, Determining diffusivities of fruits, Measuring internal gas composition of fruits

Recent techniques in fruits and vegetables: Microwave and radio frequency processing, ohmic and inductive heating, high pressure processing, pulsed electric field, high voltage arc discharge, pulsed light technology, oscillating magnetic fields and ultrasonics..

UNIT IV

Quality attributes of fresh fruits and vegetables, Quality indices of fruit and vegetable juices, Maturity and ripeness indices of fruits and vegetables, Microbiology of fresh and processed fruits and vegetable products, Advances in byproduct utilization.

Recommended books:

Author(s)	Title
P. Fellows	Food Processing Technology
W.C. Frazier.	Food microbiology
Fennema, Kerrel	Principles of food preservation
Lal, Siddappa & Tandon	Preservation of Fruits and Vegetables
Nelson & Tressler	F&V Juice Processing Technology. Vol. III
Ashurst	Food Flavorings
W.C. Frazier	Food Microbiology
Ranganna	Handbook of Analysis of F & V Products
Luh and Wudruf	Commercial Fruit Processing
Ashurst	Chemistry and Technology of Soft Drinks and Fruit Juices



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

FT-10002 : RECENT ADVANCES IN CEREALS, PULSES AND OIL SEED PROCESSING

L T P Cr
4 0 0 4

M.M.: 100
Ex. Hrs.: 3

UNIT I

Storage and Handling of Food Grains: Food grain storage structure: recent trends, Problem in bag and bulk storage and their control. Protection against rodents, mould, pests and mites, fumigation processes, aeration and drying during storage, Problems of dust explosion in grain storages, Quality changes of grains during storages and remedial measures.

Wheat: Present scenario of wheat processing industries. Quality testing of wheat grain and the milled product (flour, dough etc). Factors affecting yield and quality of flour. Working of milling equipments. Composite and alternate flours, air classification and their applications. Wheat starch processing, modification and utilization, development of wheat based extruded products.

UNIT II

Rice: Present scenario of rice processing industries. Effect of different factors on milling yield and rice quality. Working of paddy driers. Modern methods of paddy parboiling. Pretreatments to paddy before milling and their advantages. Paddy milling by-products and their utilization. Recent methods of paddy processing and quality testing. Isolation, modification and utilization of rice starch. Modern, convenience and extruded products from rice.

UNIT III

Maize, coarse and pseudo cereals: Modern dry and wet milling methods of maize, working of milling equipment. Production and utilization of corn starch derivatives. Equipments used in the milling of coarse and pseudo cereals. Nutritional products and their recovery in coarse cereals, recent utilization trends in coarse and pseudo cereals. Latest quality evaluation methods the coarse cereal grains.

UNIT IV

Pulses: Pretreatments given to pulses before milling. Latest quality evaluation methods for pulses. Modern pulse milling methods. Working of machinery and equipment employed in pulses processing. Losses during milling and their control. Utilization trend of pulses in India and abroad.

Oil Seeds: Importance and trends of oil seed processing in India. Machinery and equipments used in the crude oil extraction and its refining. Latest production technology of shortenings, lecithin, confectionery coatings, Imitation dairy products.

Recommended Books:

1. Post Harvest Technology of Cereals, Pulses and Oilseeds Chakraverty, A
The Chemistry and Technology of Cereals as Food and Feed Samuel Matz
Technology of Cereals N. L. Kent and A. D. Evans
Maize-Recent Progress in Chemistry and Technology George E Inglett
Pulses – Chemistry, Technology and Nutrition



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

2. Cereals and Cereals Products Ruth H. Matthews Dendy and Dobraszczyk Modern Cereal Science and Technology Y. Pomeranz Storage of Cereal Grains and their Products Cryde M. Christensen Hand Book Of Cereal Science and Technology Karel Kulp and Joseph P Pante Oilseeds and Oil Milling in India (A cultural and History Survey Acharya Fats in food products Maran



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

FT- 10003 : Advances in Dairy Engineering & Technology

L	T	P	Cr
3	1	0	4

M.M.: 100
Ex. Hrs.: 3

UNIT I

Homogenization of milk

Principle of homogenization, Effect of homogenization, Technical execution, valves and pumps, single and double stage homogenizers, care and maintenance of homogenizers, Efficiency of homogenization, design principles of homogenizers, operation and maintenance, application of homogenization in dairy industry. Recent advances in homogenization.

UNIT II

Tanks, Pumps, Stirrer mixtures and Centrifugation

Designs and equipment of tank, types of tanks, pumps in dairy industry, Agitation and mixing, construction of agitators and patterns of flow. Separation by gravity and centrifugal force, clarifiers and separators, centrifugal separator and efficiency of separation, flow rate and power consumption.

UNIT III

Thermal processing of milk

Pasteurization of milk; Holding methods, Agitation of liquids, HTST pasteurizer and design principle and thermal death kinetics, care and maintenance, Advantages of HTST pasteurization, Vaccination, UHT processing of milk, quality changes during processing of milk.

Concentration of milk

Evaporator, Food properties in relation to evaporator performance, Construction and types of evaporator, heat and mass balance in single and multiple effect evaporator, performance characteristics of evaporators and their selection criteria, steam economy. Recent advances in evaporating techniques.

UNIT IV

Spray and drum drying

Theory of drying, estimation of drying rates and drying time, drying equipments, particle size calculation, design of spray and drum dryer, skim milk and whole milk powders manufacturing methods. Fluidized bed drying, Principles of fluidized bed method, Types of fluidized bed drier, Drying and cooling times in fluidized bed; Freeze drying; Agglomeration, Problems of



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

reconstitution, Methods of Agglomeration, The effect of drying on milk products. Recent advances in drying.

Dairy products

Frozen dairy products; Butter; ghee; Cheese; Casein and its derivatives; Condensed and evaporated milk, Traditional products; Whey powder, protein concentrate and isolate; Lactose their composition, standards, manufacturing, process control and quality control parameters.

Recommended Books

Title

Dairy products
Milk and Milk Products
Ice Cream
Dairy Engineering

Author

Lampart, Lincoln M.
Eckles, Comb and Macy
Arbuckle
John T Bowen



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

FT- 10004 : RECENT ADVANCES IN MEAT FISH AND POULTRY TECH

L	T	P	Cr
4	0	0	4

M.M.: 100
Ex. Hrs.: 3

UNIT I

Research and Development activities on meat, fish and poultry products: The industrial profile of meat industry, Meat production and trade practices, current trends in the production of fresh meat in world, Research and Development activities on meat, fish and poultry products, changes in consumers buying habits of meat products.

UNIT II

Functional behavior of animal tissues and its effect on meat quality: Functioning of major tissues of animal body, Chemical and biochemical constituents of animal tissues, functioning of muscle in vivo, postmortem glycolysis, onset of rigor mortis, preslaughter handling, moisture loss, glycogen loss, and general consequences of circulatory failure in muscle, conditioning or aging. Relaxation and contraction of muscle and its effect on meat quality.

Slaughtering methods and carcass fabrication: Skeleton, ante and post mortem inspection and humane slaughter techniques and dressing percentage. Types of carcass, indication of quality, regional variation and different meat cutting techniques.

UNIT III

Meat inspection, sanitation and preservation techniques: Application and Enforcement of inspection laws, elements of inspection (sanitation, antemortem inspection, postmortem inspection, condemnation, product inspection, laboratory inspection, labeling). Laboratory techniques for the microbial examination of meat and equipment. Meat preservation by radiation and freeze drying techniques.

Eating quality of meat: Color, chemical nature of myoglobin, methods to improve meat color, discoloration of meat, water holding capacity and juiciness, factors determining exudation, texture and tenderness, preslaughter and post slaughter factors effecting tenderness, Electrical stimulation to improve tenderness.



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

UNIT IV

Poultry meat: Kind of poultry, processing of poultry. Special poultry products, Breaded poultry, Smoked turkey, Packaged pre cooked chicken, Freeze dried poultry meat

Ready to serve meats: meat analogues and restructured meat products.

Fish and other sea foods: fish regulations, grading of fish, processing of finfish, recent techniques to cook fish, shrimps and oysters.

Recommended Books:

Title	Author
Meat poultry and Sea Food Technology	Henricksons
Fish Technology	R.J. Robert
Poultry product Technology	G.J.Mountney
Meat Processing Joseph Kerry,	John Kerry and David Ledwood
Meat Hand Book	Albert Levie
Poultry Processing	G.H.Weiss
Processing of Aquatic Food Products	F.W. Wheaton and T. B. Lawson
Poultry meat processing and quality	G Mead



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

FT- 10005: ADVANCES IN FOOD PROCESS ENGINEERING

L	T	P	Cr
3	1	0	4

M.M.: 100
Ex. Hrs.: 3

UNIT- I

Units and dimensions, concept of entropy, Energy, Anergy, exergy, Degrdaton of exergy, Material and energy balances. Rules for the efficient conversion of energy and materials, Material and energy balance diagrams. Technologies for energy conservation, Numerical problems.

Novel evaporation/ dehydration techniques, New direction in evaporation and drying concentration, cyclic pressure freeze drying, spray drying. Microwave drying and vacuum drying, osmotic dehydration efficient drying systems, infrared heating, freezing of foods, freeze concentration and drying, freezing point curves, methods of freeze concentration, design problems.

UNIT-II

Fluid flow operations and food rheology: Some important properties of fluids, Factors affecting the rheological parameters, Preesure and its measurement by Manometers, Concept of Reynolds's number, Types of fluid flow, Continuity equation, Different types of fluid energies, Eulers's equation Derivation of Bernoulli equation, Hydraulic coefficients, Practical applications of bernoullies equation, Venturimeter, Orifice meter, Pitot tube, Rotameter (variable area meter). Rheology, stress strain diagram, types of fluids, time independent fluids, time dependent fluids. Viscoelastic fluids, Flow of viscous fluid between two parallel plates, Flow of viscous fluid through circula pipe or derivation of hagen-poiselle equation or theory of capillary viscometer, Coefficient of friction or fanning friction factor or skin friction factor, Energy losses in pipes, Drag coefficient, Stokes law (laminar flow arround a sphere), Viscometry, Capillary tube viscometer, Rotational viscometer, Ostwald viscometer, Falling sphere resistance method, Cone and plate type viscometer, Circular disc viscometer, Laminar flow through porous media (Darcy's law), Pressure drop in flow through porous media, Pumps for fluid flow, Viscoelastic fluids, Static (constant stress or strain) measurement method, Maxwel model, Kelvin-voigt model, burger model: (or four element model), Dynamic (varying stress or strain) or oscilatory measurements method, Textural profile analysis, numerical Problems.



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

UNIT-III

Different types of membrane processes, physical characterisation of membrane structure, driving force for membrane separation, concept of partial molar properties and chemical potential, fugacity, activity of solution, activity coefficient, general mass transfer equation during mass transfer, Fick's law of diffusion mass transfer, pore diffusion model, types of membranes, membrane modules configurations, derivation of equation for osmotic pressure for concentrated and dilute solutions, detailed description of microfiltration, ultrafiltration, nanofiltration, reverse osmosis etc. Derivation of various mass transfer equations for mass transfer through membrane, polarization layer by concentration and fouling, factors affecting reverse osmosis and other membrane separation processes, applications of various membrane separation processes.

UNIT-IV

Extrusion cooking - recent developments, methods, equipment, design criteria of extruders. Engineering aspects of single and twin screw extrusion cooking; Non-thermal processing: Microwave, irradiation, ohmic heating, pulsed electric field reservation, hydrostatic pressure technique etc.

Recommended Books:

Title	Author
Food Engineering Operations	Brennan JG, Butters JR, Cowell ND & Lilly AEI
Chemical Engineering. VolS. II, IV	Coulson JM & Richardson JF
Unit Operations in Food Processing	Earle RL
Food Processing Technology: Principle and Practice	Fellows P.
Transport Process and Unit Operations	Geankoplis J Christie.
Agricultural Process Engineering	Henderson S & Perry SM
Unit Operations of Chemical Engineering	McCabe WL & Smith JC
Extrusion cooking Technology.	Ronald Jowitt
Design and Management for energy conservation	O'Callaghan P W
Unit Operation of Agricultural Processing	Sahay KM & Singh KK.
Singh RP & Heldman DR	Introduction to Food Engineering
Singh RP	Fundamentals of Food Process Engineering



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

FT- 10006: Statistical Quality Control

L T P Cr
3 1 0 4

M.M.: 100
Ex. Hrs.: 3

UNIT I

Introduction: The meaning of quality and quality improvement, quality control programs, quality control tools, problems with tool selection, Statistical methods for quality control and improvement. The formalized quality system, quality system guidelines, Total quality management, team quality systems, computer network quality systems; The link between quality and productivity; Quality costs; Legal aspects of quality; implementing quality improvement. Analysis of data, probability, binomial distribution, the normal distribution, distribution of sample means, normal approximation to the binomial distribution, t-distribution, statistical hypotheses, paired observations, F-distribution, Analysis of variance

UNIT II

Design of Experiments: Introduction, elimination of extraneous variables, handling many factors simultaneously, full factorial design, fractional factorial designs, composite design, central composite rotatable design, Box Behenken design, applications of various designs in food processing research, limitations of individual design

UNIT III

Data analysis and modeling: Multiple regression analysis, canonical analysis, ridge analysis, variable selection, mathematical modeling, interpretation of model parameters and selection criteria of best models.

UNIT IV

Multivariate analysis: Concept of cluster analysis, factor analysis, principal component analysis
Six Sigma: Introduction, Six-sigma control chart, Six-sigma quality performance

Books Recommended

Title	Author
Statistical Quality Control for the Food Industry	Merton R. Hubbard
Introduction to Statistical Quality Control	D.C. Montgomery
Introductory Statistics	P.S.Mann
Fundamentals of Statistical Quality Control	Jerome D. Braverman
Response surface methodology	R. H. Myers
Response surfaces design and analysis	A. I. Khuri & J. A. Cornell



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

FT- 10007: Advances in Food Biotechnology

L	T	P	Cr
4	0	0	4

M.M.: 100
Ex. Hrs.: 3

UNIT-I

Introduction

Concept of biotechnology, historical developments, Interdisciplinary nature of biotechnology, scope and present status of biotechnology in India in relation to food technology and its general applications.

Fermentation and Fermenter Design

Types of fermentation-submerged, surface and solid substrate fermentation, factors affecting fermentations, Concept of fermenter and its design, scale up of fermentation, problems in scale up, Role of fermentation in food preservation, Developments in solid-state fermentation for food applications.

UNIT-II

Production of Alcoholic Beverages

Introduction, classification of alcoholic beverage, Production of alcoholic beverages: raw materials, culture, fermentation technology of non-distilled beverages (beer and wine) and distilled alcoholic beverages (brandy, whiskey, vodka, rum, gin)

Production of Single Cell Proteins

Single cell proteins production: substrates, factors effecting SCP production, composition, uses, economic parameters and constrains including safety aspects of SCPs with special reference to RNA content

UNIT-III

Production of Organic Acids/Acidulants

Raw materials, Starters and fermentation conditions, recovery and applications, Case studies production of acetic acid (vinegar), citric acid, lactic acid and gluconic acid

Biocatalysts in Food processing

Sources of enzymes, advantages of microbial enzymes, mechanism of enzyme function, Production and purification of enzymes, immobilization and applications of biocatalysts in food processing, enzyme biosensors.



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

UNIT-IV

Genetic Engineering and Genetically Modified Foods

Genetic manipulation of microorganisms, Gene cloning procedures, vectors involved: plasmids, cosmids and phagemids, transfer of recombinant molecules into host organisms, Genetically Modified (GM) foods and their safety concerns.

Treatment of Food Processing Wastes

Food wastes (Whey, molasses, starch substrates and others), waste treatment technologies: aerobic and anaerobic methods of treatment of food industry wastes, bioremediation, Microbial production and importance of bio-surfactants, Microorganisms for bio energy, bio-conversion of food wastes to useful products.

Recommended Books:

Title

Biotechnology
Biotechnology
Biotechnology: Food Fermentation
Food Processing : Biotechnological Applications
Enzymes in Food Processing
Biotechnology

Author

M.D. Trevan
P.K. Gupta
V.K. Joshi
S.S. Marwaha
P.S. Panesar
Crueger and Crueger



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

FT- 10008: Recent Advances in Bioprocess Engineering

L	T	P	Cr
3	1	0	4

M.M.: 100
Ex. Hrs.: 3

UNIT I

Introduction

Progress in biochemical engineering, bridging gap: Bioscience, engineering and technology, global impact and scenario, reaction kinetics, biocatalyst and bioengineering.

UNIT II

Medium Engineering for Cell Cultivation and Bioreactions

Basic concepts in medium design, design procedure, basics of material balance, growth limiting nutrient in designed medium, engineered medium in cell growth and product formation, metabolic engineering, novel medium, advances in medium sterilization process and equipment.

Bioreactors and Biosensors

Growth kinetics of batch and continuous processes, transport phenomenon in microbial systems, design and analysis of fermenter and bioreactors; advances in continuous fermentation, biosensors in bioprocessing, enzyme bioreactors.

UNIT III

Bioproducts: Modern Estimation and Bioassay, Recovery and Purification

On line instrumental analysis, PCR instrumental analysis, bioassay procedures, separation of insoluble and soluble products(filtration, centrifugation, sedimentation, chromatography, membrane separation (UF and NF) and electrophoresis), purification by crystallization and drying, new developments in product recovery operations.

Bioprocess instrumentation

Offline analytical methods, physical, chemical and biosensors, online sensors and recent development in bioprocess instrumentation.

UNIT IV

Modeling, simulation and scale-up

Bioprocess modeling and simulation and its application in industrial fermentation, scale-up of



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

fermentation processes, bioprocessing plant design calculations considering Penicillin production system.

Recommended Books

Author	Title
Michael L Shuler and Fickret	KargiBioprocess Engineering Basic Concepts
James M Lee	Biochemical Engineering
S N Mukhopadhyay	Process Biotechnology Fundamentals
Aiba and Humphrey	Biochemical Engineering
Bailley and Ollis	Biochemical Engineering Fundamentals
Schimid	Advances in Biochemical Engineering
Stanbury	Principles of Fermentation Technology



SLIET LONGOWAL

2.2.5 - FOOD ENGINEERING AND TECHNOLOGY (Ph.D. - FET)

FT- 10009: Comprehensive Course in Food Engineering & Technology

All concepts related to following fields

1. Food Science and Technology like Fruits and Vegetables processing; Cereal and Pulse processing; Dairy technology; Meat, Poultry and Fish technology; Health foods and Beverage technology.
2. Food Engineering like all Basics and Unit Operations used in Food Process engineering etc.
3. Food Bioprocess Engineering, Food Biotechnology, Biochemistry and Food Microbiology, Food Analysis & Quality Control.
4. Related to research field opted by student.