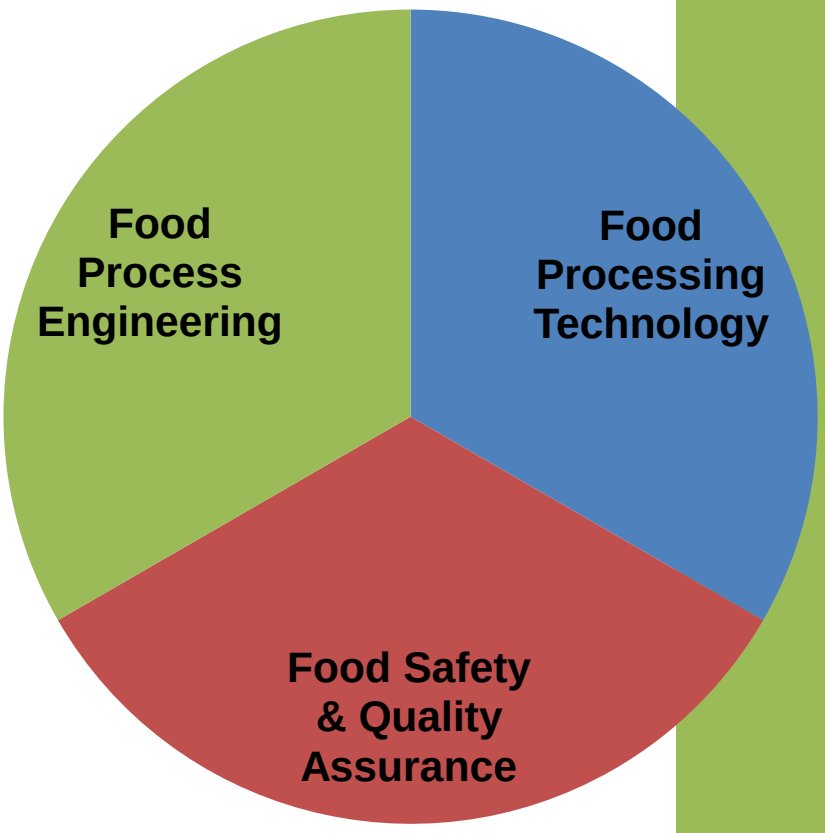
Syllabus

for

M. Tech & Ph. D.

in

Food Technology



COLLEGE OF FOOD PROCESSING TECHNOLOGY & BIO ENERGY
ANAND AGRICULTURAL UNIVERSITY
ANAND – 388 110

May, 2017

College of Food Processing Technology & Bio-Energy

Anand Agricultural University, Anand – 388 110

Dr. D. C. Joshi, Principal & Dean Ph. / Fx. : (02692) 261302 E mail I.D: dcjoshi@aau.in

Syllabus of the P.G. Programmes in Food Technology in the Faculty of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand.

Read: Resolution of 45th Meeting of the Academic Council of Anand Agricultural University held on 29/04/2017

NOTIFICATION

It is hereby notified to all concerned that vide item no 45.26 of the 45th meeting held on 29/04/2017, the Academic Council of the Anand Agricultural University has resolved as under;

"The Academic Council resolved to approve the syllabus of PG Programmes in Food Technology as per **Annexure –I (A), I (B)** and **I (C)**. The same is to be implemented for the students admitted from academic year 2017-18 and onwards"

(D.C.Joshi)
Dean

NO.: AAU/FPT&BE/PG Acad/476/2017
Date: 18/05/2017

Encl: As Above

Copy F.W.Cs to:

1. All members of the Academic Council of University
2. All officers of Anand Agricultural University, Anand
3. Registrar AAU, Anand

Copy to:

1. All the HODs of this college
2. P.S to Hon. Vice Chancellor, AAU, Anand
3. PG Academic Branch of this college
4. Notification File

ANNEXURE- I (A)

Syllabus

for

Post Graduate Program
(M. Tech. & Ph. D.)

in

FOOD TECHNOLOGY

with Specialization in

Food Processing Technology

Centre:

College of Food Processing Technology & Bio-Energy
ANAND AGRICULTURAL UNIVERSITY
ANAND – 388 110
March– 2017

MINIMUM CREDIT REQUIREMENTS

Subject	Masters	Doctoral
Major	**20**	**15**
Minor	**09**	**08**
Supporting	**05**	**05**
Seminar	**01**	**02**
Research	**20**	**45**
Total Credits	**55**	**75**

Compulsory Non- Credit Courses

Code	Course Title	Credits
PGS 501	Library and Information Services	0+1
PGS 502	Technical Writing and Communication Skills	0+1
PGS 503 (e course)	Intellectual Property and its management in Agriculture	1+0
PGS 504	Basic concepts in Laboratory Techniques	0+1
PGS 505 (e course)	Agricultural Research, Research ethics and Rural Development Programs	1+0
PGS 506 (e course)	Disaster Management	1+0

Food Processing Technology

S. No.	Course No.	Course Title	Credits
A. MAJOR COURSES (20 credits)			
1.	FPT-501	Advances in Food Packaging Technology	3(2+1)
2.	FPT 502	Advances in Food Processing Technology	3(2+1)
3.	FPT 503	Brewing Technology	3(2+1)
4.	FPT 504	Carbohydrate Technology	3(2+1)
5.	FPT 505	Enzymes in Food Processing	3(2+1)
6.	FPT 506	Flavor Technology	3(2+1)
7.	FPT 507	Food Product Development	2(0+2)
8.	FPT 508	Food Rheology and Microstructure	3(2+1)
9.	FPT 509	Functional Foods and Nutraceuticals	3(2+1)
10.	FPT 510	Lipid Technology	3(3+1)
11.	FPT 511	Management of By-products & Wastes	2(2+0)
12.	FPT 512	Membrane Technology in Food Processing	2(2+0)
13.	FPT 513	Protein Technology	3(3+0)
14.	FPT 514	Sensory Evaluation	2(1+1)
15.	FPT 515	Technology for RTE/RTC Food Products	3(2+1)
16.	FPT 516	Technology of Food Emulsions, Foams & Gels	3(2+1)
17.	FPT 517	Technology of Frozen Foods	2(2+0)
18.	FPT 518	Traditional and Value-added Food Products	3(2+1)
19.	FPT 519	Advances in Dairy Processing	3(2+1)
20.	FPT 597	Special Problem	0+2
21.	FPT 697*	*Special Problem	0+2
22.	FPT 598	In-Plant Training	0+2

B1 Minor Courses: Food Engineering			
1.	FPE 501	Computer aided design of food plant, machinery and equipment	3(1+2)
2.	FPE 502	Advances in food process engineering	3(2+1)
3.	FPE 503	Advances in instrumentation & process control in food industry	3(2+1)
4.	FPE 504	Thermal process engineering	3(2+1)
5.	FPE 505	Advances in dairy engineering	3(2+1)
6.	FPE 507	Advances in food refrigeration and air conditioning	3(2+1)
7.	FPE 508	Food industry energy management and auditing	3(2+1)
8.	FPE 509	Radiation in food processing	2(2+0)

9.	FPT 510	Food plant maintenance	2(1+1)
10.	FPE 511	Numerical techniques and simulation in food engineering	3(2+1)
11.	FPE 601	Transport phenomenon in food engineering	3(2+1)
12.	FPE 602	Advances in bioprocess and biochemical engineering	2(1+1)
13.	FPE 604	Product monitoring and process control	3(3+0)

B2 Minor Courses: Food Safety and Quality Assurance			
1.	FQA 501	Advances in Analytical Techniques	3(1+2)
2.	FQA 502	Food Legislations, Standards and Food Safety Management Systems	2(2+0)
3.	FQA 503	Food Safety and Risk Analysis	2(2+0)
4.	FQA 507	Advances in Protein Chemistry	3(2+1)
5.	FQA 508	Advances in Lipid Chemistry	3(2+1)
6.	FQA 509	Advances in Food Additives & Preservatives	3(2+1)
7.	FQA 511	Advances in Fermentation Technology	4(2+2)
8.	FQA 516	Advances in Food Biotechnology	3(2+1)
9.	FQA 510	Advances in Enzyme Technology	3(2+1)
10.	FQA 512	Advances in Food Microbiology	3(2+1)
11.	FQA 513	Starter cultures and fermented dairy products	3(2+1)
12.	FQA 514	Microbiology of Food-Borne Pathogens	3(3+0)
13.	FQA 505	Food Toxicology	2(2+0)

C. Supporting Courses			
1.	AG. STAT 512	Experimental Design	3(2+1)
2.	AG. STAT. 531	Data Analysis Using Statistical Packages	3(2+1)
3.	AG. STAT 573	Statistical Quality Control	2(2+0)
4.	BIOCHEM 601	Biochemistry of Cereals, Oilseeds and Pulses	2(2+0)
5.	BE 501	Non- conventional Sources of Energy	3(2+1)
6.	BE 502	Environmental Engineering	3(2+1)
7.	DT 512	Advanced Food Processing	4(3+1)
8.	DT 522	Advanced Dairy and Food Packaging	3(2+1)
9.	DT 621	Product Monitoring and Process Control	3(3+0)
10.	FBM 501	Computer Application in Food Industry	3(2+1)
11.	FBM 502	Operations Management	2(2+0)
12.	FBM 505	Operation Research	2(2+0)
13.	FBM 504	Advances in statistical methods in food processing	3(2+1)
14.	FPT 996	Research Methodology	2(2+0)

D Seminar			
1.	FPT 531	Masters seminar	1+0
2.	FPT 641	*Doctoral Seminar (Major)	1+0
3.	FPT 642*	*Doctoral Seminar (Minor)	1+0

• For doctoral programme

E Research (Thesis)			
1.	FPT 541	Masters Research	20
2.	FPT 641	Doctoral Research	45

FPT 501 Advances in Food Packaging Technology 3 (2+1)

Unit No.	Content	Lectures
1	Active and intelligent packaging systems, Advances in Active packaging techniques and Intelligent packaging techniques	02
	Current use of novel packaging techniques in different food products, consumers acceptance of novel food packaging	02
2	Oxygen and ethylene, scavenging technology, concept and its food applications	02
	Carbon dioxide, odor and flavour absorber and other scavengers, ethanol emitters and preservative releaser, and their food packaging uses	02
	Antimicrobial food packaging: concept and mechanism, Factors affecting the effectiveness of antimicrobial packaging.	02
3	Non-migratory bioactive polymers (NMBP) in food packaging, Advantages and limitations	02
	Inherently bioactive synthetic polymers: types and applications,	02
	Polymers with immobilized bioactive compounds.	02
4	Time-temperature indicators (TTIs), Definition and classification of TTIs, Requirement, development and current TTI systems, effectiveness of TTIs,	02
	Application of TTIs- to monitor shelf-life, and optimization of distribution and stock rotation	02
5	Packaging-flavour interactions, Factors affecting flavour absorption, Role of the food matrix and different packaging materials.	02
	Case studies: Packaging and lipid oxidation, Modelling lipid oxidation and absorption	02
	Shelf life evaluation of packaged food	02
6	Permeability properties of polymer packaging, measurement of permeability – water and gases. Selection criteria of packaging films	02
	Novel MAP gases, Testing novel MAP applications, Novel MAP applications for fresh and prepared food products,	02
7	Aseptic packaging technology-advances, systems and its food applications, packaging for high pressure processing	02

List of Practicals

1. Determination of WVTR in different packaging materials
2. Determination of GTR in different packaging materials.
3. Development of ethylene scavengers for fresh fruits and vegetables
4. Development of oxygen scavengers systems for food products
5. Application of anti-microbial packaging for moisture sensitive foods
6. Evaluation of chemical residue migration from package to food
7. Application of MAP packaging in selected foods
8. Study of time temperature indicators
9. Determination of oxidative changes in packaged foods
10. Comparative evaluation of flexible and rigid packages for fragile foods
11. Packaging of foods under inert atmosphere.
12. To study textural characteristics of selected fruit/ vegetable under MAP storage
13. Shelf life evaluation of packaged food product.
14. Study of aseptic packaging system
15. Determination of oil and grease resistant test for packaging films
16. Determination of respiration rate in fresh fruits and vegetables
17. Visit to food packaging material manufacturing industry

Suggested Readings

Ahvenainen R. 2001. *Novel Food Packaging Techniques*. CRC.

Crosby NT. 1981. *Food Packaging Materials*. App. Sci. Publ.

Mahadeviah M & Gowramma RV. 1996. *Food Packaging Materials*. Tata McGraw Hill.

Painy FA. 1992. *A Handbook of Food Packaging*. Blackie.

Palling SJ. 1980. *Developments in Food Packaging*. App. Sci. Publ.

Rooney ML. 1988. *Active Food Packaging.* Chapman & Hall.

Sacharow S & Griffin RC.1980. *Principles of Food Packaging*. AVI Publ.

FPT 502 Advances in Food Processing Technology 3 (2+1)

Unit No.	Content	Lectures
1	Emerging technology in food processing- Active and intelligent packaging, membrane technology, HPP, PEF, Ultra sound. Supercritical fluid extraction: Concept, property of near critical fluids NCF and extraction methods. Application of SCFE in food processing	02 02
2	Microwave and radio frequency, IR drying: Definition, Advantages, mechanism of heat generation, inductive heating in food processing and preservation. Application in food processing: microwave blanching, sterilization and finish drying. Hurdle technology: Types of preservation techniques and their principles, concept of hurdle technology and its application.	02 02 02
3	High Pressure processing: Types of equipment, mechanism of microbial inactivation Effect of HPP on -fruit juices, meat products, jam Ultrasonic processing: Properties of ultrasonic, types of equipment, effect of ultrasonic treatment on microbial inactivation, oil yield etc.	02 02 02
4	High intensity light generation system, Application of high intensity light in food processing, Pulse electric field-mechanism of inactivation, PEF generation system, PEF treatment chambers, Mechanism of ohmic heating and its application in liquid food processing, Principle of cold plasma technology and its generation systems and its application Nanotechnology: Principles and its applications in foods.	02 02 02 02
5	Cryogenic grinding- Properties of cryogens, systems, and their different applications	02

List of Practicals

1. To evaluate the characteristics of treated water using RO system
2. To carry out ultrafiltration study on fruit juices
3. To carry out nanofiltration study on liquid foods
4. To study super critical fluid extraction system and to carry out extraction of eugenol from Basil leaves
5. To carry out extraction of lycopene from tomato using SCFE system
6. To study microwave system and to evaluate the effect of different power on drying characteristics of selected vegetable product
7. To study microwave blanching of fruits and vegetable and determination of blanching efficacy
8. To study the ultrasonicator and evaluate the effect of ultrasonication on micro-organism present in idli batter
9. To study the ultrasonicator and to evaluate the effect of ultrasonication on extracted juice yield from fruit pomace
10. To evaluate the different pre-treatment on oil yield from oil seed cake
11. To study cryogenic grinding of selected spices
12. To compare the yield and quality of bioactive compounds obtained from cryogenically ground spice
13. To prepare nano emulsion and study of their characteristics
14. To study ohmic heating system and to study the processing of fruit pup using ohmic heating system
15. To visit food industries utilizing advance food processing techniques

Suggested Readings

Barbosa-Canovas 2002. *Novel Food Processing Technologies*. CRC.
Dutta AK & Anantheswaran RC.1999. *Hand Book of Microwave Technology for Food Applications*.
Frame ND. (Ed.). 1994. *The Technology of Extrusion Cooking*. Blackie.
Gould GW. 2000. *New Methods of Food Preservation*. CRC.

FPT 503 Brewing Technology **3 (2+1)**

Unit No.	Content	Lectures
1	Introduction of brewing, history of brewing; Raw materials: barley, hops, water, yeast; Adjuncts for beer production: Maize, rice, millet, wheat, sugar etc	02 02
2	Malt production, role of enzymes for malting; Barley storage, steeping, germination, kilning, cooling, storage; Malt from other cereals, caramel malt, roasted malt, smoked malt, malt extract; Malt quality evaluation	02 02
3	Wort production, malt milling, Mashing, Mashing vessels; Wort boiling, clarification, cooling and aeration Enzyme properties, starch degradation, b-glucan degradation; Conversion of fatty matter, Biological acidification	02 02 02
4	Beer production methods, fermentation technology, changes during fermentation; Filtration procedure and equipment, beer stabilization conditions and durations, beer carbonation process; Packaging equipment and packaging materials, storage conditions and distribution process	02 02 02
5	Brewing Equipments. Grain mill, kettles, siphons, carboys, fermentation equipment, wort chillers, pumps beer bottles, cans, labels, bottle caps, sanitation equipments	02
6	Preventive Production of beer against technology, ling phenomenon of beer, possible measures against staling reactions, oxidation Recent advances: Immobilized Cell Technology in Beer Production, immobilized yeast cell technology	02 02 02
7	Energy management in the brewery and maltings; waste water treatment Automation and plant planning	02 02

List of Practicals

1. Preparation of raw material for malting
2. To check enzyme activity for malting
3. Preparation of malt from barley
4. Preparation of malt from other cereals
5. To study physico-chemical properties of malt
6. Dry and wet milling of malt
7. Preparation of wort
8. Bio-chemical analysis of wort
9. To study beer fermentation
10. Preparation of beer
11. Chemical and physical properties of beer
12. Beer flavor and sensory assessment
13. Microbial analysis of beer
14. Packaging and storage study of beer
15. Visit to beer manufacturing industry
16. Visit to malt manufacturing industry

Suggested Readings

Dennis E. Briggs, Chris A. Boulton, Peter A. 2004, Brewing: science and practice, Brookes and Roger Stevens, Woodhead publishing limited

Wolfgang Kunze. 2010, Technology: brewing and malting, Bibliographic information published by Die Deutsche Bibliothek

Hans Michael Eßlinger**.** 2009, Handbook of Brewing: Process, Technology, Markets, Wiley-VCH Verlag GmbH & Co.KgaA

Charles W. Bamforth. 2006, Brewing: New Technologies, Woodhead Pub.

FPT 504 Carbohydrate Technology **3 (2+1)**

Unit No.	Contents	Lectures
1	Carbohydrates: introduction, classification Carbohydrate structure, functions, chemical, physical and rheological properties	02 02
2	Use of carbohydrates in food industries: role of sugar, liquid sugar, starches, starch hydrolyzates, pectin, invert sugar Role of Carbohydrates in confectionery, beverage industry; Role of Carbohydrates in frozen foods, meat processing, role of sweeteners in food flavours, sugar in human nutrition	02 02 02
3	Dietary fibers and their role in human health. The role of dietary fiber in the prevention of lipid metabolism disorders; Polydextrose as soluble fiber and complex carbohydrate to reduce calorie intake. Complex carbohydrates as fat mimetics. Carbohydrates as prebiotics	02 02
4	Important polysaccharides – Structures, properties and utilization: Agar, Alginates, Carrageenans, Furcellaran, Gum Arabic, Karaya Gum, Guaran Gum, Locust Bean Gum, Tamarind Flour, Pectin, Dextrins, Inulin and Oligofructose.	02
5	Role of Carbohydrates as food additives, (bulking agents, emulsifiers, stabilizers, sweeteners, gelling and textural agent, carriers of flavor, hydrocolloids)	02 02
6	Industrial production of plant carbohydrates and the impact on human health & nutrition, Functional food ingredients, Pectins, carrageenans and other hydrocolloids; Glucans and arabinoxylans, Fibre function, resistant starch and health	02 02
7	Starch-lipid composites, starch-protein blend and its applications, Thermoreversible gels from grain; Heart-healthy foods from modified carbohydrate Carbohydrate arrays (Glycan array)	02 02
8	Analysis of carbohydrates using various analytical methods- HPLC and others: Methods for the analysis of dietary fiber and complex Carbohydrates, resistant starch; NIR Analysis of dietary fiber	02 02

List of Practical

1	Tests for reducing sugars by rapid tasters
2	Estimation of total sugars in foods
3	To study sugar inversion process
4	Analysis of starch content
5	To study process of retrogradation
6	Food product development using carbohydrate additives
6	Gelatinization of starches form various food sources
7	Estimation of amylase enzymes in food
8	Estimation of dietary fibres in given food sample
9	To study modification of starch
10	NIR analysis of dietary fibre
11	Analysis of resistant starches
12	HPLC analysis of carbohydrates
13	Sensory evaluation of various sweeteners
14	Estimation of psyllium content in ready-to-eat cereals
15	Estimation of various carbohydrates forms ready to eat foods
16	Preparation of fibre enriched bread

Suggested Readings

1. Damodaran, S., Parkin, K. L., and Fennema, O.R. (2008) Fennema's Food Chemistry 4th Edition, CRC Press
2. Belitz, H-D., Grosch, W. & Schieberle, P. (2004) Food Chemistry 3rd Ed. (translation of fifth German edition), Springer

Atkins, P. (1997) The Elements of Physical Chemistry, W.H. Freeman & Co.

FPT 505 Enzymes in Food Processing **3(2+1)**

Unit No.	Content	Lectures
1	Enzymes: Introduction, classification, properties, characterization, Enzyme kinetics- enzyme concentration, substrate concentration, environment conditions and enzyme immobilization Enzymes in food industry: commercialization of enzyme processes, alternative method to use the enzymes, types of reaction Sources of enzymes, legal and safety implications	02 02 02 02
2	Enzymes in milk production: Enzymes in milk preservation, lactose hydrolysis, Use of enzymes for determining milk quality enzymes in cheese manufacturing: Endogenous microbial enzymes, exogenous enzymes, Coagulant technology, enzymes in cheese preservation	02 02 02
3	Enzymes in beverage: Application of enzymes in tea and cocoa processing Application of enzymes in alcoholic beverages as beer, whisky, wine and ciders. Role of the enzymes in fruit juice production, factors affecting the enzymatic activity. Enzymatic clarification of apple and guava juices, factors affecting the clarity of fruit juices.	02 02 02 02
4	Enzymes in baking industry: Introduction, Enzymes for baking industry, , Use of the proteinases, lipases and pentosans in baking industry, Starch degrading enzymes: sources, analysis and application of starch degrading enzymes Hemicellulase: sources, analysis and application	02 02 02
5	Enzymes in the processing of fats and oils: specificity, stability and application of lipases and related enzymes Role of enzymes in hydrolysis of triglycerides, interesterification and randomisation	02 02

List of Practicals

1. To assay enzymes for activity and specific activity
2. To study enzyme kinetics
3. To study the starch and protein hydrolysis by enzymes
4. To study the individual effect of temperature, pH and storage on stability of enzyme
5. To study the combine effect of temperature, pH and storage on stability of enzyme
6. To study the role of enzyme in cheese making
7. To study the enzyme added extraction of fruit juices
8. To study the enzyme added clarification of juices
9. To study the applications of enzymes in baking
10. To study the role of enzyme in hydrolysis of triglycerides
11. To carry out crude extraction of bromelain from pineapple
12. To carry out crude extraction of papain from papaya
13. To carry out immobilization of enzyme
14. To study the effect of enzyme in extraction of oil from oil seed and compare it with traditional method.

Suggested Readings

Flickinger MC & Drew SW. 1999. *Encyclopedia of Bioprocess Technology*. A Wiley- Inter Science Publ.
Kruger JE. *et al*. 1987. *Enzymes and their Role in Cereal Technology*. American Association of Cereal Chemists Inc.
Nagodawithana T & Reed G. 1993. *Enzymes in Food Processing*. Academic Press.
Tucker GA & Woods LFJ. 1991. *Enzymes in Food Processing*.
Whitehurst R & Law B. 2002. *Enzymes in Food Technology*. Blackwell Publ.

FPT-506 Flavour Technology **3 (2+1)**

Unit No.	Content	Lectures
1	Basics of flavour, smell and taste sensation, olfaction, flavor compounds, volatile flavor compounds	02
2	Methods of flavour extraction, isolation, separation; Distillation, solvent extraction, enzymatic extraction, static headspace, dynamic headspace etc	02 02
3	Principal types of flavorings used in foods, natural flavoring substances, Flavour constituents from Onion, garlic, cheese, milk, meat, vegetables, fruits; Flavour constituents of wine, coffee, tea, chocolate, spices and condiments	02 02
4	Nature-identical flavoring substances (Flavoring substances that are obtained by synthesis or isolated through chemical processes, which are chemically and organoleptically identical to flavoring substances naturally present in products intended for human consumption. They cannot contain any artificial flavoring substances. Artificial flavoring substances (Flavoring substances not identified in a natural product intended for human consumption, whether or not the product is processed. These are typically produced by fractional distillation and additional chemical manipulation of naturally sourced chemicals, crude oil or coal tar. Although they are chemically different, in sensory characteristics are the same as natural ones.)	02 02
5	Aroma compounds, flavour chemical components (buttery : Diacetyl, Acetylpropionyl, Acetoin, Banana: Isoamyl acetate, Bitter almond, Cherry: Benzaldehyde, cinnamon: Cinnamaldehyde, fruity: Ethyl propionate, etc.) Food acids their tastes and flavours (Glutamic acid salts, Glycine salts, Guanylic acid salts, acetic acid, malic acid etc)	02 02
6	Creating and formulating flavor, Synthetic flavours, Blended flavouring, flavour creation for new products, Biotechnological flavour generation Flavour legislation, Modelling flavour release, Useful principles to predict the performance of polymeric flavour delivery systems, Delivery of flavours from food matrices Instrumental methods of analysis, On-line monitoring of flavour processes, Sensory methods of flavour analysis, Brain imaging	02 02 02
7	Fragrance oil (Vanilla, Mandarin orange, Cinnamon, Lemongrass, Rosehip, Peppermint etc.) essential oil flavour	02
8	Effect of processing on organoleptic quality of food, flavour precursors flavour development on cooking, microwave heating, roasting, baking, smoking, boiling, cooling, freezing, storage Maillard reaction, caramalization, fermentation	02
9	Off flavour, off odour, bad smell	01
10	Principles and techniques of flavour encapsulation, types of encapsulation; Factors affecting stabilization of encapsulated flavour and their applications in food industry; Packaging and flavor compounds interaction, Effect of storage, processing, transportation and environmental conditions on flavour components / constituents	02 01

List of Practicals

1. Qualitative identification of different flavouring compounds
2. Extraction of essential oil/ flavouring compound of basil leave by hydrodistillation
3. Extraction of essential oil/ flavouring compound of basil leave by SCFE
4. Comparison of the quality of flavouring component obtained by hydrodistillation and SCFE
5. Extraction of essential oil/ flavouring compound of ginger by SCFE
6. Effect of storage conditions on flavouring compound of ginger
7. To study effects of staling on food flavours and its adverse effects
8. Analysis of flavouring compound of ginger by gas chromatography system
9. Sensory evaluation of different flavors
10. To check effect of cooking on flavor of food sample
11. To check effect of fermentation on food flavor

12. To study sugar caramalization reaction for flavor development
13. Development of blended food flavor based products
14. To study effects of storage conditions on food flavor
15. Encapsulation of flavouring compounds
16. To study effects of overdoses of flavors
17. To study flavor development on roasting/ baking

Suggested Readings

1. Reineccius, G. Source Book of Flavors
2. Heath, H. B. Flavour chemistry and technology
3. Piggott, J. R., Paterson, A. Understanding Natural Flavors.
4. Morton, I. D., Macleod A. J. Food Flavor
5. Yamanishi, T. Recent advances in flavour researches
6. Gabelman, A. Bioprocess Production of Flavor
7. Ashurst P. R. Fragrance, and Color Ingredients Food Flavorings.

FPT 507 Food Product Development 2 (2+0)

Unit No.	Content	Lectures
	Intro, Overview, Food Ingredients, Functional properties of ingredients	02
1	Consumer and market trends, Consumer survey questionnaire. Reasons for innovation in food industry, Ideation and Evaluation of Ideas, Strategies and Tactics Preliminary market analysis, Marketing and Market Segments Teams, Organizations, and Structures	02 02 02 02
2	Guidelines for detailed study of market, product, and process	02
3	Small versus large food processors, Small Business Administration	02
4	Food package development	02
5	Preliminary processing evaluation	02
6	Food quality and health aspects in product development, Legal aspects of new products, health claims, and nutraceuticals Legal Issues in Product Development	02 02 02
7	Open Innovation Stage Gates Processes Innovation in the Brewing Industry, Innovation in the Bakery Industry Innovation in the Cheese and Dairy Industry Stability Testing of Foods	02 02 02 02

Reference Book

Brody, A.L. and Lord, J. 2008. Developing New Food Products for a Changing Marketplace, 2nd Edition. CRC Press, Boca Raton, FL.

Campbell-Platt, G. 2009. Food Science and Technology. Blackwell Publishing Ltd., Oxford, UK.

deMan, J.M. 1999. Principles of Food Chemistry, 3rd Ed. Aspen Publishers, Gaithersburg, MD.

Fuller, G.W. 2011. New Food Product Development, 3rd Edition. CRC Press, Boca Raton, FL.

Moskowitz, H., Saguy, I. S., and Straus, T. 2009. An Integrated Approach to New Food Product Development. CRC Press, Boca Raton, FL.

Murano, P. 2003. Understanding Food Science and Technology. Wadsworth/Thompson Learning, Belmont, CA.

FPT 508 Food Rheology and Microstructure 3 (2+1)

Unit No.	Content	Lectures
1	Introduction to rheology of foods: Definition of "texture", "rheology" and "psychophysics" – their structural basis; physical considerations in study of foods; salient definitions –Stress tensor and different kinds of stresses.	02
2	Rheological classification of fluid foods : Shear-rate dependence and time dependence of the flow-curve; Non-Newtonian fluids; thixotropy; Mechanisms and	03

	relevant models for non-Newtonian flow; Effect of temperature; Compositional factors affecting flow behaviour; Viscosity of food dispersions – dilute and semi-dilute systems, concentration effects.	03
3	Rheology of semi-solid and solid food; Rheological characterization of foods in terms of stress-strain relationship; rheology and flow characteristics of food powders, Viscoelasticity; Transient tests - Creep Compliance and Stress Relaxation Mechanical models for viscoelastic foods: Maxwell, Kelvin, Burgers and generalized models and their application; Dynamic measurement of viscoelasticity.	03 03
4	Large Deformations and failure in foods: Definitions of fracture, rupture and other related phenomena; Texture Profile Analysis; Instrumental measurements – Empirical and Fundamental methods; Rheometers and Texture Analyzers; Measurement of Extensional viscosity; Acoustic measurements on crunchy foods.	03
5	Rheological and textural properties of selected food products: Measurement modes and techniques; Effect of processing and additives (stabilizers and emulsifiers) on food product rheology; Relationship between instrumental and sensory data.	03
6	Examining food microstructures: history of food microstructure studies, light microscopy, transmission electron microscopy, scanning electron microscopy, other instrumentation and techniques, image analysis: image acquisition, image processing, measurement analysis.	03 03
7	Food structure: traditional food structure and texture improvement, approaches to food structure, extrusion and spinning, structured fat products, structure and stability, gels, gelation mechanisms, mixed gels, the microstructure of gels, structure-property relations in gels.	06

List of Practicals

1. Viscosity measurements of fruit juices using ostwald visometer
2. Viscosity measurements of liquid food products using Brookefield viscometer
3. To study the effect of temperature on viscosity of liquid foods
4. Development of stress and strain curve for Newtonian fluids
5. Development of stress and strain curve for Non Newtonian fluids
6. Determination of thermal conductivity of selected food products
7. Determination of specific heat of selected food products using differential scanning calorimetry (DSC)
8. Texture analysis of fruits, vegetables and their products
9. Texture analysis of baked products (bread/ biscuit)
10. Starch characterization using starch master
11. Dough rehology using doughlab
12. Preparation of food emulsions and their stability study
13. Preparation of food gels and their characteristics
14. Determination of microstructures in selected foods using light microscopy
15. TEM and SEM, image analysis and image processing techniques
16. Evaluation of phase transition in colloidal systems, evaluation of structure texture function relations
17. To correlate subjective sensory evaluation with textural analyzer
18. Visit to food microstructure laboratory

Suggested Readings

Barbosa-Canovas GV, Kokini JL, Ma L & Ibarz A. 1997. *Rheology of Semi-liquid foods*. *Adv. Food & Nutr. Res*., 39:1-69.

DeMann JM, Voisey PW, Rasper VF & Stanley DW. 1976. *Rheology and Texture in Food Quality*. AVI Publ.

Aguilera JM. 2001. *Micro Structure: Principles of Food Processing Engineering.*

Bechtel DB. 1983. *New Frontiers in Food Microstructure*. American Association of Cereal Chemists.

Moskowitz 1999. *Food Texture.* AVI Publ.

Stefee J.F. Rehological methods in food process engineering. Freeman Press.

FPT 509 Functional Foods and Nutraceuticals 3(2+1)

Unit	Content	Lecture
1	Introduction to nutraceuticals: definitions, synonymous terms, basis of claims for a compound as a nutraceutical, regulatory issues for nutraceuticals including CODEX	02
	Classification of functional food, concept of angiogenesis and the role of nutraceuticals/functional foods	02
2	Functional food and nutraceuticals for management of cholesterol, cardiovascular diseases, compounds and their mechanisms of action, dosage levels	02
	Functional food and nutraceuticals for diabetes, compounds and their mechanisms of action, dosage levels	02
3	Functional food and nutraceuticals for management of cancer, compounds and their mechanisms of action, dosage levels	02
	Functional food and nutraceuticals for obesity and weight management, compounds and their mechanisms of action, dosage levels	02
	Functional food and nutraceuticals for joint pain, age-related macular degeneration, compounds and their mechanisms of action, dosage levels	02
	Functional food and nutraceuticals for endurance performance and mood disorders compounds and their mechanisms of action, dosage levels	02
4	Manufacturing aspects of selected nutraceuticals such as lycopene, isoflavonoids, glucosamine, phytosterols etc.	02
	prebiotics their health benefits and selection criteria and types;	02
	probiotics their health benefits and selection criteria and types;	02
	Synbiotics food formulations and their health benefits	02
	Formulation of functional foods containing nutraceuticals – stability and analytical issues, labelling issues.	03
5	Antioxidants, dietary fiber and their health benefits	02
	Clinical testing of nutraceuticals and health foods; interactions of prescription drugs and nutraceuticals; adverse effects and toxicity of nutraceuticals	03

List of Practicals

1. Market survey of existing health foods
2. Identification and estimation of lycopene
3. Identification and estimation of carotene
4. Determination of total antioxidant capacity of selected nutraceuticals
5. Determination of gamma oryzanol content in rice bran oil
6. Determination of tocopherol content in rice bran oil
7. Determination of tannin content, ascorbic acid content in aonla juice
8. Development of protein enriched biscuits as a functional food
9. Production of functional food for diabetic patient
10. Determination of dietary fibre content in selected functional food
11. Preparation of symbiotic yoghurt/ dahi and its sensory and microbiological evaluation
12. Production of flavonoid rich food product and evaluation of flavonoid content in it
13. Development of labels for health foods
14. Production of carotenoids from pumpkin powder
15. Production of ginger and turmeric oleoresins and their used in food products
16. Visit to Functional food/ Nutraceuticals manufacturing industry

Suggested Readings

Cupp J & Tracy TS. 2003. *Dietary Supplements: Toxicology and Clinical Pharmacology*. Humana Press.

Gibson GR & William CM. 2000. *Functional Foods - Concept to Product*.

Losso JN. 2007. *Angi-angiogenic Functional and Medicinal Foods*. CRC Press.

Neeser JR & German BJ. 2004. *Bioprocesses and Biotechnology for Nutraceuticals.* Chapman & Hall.

Robert EC. 2006. *Handbook of Nutraceuticals and Functional Foods*. 2nd Ed. Wildman.

Shi J. (Ed.). 2006. *Functional Food Ingredients and Nutraceuticals: Processing Technologies*. CRC Press.

Webb GP. 2006. *Dietary Supplements and Functional Foods*. Blackwell Publ.

Tomar S.K. 2011. *Functional Dairy Foods Concepts and Applications*. Satish Serial Publishing House, Delhi.

Mingruo Guo. 2009. *Functional food: principle and technology.* CRC Press .Woodhead publishing limited. New Delhi.

FPT 510 Lipid Technology **3 (3+0)**

Unit No.	Content	Lectures
Unit 1	Sources of Lipid: Plant, Animal, Microbial, Marine	03
Unit 2	Structure function relation to food, polymorphism of fats; plasticity of edible oil and fat, lipid- protein and lipid-saccharide interactions	02 02 02
Unit 3	Oil and fat processing- Extraction/ rendering, refining, degumming, Bleaching, filtration, hydrogenation, inter-esterification, winterization, Dewaxing, fractionation, blending, deodorization, packaging and handling finished fat	02 02 02
Unit 4	Bakery Fat- functions of fat in cake, pastry and biscuit; Quality parameters for shortening; Liquid shortening and powdered fat	02 03
Unit 5	Salad dressing- types and categories- pourable, spoonable etc., Ingredients and manufacturing process of mayonnaise, salad cream, French dressing	02 03
Unit 6	Fat for chocolate and sugar confectionery- Properties and processing of cocoa butter; Fat bloom in confectionery- causes and control	02 02
Unit 7	Spreadable fats- types- margarine, sweet and svaoury spreads; Ingredients and process technology	02 02
Unit 8	Culinary fats and speciality oils- selection criteria of a frying fat Process Technology for powdered or beaded fat; Fat flakes;	02 02
Unit 9	Quality analysis of fats and oils Food reformulation to reduce saturated fats- biscuits, savoury snacks, pastry and confectionery	04 03
Unit 10	Structured lipids and fats	03

Suggested Readings

Food Chemistry, O.R. Fennema, Ed., 2008. Marcel and Dekker, Inc., New York, NY.

Bailey's Industrial Oil & Fats Products, Ed. by Y.H. Hui, John Wiley & Sons, Inc

Akoh, C. C. and Min, D. B. 2002. Food Lipids: Chemistry, Nutrition, and Biotechnology. Marcel Dekker, Inc. Newyork.

Gunstone, F. D. 2006. Modifying lipids for use in food. Woodhead Publishing Limited

Gunstone, F. D. 2008. Oils and fats in the food industry. Wiley-Blackwell

Talbot, G. 2011. Reducing saturated fats in foods. Woodhead Publishing Limited

Rajah, K.K. 2002. Fats in Food Technology. Sheffield Academic Press Ltd

FPT 511 Management of By-products & Wastes **2 (2+0)**

Unit No.	Content	Lectures
1	Waste generation in food industry, Classification of waste from food industry-fruits and vegetable processing; baking industry; grain processing industry; snack food industry; meat processing abattoir; BOD and	02 02
2	Technologies for separation of waste-Physical, chemical and advance technologies Physical- screening; sedimentation; flotation; centrifugation; filtration; adsorption; hydro-cyclones etc. Chemical- precipitation; coagulation etc. Advanced Processes- reverse osmosis, ion-exchange; electro-coagulation; ultrafiltration; electrodiaysis; supercritical fluid extraction	02 02 01 03
3	Process optimization to minimise water use in food processing	02
4	Super critical extraction and other technologies for extraction of high-value food processing co-products	02
5	Membrane and filtration technologies and the separation and recovery of food processing waste	02

Suggested Readings

Waldron K. 2007 Handbook of waste management and co-product recovery in food processing Vol 1. Woodhead Publishing Limited, Cambridge, England

FPT 512 Membrane Technology in Food Processing 2 (2+0)

Unit No.	Content	Lectures
1	Membrane techniques: Introduction, principle and classification	02
	Membrane characterization: Physical and chemical characteristics of membrane, components of a membrane processing system	02
	Construction materials of membrane- cellulosic and non-cellulosic membrane, configuration of membranes	02
	Techniques for membrane preparation	02
	Functionality and selection of membrane,	02
2	Applications of membranes for concentration and separation of food products	02
	Factors affecting membrane fouling, flux enhancement and fouling control	
	Membrane maintenance-Physical and chemical cleaning, mechanism and efficiency of cleaning and sanitization,	02 02
3	Ultrafiltration and Nano filtration: concept and working principle Vs conventional filtration,	02
	Application in the food industry- fruit juices, soy sauce, vegetable oil. Reverse osmosis, and microfiltration: concept and working principle, Application in the food industry- fruit juices, milk. Whey processing soy sauce, vegetable oil.	02 02
	Developments in the manufacture and utilization of food grade lactose from UF permeate.	02
	Use of membrane in preparation of-organic acids, biopolymers, vitamins, amino acids, low lactose powder, casein etc.	02
4	Membrane technology for food processing waste treatment- concept and working, membrane bioreactor and its application	02
	Emerging application of membrane processing(osmo-distillation): Introduction, concept and working	02 02
	Various commercial application and future trends	

Suggested Readings

Cui Z.F. and Muralidhara H.S. 2010. *Membrane Technology A Practical Guide to Membrane Technology and Applications in Food and Bioprocessing*. Butterworth-Heinemann (imprint of Elsevier), Oxford, UK
Cheryan M.1998. *Ultrafiltration and Microfiltration Handbook*. Technomic Publ. House.
Zadow JG. 1994. *Whey and Lactose Processing*. Elsevier

FPT 513 Protein Technology 3 (3+0)

Unit No.	Content	Lectures
1	Survey of protein availability and world's protein need. Present status of proteins in food industry	02
	Classification of proteins by structure or function; Chemical and functional properties of proteins in food systems,	02
	Modification of chemical and functional properties of food proteins, Protein interactions with other food constituents	02
2	Rheological properties of protein- solubility, viscosity, gelling, surfactants	03
	Proteins functionality test- Model foods for testing- foam, gelation, emulsification (Whipped topping, Angel cake)	03
3	Milk proteins- casein: Structure and properties, manufacture of casein based ingredients,	02
	Use and application of casein based ingredients, interaction with other ingredients	02
4	Cereal protein- Gluten: formation, properties and modification and food applications (bread, biscuit, pasta),	02
	Gluten manufacturing process, use and application of gluten	02
5	Soy protein- structures and functional properties of β-conglycinin and glycinin, production technology for soy protein isolate;	02
	Application of soy proteins as food ingredients, improving soy protein functionality	02
6	Gelatin: Introduction, manufacturing process, regulations and standard quality test methods, chemical composition and physical properties,	02
	Gelatin derivatives, application of gelatin	02

7	Textured vegetable proteins and spun fiber technology, types of textured vegetable proteins, Processing of raw materials for texturization, Application of textured vegetable proteins	02 03
8	Protein gels – types (egg protein, myosin, surimi etc.), mechanism of formation Protein based film and coating manufacturing techniques Application of protein based films for fried foods, nut and nut containing product, minimally processed vegetables	03 02 02
9	Potato proteins: Introduction, physico-chemical properties, functionality, potato protein isolation, application and uses	02
10	Single cell protein- significance, historical evolution in production, harvesting and commercialization, functional properties , utilization	02
11	Protein as antifreeze agent- evolution and structures, mechanism of action, application Taste modifying proteins- types, methods of extraction and purification	02 02

Suggested Readings

Yada, R. Y. 2004. Proteins in food processing. Woodhead Publishing Limited and CRC Press LLC

Gennadios, A. 2002. Protein-Based Films and Coatings. CRC Press LLC

Mine, Y. and Shahidi, F. 2006. Nutraceutical Proteins and Peptides in Health and Disease, CRC Press Taylor & Francis Group

Phillips. G.O and Williams.P.A. 2011. Handbook of food proteins, Woodhead Publishing Limited, New Delhi.

Encyclopedia of Food Science, Food Technology and Nutrition. 1993. Vols. I-VII, Academic Press.

Fennema OR. 1985. Food Chemistry. Marcer Dekker.

Fox PF. 1983. Development in Dairy Chemistry. Vol. II. Applied Science Publ.

Fox PF. 1992. Advanced Dairy Chemistry. Vol I. Proteins. Elsevier.

Macrac R, Robinson RK & Sadler MJ. 1993. IDF Special Issue 9303.

Walstra P & Jenness R. 1984. Dairy Chemistry and Physics. John Wiley & Sons.

Thompson**.** Abby, Boland, Mike and Harjinder Singh. 2009. Milk Proteins:from Expression to Food. Academic Press is an imprint of Elsevier.

FPT 514 Sensory Evaluation 2 (1+1)

Unit No.	Content	Lectures
1	Introduction to sensory analysis; general testing conditions, Requirements of sensory laboratory; Organizing sensory evaluation program, Development of sensory testing, human subjects as instruments (test design, instrumentation, interpretation of results)	02 01
2	Sensory attributes, appearance (colour, size and shape, surface texture, clarity, carbonation), odour/ aroma/ fragrance, consistency and texture, noise Human senses (sense of vision, sense of touch, olfactory sense, sense of taste, sense of hearing)	02
3	Test controls, test room design, location, the booth, descriptive analysis and training area, preparation area, storage General design factor, colour and lightning, air circulation, temperature and humidity, construction material Sample preparation, supplies and equipment, materials, preparation procedure, sample preparation, order, coding, number of samples, product sampling	02 01
4	Panelist control, Panel training orientation, Factors affecting sensory verdicts, physiological factors, psychological factors, poor physical condition,	02
5	Different tests for sensory evaluation, Difference (Qualitative test: Paired comparison, duo-Trio, Triangle test) Rating (Quantitative: Ranking, single, two and multiple sample, hedonic, Numerical scoring, composite), Sensitivity (Threshold, dilution)	02 01
6	Applications and Advances in Electronic-Nose Technologies, Aroma Types and	02

	Characteristics, Conceptual Development of the Electronic Nose and instrumentation, Data Analysis for Electronic Noses, E nose applications	
7	Computer-aided sensory evaluation of food & beverage, statistical analysis of sensory data.	01

List of Practicals

1. Selection and training of sensory panel
2. Detection and threshold tests
3. To study the masking effect of different taste
4. To study Paired comparison test
5. To study Duo-Trio test
6. Ranking tests for taste, aroma colour and texture
7. To study hedonic rating test
8. Sensory evaluation of various food products using hedonic scales
9. Sensory evaluation of various food products using different scales, score cards and tests
10. Sensory evaluation of various food products using fuzzy logic
11. Objective estimation of color and texture
12. Subjective estimation of color and texture
13. To study single sample test
14. Statistical analysis of single sample test
15. To study two sample difference test
16. Statistical analysis of single sample test

Suggested Readings

1. Amerine MA, Pangborn RM & Rossles EB. 1965. *Principles of Sensory Evaluation of Food.* Academic Press.
2. Early R.1995. *Guide to Quality Management Systems for Food Industries*. Blackie Academic.
3. Jellinek G. 1985. *Sensory Evaluation of Food - Theory and Practice*. Ellis Horwoood.
4. Lawless HT & Klein BP. 1991. *Sensory Science Theory and Applications in Foods*. Marcel Dekker.
5. Maslowitz H. 2000. *Applied Sensory Analysis of Foods*. Vols. I, II. CRC Press.
6. Morten C. Meilgaard, B. 2007. Sensory Evaluation Techniques, Fourth Edition. Thomas Carr, Gail Vance Civille
7. Piggot JR. 1984. *Sensory Evaluation of Foods*. Elbview Applied Science Publ.
8. Rai SC & Bhatia VK. 1988. *Sensory Evaluation of Agricultural Products.*Indian Agricultural Statistics Research Institute (ICAR).
9. Stone H & Sidel JL. 1985. *Sensory Evaluation Practices*. Academic Press.
10. Watts CM, Ylimaki CL, Jaffery LE & Elias LG. 1989. *Basic SensoryMethods for Food Evaluation*. Int. Dev. Res. Centre, Canada.

FPT 515 Technology for RTE/RTC Food Products 3 (2+1)

Unit No.	Content	Lectures
1	Overview of grain-based snacks: whole grains – roasted, toasted, puffed, popped and flakes	02
	Coated grains-salted, spiced and sweetened	02
	Flour based snack– batter and dough based products; *savoury* and *farsans*; formulated chips and wafers, papads.	02
2	Technology for fruit and vegetable based snacks: chips, wafers, papads etc.	02
	Technology for coated nuts – salted, spiced and sweetened products- *chikkis,Sing bhujia*	02
	Technology of ready to eat fruits and vegetable based food products like, sauces, fruit bars, glazed candy etc.	02
	Technology of ready to eat canned value added fruits/vegetables and mixes and ready to serve beverages etc.	02
3	Technology of ready- to- eat baked food products, drying, toasting roasting and flaking, coating, chipping	02
	Extruded snack foods: Formulation and processing technology, colouring, flavouring and packaging	02

4	Technology for ready-to-cook food products- different puddings and curried vegetables etc. Technology for ready-to-cook and ready to eat meat and meat food products	02 02
5	Technology for preparation of instant cooked rice, carrot and other cereals based food products Technology of ready to eat instant premixes based on cereals, pulses etc.	02 03
6	Technology for RTE puffed snack- sand puffing, hot air puffing, explosion puffing, gun puffing etc. Technology for preparation of traditional Indian dairy products	02 03

List of Practicals

1. Preparation of cereals based fried snack foods
2. Preparation of legume based fried snack foods
3. Preparation of cereal, pulses based ready-to-eat snack food by extrusion cooking their quality evaluation
4. Preparation of cereal grain based puffed products
5. To study the effect of frying time and temperature on potato chips
6. Development of instant food premixes
7. Preparation of cereal and legume based roasted snack
8. Preparation of flaked rice product
9. To study the effect of roasting time and temperature on quality of pop-corn
10. Determination of shelf-life and packaging requirements of snack food products
11. Preparation of fruits/vegetable based ready to serve beverages and quality evaluation
12. Preparation of canned fruits and vegetables products and quality evaluation
13. Preparation of pumpkin powder added cookies and quality evaluation
14. Preparation of pumpkin Tutti-frutti/petha
15 Preparation of pickle using natural preservatives
16. Visit to industries manufacturing snack foods.

Suggested Readings

Edmund WL. *Snack Foods Processing*. AVI Publ.
Frame ND .1994. *Technology of Extrusion Cooking*. Blackie Academic.
Gordon BR.1997 *Snack Food*.AVI Publ
Samuel AM.1976. *Snack Food Technology*. AVI Publ.
Kamaliya M.K and Kamaliya K.B. 2001.*Baking science and Industries* , Vol.1 and 2, M.K.Kamaliya Publisher,Anand.
Lal Girdhari, Siddappaa.G.S, and TandonG.L. 1998. *Preservation of fruits and vegetables*. Indian Council of Agricultural Research, New Delhi.
Chavan U.D. and Patil J.V. 2013. *Industrial Processing of Fruits and Vegetables***.** Daya Publishing House New Delhi.
Duncan Manley**.**2000**.** *Technology of Biscuits,Crackers And Cookies*. CRC Press .Woodhead PublishingLimited, Cambridge, England.

FPT 516 Technology of Food Emulsions, Foams and Gels 3 (2+1)

Unit No.	Content	Lectures
1	Food dispersions, their characteristics and factors affecting food dispersions.	02
2	Food emulsions- conventional and nano emulsions; emulsifiers and their functions in foods; HLB concept in food emulsifiers; Emulsion formation and stability; Examples of emulsions in food- mayonnaise, sauce, beverages Polymers and surfactants.	02 02 02 02

3	Foam morphology- dry and wet, Structure of foams- ordered and disordered, foam formation and stability, Foam ripening and coalesce, Advantage and disadvantages of foam in food processing, Foam generation, Foaming agents, antifoaming agents Egg foams and uses, milk foams and their applications,	02 02 02 02
4	Theory of gel formation; pectic substances and jellies; fruit pectin gels; fruit jellies.	02
5	Structure of foods representing emulsions, foams and gels; Physical structure of fat rich, concentrated, fermented, coagulated and dried products.	02 02
6	Techniques for evaluation of structure for food emulsions, foams and gels.	02
7	Application of foams in other food processing application Case study foam mat drying	02 02

List of Practicals

1. Determination of the rate of formation and stability of emulsions
2. Determination of creaming index for an emulsion
3. Determination of emulsion stability index of emulsifier
4. Determination of emulsion capacity of an emulsifier
5. Determination of HLB value for an emulsifier
6. Preparation of mayonnaise (o/w emulsion)
7. To study role of emulsifier food emulsions
8. To carry out ringing test for beverage emulsions
9. Particle size characterization in beverage emulsion
10. To examine foam formation and determination of foam stability
11. To study foaming in food systems (Foam mat drying to product instant tomato powder)
12. To study gel formation and gel properties
13. Preparation of gelatine based food gels
14. Preparation of pectin based food gels
15. To study properties of various gelling agents for foods.

Suggested Readings

Blanshard JMV & Lillford P. 1987. *Food Structure and Behaviour*. Academic Press.
Haseuhuetti GL.1977. *Food Emulsifiers and their Application*. Chapman & Hall.
McClement DJ.1999. *Food Emulsions - Principles, Practice and Techniques*. CRC Press.
Srinivas D & Alain P.1977. *Food Proteins and their Applications*. Marcel Dekker.

FPT 517 Technology of Frozen Foods 2 (2+0)

Unit No.	Content	Lectures
1	Glass transitions in frozen foods and biomaterials, Microbiology of frozen foods, Thermophysical properties of frozen foods, Freezing loads and Freezing time calculation, Innovations in freezing process	02 02
2	Freezing methods and equipment, Cold store design and maintenance, Transportation of frozen foods, Retail display equipment and management, Household refrigerators and freezers, Monitoring and control of the cold chain.	04 04
3	Quality and safety of frozen vegetables, Quality and safety of frozen fruits, Quality and safety of frozen dairy products, Quality and safety of frozen ready meals, Quality and safety of frozen bakery products Quality and safety of frozen meat and meat product, Quality and safety of frozen poultry and poultry products, Safety and quality of frozen fish, Shellfish, and related products, Quality and safety of frozen eggs and egg products	04 04
4	Chemical Measurements, Sensory analysis of frozen foods, Foodborne illnesses and detection of pathogenic microorganisms, Shelf-life prediction of frozen foods.	02 04
5	Introduction to frozen food packaging, Plastic packaging of frozen foods, Paper and card packaging of frozen foods, Packaging of frozen foods with other materials, Packaging machinery	04 02

Suggested Readings

Marilyn C. Erickson, Yen-Con Hung. *Quality in Frozen Foods*
Isabel Guerrero Legaretta. *Handbook of Frozen Foods*
Kennedy Chris J *Managing Frozen Foods* CBS, New Delhi

FPT 518 Traditional and Value Added Food Products 3 (2+1)

Unit No.	Content	Lectures
1	Present status of traditional food products	02
	Globalization of traditional food products; Plans and policies of the Government and developmental agencies.	02
2	Overview of heat-desiccated, coagulated, fried, fermented traditional food products	02
	Process technology for Indian bread (chapatti), paratha, stuffed paratha, pani poori	
	Process technology for Indian fried foods- poori, samosa, sev, fafda, chorafali, Jalebi	02
	Process technology for fermented traditional food and its improvement- pickle, idli, khaman, nan, dahi, dhokla, Handvo, Spiced buttermilk etc.	02
	Process improvement in production of Indian sweets (Halwasan, kaju katli, carrot halwa, Rabdi, chocolate burfi,Chikki etc).	02
	Process improvement in production of puffed cereals and grains by microwave technique	02
3	New products based on fruits, vegetables and cereals	02
	Application of membrane technology; microwave heating, steaming, extrusion for industrial production of traditional food products (Shrikhand, Dhokla, wadi, murukku/chakri, Patra, Khandvi)	03
	Utilization and scope of legumes and grains in India for novel food products development like- flour, ready to eat products, flour mixes etc (puranpoli, Idlimix, Wadamix, Gotamix)	02 02
4	Process technology for convenience traditional food products (ready to eat and serve- Curried vegetables, pulses and legumes and Undhiyu etc.), chutneys, paste	03
	Use of natural and permitted synthetic preservatives and new packaging systems for traditional food products	03
5	Techno-economic aspects for establishing commercial units for traditional products.	03

List of Practicals

1. To study the effect of different combination of salt and oil in quality of traditional fermented food product (pickle)
2. To study the effect of different starter culture on taste and texture of idli
3. To evaluate the shelf life of stuffed paratha under different storage conditions
4. To study the effect of time and temperature on quality of fried food products (poori/ pani poori etc.
5. To study effect of sugar and Artificial sweetners in the preparation of kaju katli
6. To study the microwave heating in drying of khaman/ dhokla
7. To study the effect of cold extrusion on mixing of vermicilli
8. To prepare instant carrot halwa mix
9. To study the effect of different packaging material on shelf life of traditional Indian food products
10. To study the effect of different natural food preservatives in traditional sweets
11. Preparation of spiced buttermilk
12. Preparation of puffed cereals and grains
13. Preparation and quality evaluation of Instant Premixes (Puranmix)
14. Preparation of quality evaluation of dried malted moth bean powder
15. Preparation of Indian traditional confections (chikki)
16. Visit to ethnic food industry (Instant mixes/Pickle making)

FPT 519 Advances in Dairy Processing 3 (2+1)

Unit No.	Content	Lectures
Unit 1	Use of bio-protective factors for preservation of raw milk: effects on physicochemical, microbial and nutritional properties of milk and milk products, present status of preservation of raw milk by chemical preservatives; thermal processing for preservation	04
Unit 2	Methods of determining lethality of thermal processing, UHT processed milk products, their properties and prospects, types of UHT plants, aseptic fillers, heat stability and deposit formation aspects, effect on milk quality; techno- economic considerations; retort processing.	06
Unit 3	Principles and equipment for bactofugation and Bactotherm processes, Microfluidization of milk: Principle, equipment, effects and applications, Homogenization and their applications in dairy industry.	05
Unit 4	Dehydration: advances in drying of milk and milk products; freeze concentration, freeze dehydration: physicochemical changes during freeze drying and industrial developments.	05
Unit 5	Water activity; sorption behaviour of foods, energy of binding water, control of water activity of different milk products in relation to their chemical; microbiological and textural properties; hurdle technology and its application in development of shelf-stable and intermediate-moisture foods, Use of carbonation in extending the shelf life of dairy products.	06
Unit 6	Current trends in cleaning and sanitization of dairy equipment: biological; detergents; Automation; Ultrasonic techniques in cleaning; bio-detergents, development of sanitizers- heat; chemical; radiation, mechanism of fouling and soil removal; Bio-films, assessing the effectiveness of cleaning and sanitization of dairy products.	06

List of Practicals

1 LP system for extension of keeping quality raw milk.
2 Determination of pH: HCT profile of milk systems.
3 Measurement of thiocyanate in milk system.
4 Determination of water activity and sorption isotherms of milk products.
5 Determination of thermal load during retort processing of milk and milk products.
6 Heat classification of milk powders.
7 Functional properties of powders: porosity, interstitial air content, occluded air content, flowability.
8 Determination of degree of browning-chemical/physical methods.
9 Freeze drying of milk/milk products, and heat sensitive products.
10 Homogenization efficiency.
11 Cleaning efficiency in dairy equipment.
12 Thermal process calculations.
13 Visit to a UHT Processing plant.

Suggested Readings

Burton H. 1998. *Ultra-high Temperature Processing of Milk and Milk Products*. Elsevier.
Fellow P. 1988. *Food Processing Technology*. Elliss Horwood Ltd.
Gould GW. 1995. *New Methods of Food Preservation*. Blackie.
IDF Bulletin 1981. *New Monograph on UHT Milk*. Document No. 133, Intern. Dairy Fed., Brussels.
Smit G. 2003. *Dairy Processing – Improving Quality*. CRC-Woodhead Publ.
Troller JA & Christian HB. 1978. *Water Activity and Food, Food Science and Technology*. A Series of Monograph Academic Press, London.
Walstra P, Geurts TJ, Noomen A, Jellema A & Van Boekel MAJS. 1999. *Dairy Technology – Principles of Milk Properties and Processes*. Marcel Dekker.

SUPPORTING COURSES

AG. STAT. 512 EXPERIMENTAL DESIGNS 3(2+1)

Objective

This course is meant for students of agricultural and animal sciences other than Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

UNIT I	Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.
UNIT II	Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.
UNIT III	Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.
UNIT IV	Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ Lattice design, alpha design - concepts, randomisation procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.
UNIT V	Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation.

Practicals

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Analysis of resolvable designs; Fitting of response surfaces.

Suggested Readings

Cochran WG & Cox GM. 1957. *Experimental Designs* . 2nd Ed. John Wiley.
Dean AM & Voss D. 1999. *Design and Analysis of Experiments* . Springer.
Federer WT. 1985. *Experimental Designs* . MacMillan.
Fisher RA. 1953. *Design and Analysis of Experiments* . Oliver & Boyd.

AG. STAT. 531 DATA ANALYSIS USING STATISTICAL PACKAGES 3(2+1)

Objective

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students an hands on experience in the analysis of their research data. This course is useful to all disciplines.

Theory

UNIT I	Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.
UNIT II	Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, *t* and *F* statistics.
UNIT III	Concept of analysis of variance and covariance of data for single factor, multi-factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.
UNIT IV	Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.
UNIT V	Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data; Spatial analysis; Neural networks.

Practical

Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data. Robust Estimation, Testing linearity and normality assumption, Estimation of trimmed means etc., Cross tabulation of data including its statistics, cell display and table format and means for different sub-classifications; Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample *t* -test, two sample *t* -test, paired *t* -test, test for large samples - Chi-squares test, F test, One way analysis of variance, contrast and its testing, pairwise comparisons; Multiway classified analysis of variance - cross-classification, nested classification, factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components; Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets - maximum likelihood, ANOVA, REML, MINQUE; Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models - curve estimation models, examination of residuals; Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis - obtaining principal component, spectral composition; Analysis of time series data - fitting of ARIMA models, working out moving averages. Spatial analysis; Neural networks.

Suggested Readings

Anderson CW & Loynes RM. 1987. *The Teaching of Practical Statistics* . John Wiley.
Atkinson AC. 1985. *Plots Transformations and Regression* . Oxford University Press.
Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. *Graphical Methods for Data Analysis* . Wadsworth, Belmount, California.
Chatfield C & Collins AJ. 1980. *Introduction to Multivariate Analysis* . Chapman & Hall.
Chatfield C. 1983. *Statistics for Technology* . 3rd Ed. Chapman & Hall.
Chatfield C. 1995. *Problem Solving: A Statistician's Guide* . Chapman & Hall.
Cleveland WS. 1985. *The Elements of Graphing Data* . Wadsworth, Belmont, California.
Ehrenberg ASC. 1982. *A Primer in Data Reduction* . John Wiley.
Erickson BH & Nosanchuk TA. 1992. *Understanding Data* . 2nd Ed. Open University Press, Milton Keynes.
Snell EJ & Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses* . Chapman & Hall.
Sprent P. 1993. *Applied Non-parametric Statistical Methods* . 2nd Ed. Chapman & Hall.
Tufte ER. 1983. *The Visual Display of Quantitative Information* . Graphics Press, Cheshire, Conn.
Velleman PF & Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis* . Duxbury Press.
Weisberg S. 1985. *Applied Linear Regression* . John Wiley.
Wetherill GB. 1982. *Elementary Statistical Methods* . Chapman & Hall.
Wetherill GB.1986. *Regression Analysis with Applications* . Chapman & Hall.
Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
Course on Experimental design:
http://www.stat.sc.edu/~grego/courses/stat706/.
Design Resources Server: www.iasri.res.in/design.
Analysis of Data: Design Resources Server.
http://www.iasri.res.in/design/Analysis%20of%20data/Analysis%20of%2 Data.html.

AG. STAT 573 STATISTICAL QUALITY CONTROL 2 (2+0)

Objective

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agribusiness and agro-processing industries. This course would enable the students to have an idea about the statistical techniques used in quality control. students who do not have sufficient background of Statistical Methods.

Theory

UNIT I	Introduction to Statistical Quality Control; Control Charts for Variables – Mean, Standard deviation and Range charts; Statistical basis; Rational subgroups.
UNIT II	Control charts for attributes- _np‘, _p‘ and _c‘ charts.
UNIT III	Fundamental concepts of acceptance, sampling plans, single, double and sequential sampling plans for attributes inspection.
UNIT IV	Sampling inspection tables for selection of single and double sampling plans

Suggested Readings

Cowden DJ. 1957. *Statistical Methods in Quality Control* . Prentice Hall of India.
Dodge HF & Romig HG. 1959. *Sampling Inspection Tables* . John Wiley.
Duncan A.J. 1986. *Quality Control and Industrial Statistics* . 5th Ed. Irwin Book Co.
Grant EL & Leavenworth RS. 1996. *Statistical Quality Control* . 7th Ed. McGraw Hill.
Montgomery DC. 2005. *Introduction to Statistical Quality Control* . 5th Ed. John Wiley.
Wetherhil G.B. 1977. *Sampling Inspection and Quality Control* . Halsted Press.

BIOCHEM 601 BIOCHEMISTRY OF CEREALS, OILSEEDS AND PULSES 2(2+0)

Theory

Biochemical changes during germination, development and maturation of cereals, oilseeds and pulses, Chemical composition and nutritive values of cereals (rice, wheat, maize, sorghum and bajra), oilseeds (groundnut, cotton seed, castor, sesamum rape and mustard) and pulses crop (bengal gram, pigeonpea). Phytotoxin, aflatoxins, gossypol, naturally occurring protenase inhibitors and other plant toxins. Chemical changes and nutritional deterioration in infested cereals, oilseeds and pulses crop. Prospect of genetic upgrading of grain quality.

Practical

Proximate analysis, essential amino acids fatty acids profile, antinutritional factors, biochemical changes during seed development and germination.

BE – 501 Non- conventional Sources of Energy 3 (2+1)

S. No.	Topics of Lectures
Unit 1	Classification of energy sources; Introduction to renewable energy sources and technologies, their importance for sustainable development and environmental protection, production and potential.
Unit 2	Solar radiation, measurement of solar radiation, types of solar collectors and their uses, solar thermal energy conversion and storage
Unit 3	Solar PV cells, modules, arrays, conversion process of solar energy into electricity, applications.
Unit 4	Wind energy, potential & process of conversion, types of wind energy conversion systems
Unit 5	Characterization of biomass; briquetting of biomass, biomass combustion, pyrolysis, gasification, types and uses of gasifiers,.
Unit 6	Importance of biogas technology, production mechanism, types of biogas plants, uses of biogas, handling & utilization of digested slurry.
Unit 7	Brief introduction to geothermal energy, wave energy, ocean thermal energy conversion,

Practical	Title
1	Demonstration of solar cooker
2	Demonstration of solar water heater
3	Demonstration of solar dryer
4	Demonstration of solar still
5	Demonstration of solar radiation measuring instruments
6	Demonstration of solar PV system
7	Demonstration of wind measuring instruments
8	Study of wind mill
9	Estimation of moisture content of biomass
10	Determination of calorific value of biomass
11	Estimation of ash content of biomass
12	Estimation of fixed carbon and volatile matter of biomass

13	Demonstration of up draft gasifier
14	Demonstration of down draft gasifier
15	Demonstration of working of a fixed dome type biogas plants
16	Demonstration of working of a floating drum type biogas plants

Suggested Readings

Rai, G.D. 2013. Non-Conventional Energy Sources, Khanna Publishers, Delhi.
Rai, G.D., Solar Energy Utilization, Khanna Publishers, Delhi.
Khandelwal, K.C. & S. S. Mahdi. 1990. Biogas Technology- A Practical Handbook.
Rathore N. S., Kurchania A. K., Panwar N. L. 2007. Non Conventional Energy Sources, Himanshu Publications.
Tiwari, G.N. and Ghoshal, M.K. 2005. Renewable Energy Resources: Basic Principles and Applications. Narosa Pub. House. Delhi.
Rathore N. S., Kurchania A. K., Panwar N. L. 2007. Renewable Energy, Theory and Practice, Himanshu Publications.

BE – 502 Environmental Engineering 3 (2+1)

S. No.	Topics of Lectures
Unit 1	Introduction, earth's environment, ecology and various ecosystems.
Unit 2	Bio-geochemical cycle, hydrological cycle, carbon cycle, nitrogen cycle, sulphur cycle, energy flow in ecosystem, food chains & food webs, ecological pyramids, major ecosystems, bio-diversity
Unit 3	Natural Resources, water resources - surface & ground water sources, uses & overuses of water resources, problems due to overexploitation of water resources.
Unit 4	Water pollution: water quality standards, sources of water pollution, classification & effects of water pollutants, effluent treatment plant, working, waste management in food processing industry, BOD, COD, air pollution & its control.
Unit 5	Food behavior and spoilage in storage, economical aspects of fruit and vegetable storage, modified atmospheric storage and control of its environment, storage sanitation.
Unit 6	Storage of grains, moisture and temperature changes in stored grains; conditioning of environment inside storage, drying, grain storage structures, silo and control of environment inside silo.
Unit 7	Introduction to green house, type's classification and its applications.

Practical	Title
1	Study of the Earth's atmosphere and hydrosphere
2	Study of Lithosphere & biosphere
3	Study of major ecosystems of the earth
4	Study of energy resources
5	Determination of pH of a given sample.
6	Determination of electric conductivity of a given sample
7	Determination of total solids of a given sample
8	Determination of total dissolves solids of a given sample.
9	Determination of hardness of a given water sample.
10.	Determination of total settable solids of a given sample
11.	Estimation of BOD exerted by the given waste water sample
12	Estimation of COD exerted by the given waste water sample
13-14	Visit of an effluent treatment plant in a food processing industry
15	Study of types of storage systems for fruits & vegetables
16	Study of various types of greenhouses and its environmental control

Suggested Readings

Gilbert M. Masters and Wendell P. Ela. 2013. Introduction to Environmental Engineering and Science. Pearson Education Limited, NY, USA.
Suresh K. Dhameja. 2009. Environmental Engineering and Management. S. K. Kataria & Sons, New Delhi.

Bernard J. Nebel and Richard T. Wright. 1993. Environmental Science: The Way the World Works. Prentice-Hall Professional, New Delhi.

DT 512 ADVANCED FOOD PROCESSING 4(3+1)

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

Theory

UNIT I	Status of food processing industry in India and abroad; prospects and constraints in development of Indian food industry.
UNIT II	Post-harvest management of fruits and vegetables, Harvesting indices, Biochemical and physical changes during ripening of fruits & vegetables, respiration and factors affecting it, role of ethylene in accelerated ripening, post-harvest treatments for extension of shelf-life of fresh produce, Strategic interventions to minimize post-harvest losses including vapour heat treatment, wax coating, chemicals, etc.
UNIT III	Principles of chilling & refrigeration storage of foods, quality changes in cold stored products, controlled and modified atmospheric storage. Freezing of foods, principle and equipments for freezing, defects in frozen foods, re-crystallization, freezing of fruits and vegetables, freeze concentration of fruit juices.
UNIT IV	Application of heat energy to foods for preservation and processing, concept of drying rate of foods, industrial drying processes of foods; changes during drying, advanced drying processes (Freeze drying, infra-red drying and microwave drying), Canning of fruits & vegetables, unit processes involved in canning, types of cans for thermal processing of foods.
UNIT V	Basic principles involved in fermentation, Technological aspects of pickled vegetables like sauerkraut, cucumbers, Technology of wine, beer and distilled alcoholic beverages, defects in alcoholic beverages.
UNIT VI	Conversion of muscle into meat, rigor mortis, freezing and canning of meat, curing & smoking of meat, fermented sausages, cooking of poultry, utilization of milk ingredients in processed meat and poultry products.
UNIT VII	Advances in milling of rice (solvent extractive milling) and Turbo milling of wheat. Bakery products; role of ingredients, Developments in manufacturing processes for bakery products such as breads; biscuits; pizza bases, cake etc; changes during processing of bakery products. Utilization and importance of dairy ingredients in bakery products.
UNIT VIII	Definition, classification and technologies of fabricated and formulated foods and their nutritional aspects. Imitation dairy products and dairy analogues. Principle of extrusion processing, design and working of extruder, classification, application in food and dairy processing. Food additives, including stabilizers, emulsifiers, antioxidants, preservatives, etc. for formulated foods.
UNIT IX	Important group of enzymes involved in food processing; Application of enzymes in food processes like enzymes juice extraction, juice clarification, in bread manufacture, meat tenderization, ice cream manufacture, de- sugaring of egg, etc.
UNIT X	Newer concepts in food processing including organic foods, processing of organic raw material, genetically modified foods.

Practicals

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

Suggested Readings

Fellows PJ. 2000. *Food Processing Technology: Principles and Practices*.
2nd Ed. CRC-Woodhead Publ.

Fennema CR. 1975. *Principles of Food Science.* Part II. *Physical Principles of Food Preservation.* Marcel Dekker.
Guy R. 2001. *Extrusion Cooking: Technologies and Applications*. CRC- Woodhead Publ.
Honseney RC. 1986. *Cereal Science and Technology*. American
Association of Cereal Chemists, St. Paul, Minnesota.
Hui YH, Meunix-Goddick L, Hansen AS, Josephsen J, Nip WK, Stanfield PS & Toldra F. 2004. *Handbook of Food and Beverage Fermentation*. Marcel Decker.
Hui YH, Nip WK, Rogers RW & Young DA. 2001. *Meat Science and Application*. Marcel Decker.

DT 522 ADVANCED DAIRY AND FOOD PACKAGING 3(2+1)

Objective

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

Theory

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

Practicals

Testing of packaging materials for quality assurance like determination of thickness, GSM, grease resistance, bursting strength, tearing resistance, WVTR, puncture resistance; estimation of shelf life of vegetables and seasonal fresh fruits; packaging of turmeric powder and ground red chilli powder, vacuum packaging of dairy products.

Suggested Readings

Carol F, Steinhart M, Ellin D, Barbara A & Cochrane. 1995. *Food Safety*. Marcel Dekker.
Coles R, McDowell D & Kirwan M.J. 2003. *Food Packaging Technology*. Oxford Blackwell.
Frank A, Paine H & Paine Y. 1983. *A Handbook of Food Packaging*. Leonard Hill.
Gordon L Robertson. 2006. *Food Packaging: Principles and Practice*. 2nd Ed. CRC Press.
Malhlouthi M. 1994. *Food Packaging and Preservation*, Blackie. Raija A. 2006. *Novel Food Packaging*. Woodland Publ. Co.

DT 621 PRODUCT MONITORING AND PROCESS CONTROL 3 (3+0)

Objective

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

Theory

I	The concept of Product-Process Monitoring in dairy and food industries: Definition of "quality"; Optimization paradigm; Quality-prediction model based on quality kinetics and process state equations – Simulation modeling. Process/Product Optimization: Optimization procedures – Search methods, Response surface, Differentiation & Programming methods; Neural Networks; Optimization software.
II	Process Control: Objectives; Control loop – Loop elements and their functions; Modes of

	process control; Control techniques; control equipment.
III	Real-time Instrumentation : Sensors; their classification based on Proximity, working principle; examples of applications in process control; Requirements of on-line sensors; Biosensors – Construction, types, working principles, applications, merits and limitations; Time-temperature indicators – partial-history & full-history indicators; Commercial devices; Applications and limitations; E-Nose & E-Tongue – Simulation of natural organs; Components & their functions; Applications.
IV	Flavour analysis: Flavour bioassays – Gas Chromatography-Olfactometry techniques; Isolation, Separation and detection/Identification of flavour compounds – GC-MS, LC-MS, NMR, FTIR; analysis of chiral compounds.
V	Formation of flavour compounds in milk and milk products during heat processing (including UHT processing, caramelization and extrusion cooking), fermentation and ripening (cultured. products and cheese flavour, with special reference to bitteness) and storage (Maillard browning); Aroma losses/retention during the drying process (in relation to milk powder, cheese powder and dry cultured products); Industrial processes for extraction of desirable and undesirable volatile components from fresh and/or stored products by supercritical fluid (SCF) technique.
VI	Monitoring of Food Structure: (a) Application of Thermal Analysis (DTA and DSC vis-a-vis dilatometry) and Pulse Nuclear Magnetic Resonance (PNMR) spectroscopy in determination of solid-fat content (SFC) of butter in relation to various processing and storage aspects; Glass transitions in dairy products; Starch gelatinization.
VII	Monitoring of Food Structure: (b) Elucidation of crystal characteristics of milk fat in ghee and other fat-rich products by means of X-ray Crystallography with reference to the impact of cooling and storage/handling conditions on the crystal nature and product texture; Process-induced changes in sub-microscopic particulate properties of milk products; structure-texture relationship.
VIII	Monitoring of Food Structure: (c) Influence of heat processing and freezing treatments on protein denaturation and other conformational as well as aggregation-disaggregation phenomena as monitored through Spectropolarimetry, Circular Dichroism and related techniques.
IX	Monitoring of Food Structure: (d) Particle-size analysis: Image analysis; Dynamic light scattering; Laser diffraction; Sieving, and other techniques.
X	Emerging Spectroscopic techniques in assessment of foods : Raman Spectroscopy and Electron Spin Spectroscopy – Working principles and applications - Monitoring of irradiated foods, detection of lipid auto- oxidation, etc.; Microwave & NIR absorption/reflection methods for Compositional analyses – Automated milk analysers; Proximate principles in cheese and milk powder.
XI	Ultrasound in product monitoring: Speed- and Attenuation-based measurements of liquid levels, density, mass flow, etc.
XII	Monitoring of Chemical Contaminants: Heavy metal quantification by Atomic Absorption Spectrophotometer; Quantification of Agrochemicals by HPLC; Spectrofluorimetric determination of mycotoxins; Detection and quantification of Drug Residues.
XIII	Colour Characterization : Colour and appearance (gloss and translucence) monitoring through visual colorimeter, tri-stimulus colorimeters and reflectance spectrophotometer, CIE, Hunter-Lab, Munsel and other systems of three-dimensional expression of colour; Colour-based Sorting of foods; Computer Vision – Principles, applications and Benefits.
XIV	Objective Assessment of Subjective food-quality characteristics - Pitfalls and Promises

Suggested Readings

Acree TE & Teranishi R. 1993. *Flavour Science: Sensible Principles and Techniques*. Amer. Chem. Soc., Washington.

Bartlett PN, Elliott JM & Gardner JW. 1997. *Electronic Noses and their Application in the Food Industry*. Food Technology: 51 (12) 44-48. Davenel A. 1996. On-line Control and Problems with Sensors. In: *Quality Control for Foods and Agricultural Products.* (J.L. Mutton, Ed.). VCH Publ., London.

Acree TE & Teranishi R. 1993. *Flavour Science: Sensible Principles and Techniques*. Amer. Chem. Soc., Washington.

Bartlett PN, Elliott JM & Gardner JW. 1997. *Electronic Noses and their Application in the Food Industry*. Food Technology: 51 (12) 44-48. Davenel A. 1996. On-line Control and Problems with Sensors. In: *Quality Control for Foods and Agricultural Products.* (J.L. Mutton, Ed.). VCH Publ., London. Kress-Rogers E & Brimelow CJB. (Eds.). 2001. *Instrumentation and Sensors for the Food Industry*. CRC Press, Woodhead Publ. Ltd. Mann CMD & Jones AA. I994. *Shelf-life Evaluation of Foods*. Blackie. Peleg M & Bagley EB. 1983. *Physical Properties of Foods*. AVI Publ. Schartel BJ & Firstenberg ER. 1988. *Biosensors in the Food Industry: Present and Future*. *J. Food Protect*. 51(10): 811-820.

FBM 501 Computer application in food industry **3(2+1)**

Unit	Topics	Lecture
Unit 1	Importance of computerization in food industry, operating environments and information systems for various types of food industries, principles of communication	2
Unit 2	Supervisory Control and Data Acquision (SCADA): Introduction to SCADA, SCADA systems hardware and firmware, SCADA systems software and protocols, landlines, local area network systems, modems, central site computer facilities	2
Unit 3	Spreadsheet Applications: Data entry, interpretation and solving problems; Cells, cell reference, functions, preparation of charts, use of macros to solve engineering problems; use of add-ins, use of solver etc	4
Unit 4	Web hosting and Webpage Design: Domain registration, web hosting, webpage design using web publishing software; Introduction to File Transfer Protocol (FTP); Online food process control from centralized server system in processing plant	2
Unit 5	Use of Matlabs in Food Industry: Introduction, MATLAB interactive sessions, computing with MATLAB, Script files and editor/debugger; MATLAB help system, problem solving methodologies; Numeric, cell and structure array; Arrays, multidimensional arrays, element by element operations ; Matrix operations, polynomial operations using arrays, cell arrays, structure arrays; Functions and Files in MATLAB: Elementary mathematical functions, user defined functions; Advanced function programming, working with data files; Programming using MATLAB, Program design and development, Relational operators and logical variables, Logical operators and functions, Conditional statements, loops, the switch structure, debugging MATLAB programs, applications to simulation Plotting and Model Building in MATLAB; XY plotting functions, subplots and overlay plots, special plot types, interactive plotting in MATLAB, function	
	discovery, regression, the basic fitting interface, three dimensional plots; Introduction to Toolboxes useful to Food Industry: Curve fitting toolbox, Fuzzy logic toolbox, Neural Network toolbox, Image processing toolbox, statistical toolbox	10
Unit 6	Introduction to CFD Applications in Food Industry: Introduction to Computational Fluid Dynamics (CFD), governing equations of fluid dynamics. Models of flow, substantial derivative, divergence of velocity, continuity, momentum and energy equations. Physical boundary conditions, discretization. Applications of CFD in Food and beverage industry. Introduction to CFD softwares, GAMBIT and Fluent softwares	8
Unit 7	Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.	4

List of Practicals

1	Introduction to various features in different spreadsheet softwares	1
2	Solving problems using functions in spreadsheets	2
3	To use Add-Ins in spread sheet and statistical data analysis using Analysis Tool pack	1
4	Introduction to MATLAB and practice sessions	2
5	To solve problems using Curve fitting toolbox in MATLAB	1
6	To solve problems using Fuzzy logic toolbox in MATLAB	1
7	To solve problems using Neural Network toolbox in MATLAB	1
8	To solve problems using Image processing toolbox in MATLAB	1
9	Introduction to GAMBIT software	1
10	Creation of Geometry for laminar flow through pipe using GAMBIT	1
11	Introduction to FLUENT software	1

12	Import of geometry and application of boundary conditions	1
13	To solve a problem on laminar flow using FLUENT	1
14	Use of software packages for summarization and tabulation of data	1

Suggested Readings

1. David Bailey and Edwin Wright. *Practical SCADA for Industry*. Elsevier
2. William J. Palm. *Introduction to MATLAB 7 for engineers*. McGraw Hill Professional
3. Da Wen Sun. *Computation Fluid Dynamics in Food Processing*. CRC press
4. Jenny Chapman. *Web Design: A Complete Introduction*. John Wiley & Sons
5. Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall.
6. Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
7. Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
8. Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
9. http://www.iasri.res.in/design/Analysis of data/Analysis of Data.html.
10. Fundamentals of Food Process Engineering by R.T.Toledo. Published by Springer
11. Introduction to Web Design Using Microsoft FrontPage by Glencoe/McGraw-Hill Published by Glencoe/McGraw Hill

FBM 502 Operations Management **2(2+0)**

Unit	Topics	Lecture
Unit 1	An overview of Operations Management: Operations Management: Introduction and Overview, Historical Evolution - Changes & Challenges	2
	Concept of Production, Production System, Classification of Production System	2
	Objectives and Scope of Operations Management	1
	Productivity, Factors Affecting Productivity	1
Unit 2	Operations Strategy: Strategic Role of Operations, Strategic Planning	1
	Product Strategy and integrated product development, Process Strategy	1
	Characteristics of decision and decision methodology	1
	Capacity Planning Decisions	1
	Facilities Location Strategies	1
Unit 3	Product Design and Process Selection: Product design	1
	Process design	1
	Process technology and its choices	1
	Plant Layout, Classification of layout	1
	Job design and work organization	1
Unit 4	Planning and managing operations: Demand Forecasting	2
	Value chain and Supply chain Management	2
	Purchasing, vendor selection and material management, Inventory Management & Just-in-Time Systems	2
	Materials Requirement, Planning and ERP Scheduling, sequencing and dispatching	1
	Project planning and control	1
Unit 5	Managing Quality: What is quality and why is it so important?	1
	Statistical process control (SPC), Measuring and improving performances, Failure detection and analysis	2
	Total Quality management, Value analysis and Value Engineering	1
	Statistical Quality Control	1
Unit 6	The Operations Challenges: Why challenges? Globalization, Corporate social responsibility, Environmental responsibility, Technology, Knowledge management	3

Suggested Readings

Chary SN (2004), Production and Operations Management, Tata Mc Graw Hill III Edition.

Anil Kumar, S and Suresh, N (2009), Operations Management, New Age International (P) Ltd., Publishers, New Delhi

Slack, N, Chambers, S and Jhonston, R (2007) Operations Management, Pearson Education Ltd., Essex, UK

Joseph G. Monks(1997), Operations Management Theory and Problems, Mc. Graw Hill III Edition

FBM 504 Advances in statistical methods in food processing 3(2+1)

Unit 1	Applications of statistical procedures in food processing, Descriptive statistics, Analysis of differences, Types of significance test, Association, correlation and regression and Experimental design
Unit 2	Sensory and consumer data: Introduction, The quality and nature of sensory and consumer data, Experimental design issues, Consumer data (sensory and survey), Trained panel sensory data, Analysis of relationships
Unit 3	Instrumental data: Introduction, Quality and nature of instrumental data, Sampling and replication, Experimental design issues, Statistical analysis of instrumental data, Chemical analysis applications, Analysis of relationships
Unit 4	Food product formulation: Introduction, Design application in food product development, Single ingredient effects, Two or more ingredients, Screening of many ingredients, Formulation by constraints
Unit 5	Statistical quality control: Introduction, Types of statistical quality control, Sampling procedures, Control charts, Acceptance sampling
Unit 6	Multivariate applications: Introduction, Multivariate methods and their characteristics, Multivariate modes, Relationship of consumer preference with sensory measures
Unit 7	Principal component analysis, Chemometrics, Partial least square, Response surface methodology, Mixture design, Fractal analysis, Cluster analysis, ANN and Fuzzy logic

List of Practicals

1. Applications of dimensionality reduction and discriminant function analysis
2. Nonparametric tests.
3. Analysis of qualitative data
4. Analysis of data having random effects using Linear mixed effects models
5. Classification and prediction using artificial neural networks
6. Analysis of data with missing observations
7. Multiple linear regression analysis
8. Partial regression coefficients
9. Residuals and their applications in outlier detection
10. Study on robust parameter design and process robustness
11. Practice with Statistical Softwares

Suggested Readings

1. John A. Bower 2013. *Statistical Methods for Food Science: Introductory Procedures for the Food Practitioner 2ed* Wiley Blackwell.
2. Barnsley M.F.1988. *Fractals Everywhere*. Academic Press, Boston.
3. Montgomery D.C. 1997. *Design and Analysis of Experiments 4ed*. Wiley
4. Everitt BS & Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.
5. Geisser S. 1993. *Predictive Inference: An Introduction*. Chapman & Hall.

FBM 505 Operation Research 2(2+0)

Unit	**Topics**
Unit 1	Introduction to operations research
	Elementary concepts and objectives of Operations Research
	Applications of Operations Research in decision making
Unit 2	Linear programming problem
	Mathematical formulation of the linear programming problem and its graphical solution
	Simplex Method
Unit 3	Transportation problem
	Definition and mathematical formulation
	Initial basic feasible solution
	Optimal solution
Unit 4	Introduction and mathematical formulation
	Solution of Assignment problem
Unit 5	Inventory control
	Introduction and general notations

	Economic lot size models with known demand
Unit 6	Replacement theory
	Introduction and elementary concepts
	Replacement of items deteriorating with time
Unit 7	Sequencing problem
	Introduction and general notations
	Solution of a Sequencing problem
Unit 8	Queuing theory
	Introduction and classification of queues
	Solution of Queuing models
Unit 9	Project planning and network analysis
	Introduction and basic definitions in Network Analysis
	Rules for drawing Network Analysis
	Critical Path Method (CPM)
	Project Evaluation and Review Technique (PERT)

Suggested Readings

1. Ackoff R. K. and Sassioni, M.W. 1978. Fundamentals of Operations Research. Wiley Eastern, New Delhi
2. Wagner, H.M. 1978. Principles of Operations Research, with Applications to Management Decisions. Prentice Hall of India, New Delhi
3. Taha, H. A. 2007. Operations Research: An Introduction. Pearson Prentice Hall, New Jersey
4. Goel, B. S. and Mittal, S. K. 1985. Operations Research. Pragati Prakashan, Meerut

FPT – 996 Research Methodology 2(2+0)

Basic concepts of research, Planning and organization of experiments for data acquisition and analysis. Type of research methods, experimental designs, equipment and principles underlying their uses. Scientific periodicals and literature related to the subject. Form and style of writing research papers, review articles, research reports and thesis. Selection of research problem and preparation and submission of research projects. Interpretation and evaluation of research data, considerations and requirements for setting up a research laboratory.

ANNEXURE- I (B)

Syllabus

of

Post Graduate Program

(M. Tech. & Ph. D.)

in

FOOD TECHNOLOGY

Specialization in

Food Process Engineering

Faculty of Food Processing Technology & Bio-Energy
ANAND AGRICULTURAL UNIVERSITY
ANAND – 388 110
March – 2017

MINIMUM CREDIT REQUIREMENTS

Subject	Masters	Doctoral
Major	**20**	**15**
Minor	**09**	**08**
Supporting	**05**	**05**
Seminar	**01**	**02**
Research	**20**	**45**
Total Credits	**55**	**75**

Compulsory Non- Credit Courses

Code	Course Title	Credits
PGS 501	Library and Information Services	0+1
PGS 502	Technical Writing and Communication Skills	0+1
PGS 503 (e course)	Intellectual Property and its management in Agriculture	1+0
PGS 504	Basic concepts in Laboratory Techniques	0+1
PGS 505 (e course)	Agricultural Research, Research ethics and Rural Development Programs	1+0
PGS 506 (e course)	Disaster Management	1+0

Food Process Engineering

S.No.	Course No	Course Title	Credits
A. MAJOR COURSES (20 credits MTech/ 15 PhD)			
1.	FPE 501	Computer aided design of food plant, machinery and equipment	3(1+2)
2.	FPE 502	Advances in food process engineering	3(2+1)
3.	FPE 503	Advances in instrumentation & process control in food industry	3(2+1)
4.	FPE 504	Thermal process engineering	3(2+1)
5.	FPE 505	Advances in dairy engineering	3(2+1)
6.	FPE 506	Engineering, textural & rheological characteristics of food materials	3(2+1)
7.	FPE 507	Advances in food refrigeration and air conditioning	3(2+1)
8.	FPE 508	Food industry energy management and auditing	3(2+1)
9.	FPE 509	Radiation in food processing	2(2+0)
10.	FPE 510	Food plant maintenance	2(1+1)
11.	FPE 511	Numerical techniques and simulation in food engineering	3(2+1)
12.	FPE 512	Post harvest management and storage engineering	3(2+1)
13.	FPE 513	Production and operations management	2(2+0)
14.	FPE 601	Transport phenomenon in food engineering	3(2+1)
15.	FPE 602	Advances in bioprocess and biochemical engineering	2(1+1)
16.	FPE 603	Product monitoring and process control	3(3+0)
17.	FPE 596/696	Special Problem	2(0+2)
18.	FPE 597	In-Plant Training	2(0+2)

B.2 MINOR COURSES : FOOD PROCESSING TECHNOLOGY			
1.	FPT 501	Advances in food packaging technology	3(2+1)
2.	FPT 502	Advances in food processing technology	3(2+1)
3.	FPT 507	Food product development	2(2+0)
4.	FPT 509	Functional foods and nutraceuticals	3(2+1)
5.	FPT 512	Membrane technology in food processing	2(2+0)
6.	FPT 514	Sensory evaluation	2(1+1)
7.	FPT 515	Technology for RTE/RTC food products	3(2+1)
8.	FPT 516	Technology of food emulsions, foams & gels	3(2+1)
9.	FPT 517	Technology of frozen foods	2(2+0)
10.	FPT 518	Traditional and value-added food products	3(2+1)

B.3 MINOR COURSES : FOOD SAFETY AND QUALITY ASSURANCE			
1.	FQA 501	Advances in analytical techniques	3(1+2)
2.	FQA 502	Food legislations, standards and food safety management systems	2(2+0)
3.	FQA 503	Food safety and risk analysis	2(2+0)
4.	FQA 504	Advances in food chemistry and nutrition	3(2+1)
5.	FQA 509	Advances in food additives & preservatives	3(2+1)
6.	FQA 510	Advances in enzyme technology	3(2+1)
7.	FQA 511	Advances in fermentation technology	4(2+2)
8.	FQA 512	Advances in food microbiology	3(2+1)
9.	FQA 513	Starter cultures and fermented dairy products	3(2+1)
10.	FQA 516	Advances in food biotechnology	3(2+1)

C. Supporting Courses			
1.	AG. STAT 531	Data analysis using statistical packages	3(2+1)
2.	ES 529	Statistics in industrial applications	4(3+1)
3.	FBM 501	Computer application in food industry	3(2+1)
4.	FBM 503	Advance mathematics	2(2+0)
5.	FBM 504	Advances in statistical methods in food processing	3(1+2)
6.	FBM 505	Operation research	2(2+0)
7.	FBM 506	Business analysis for engineers	2(2+0)
8.	FQA 501	Advances in analytical techniques	3(1+2)
9.	FQA 502	Food legislations, standards and food safety management systems	2(2+0)
10.	FQA 512	Advances in food microbiology	3(2+1)
11.	BE 501	Non- conventional Sources of Energy	3(2+1)
12.	BE 502	Environmental engineering	3(2+1)

D. Seminar			
1	FPE 531	Masters seminar	1+0
2	FPE 641	Doctoral Seminar (Minor)	1+0
3	FPE 651	Doctoral Seminar (Major)	1+0

E. Research (Thesis)			
1	FPE 541	Masters Research	20
2	FPE 641	Doctoral Research	45

Major Courses

FPE 501 3(1+2)
Computer aided design of food plant, machinery and equipment
(16 Lectures + 32 Practical)

Unit 1	Introduction - Definition of CAD/CAM, product cycle.	1
Unit 2	Automation, CPU, types of memory, input/output devices, data presentation, data and file structures, data base design, design work station.	2
Unit 3	Graphics terminal, operating devices, plotters and other output devices, CPU secondary storage, Turnkey CAD system, selection criteria, evaluation of alternative systems.	3
Unit 4	Geometric Modeling Techniques - wireframe, surface and solid modeling, Geometric transformations, Graphics standards.	4
Unit 5	CAM - Introduction to Numerical Control (NC) technology, current status of NC, Influence of NC in design & manufacturing.	3
Unit 6	Computer aided NC programming in APT language, elements of APT language, APT vocabulary, symbols, numbers and scalars, punctuation, definition, statement labels, notations for APT statement format, statements defining point, line, circle, vector, planes and curves, point to point motion	3
		16

List of Practicals

1	Preparation of manual drawings with dimensions from Models and Isometric drawings of objects and machine components	3
2	Preparation of sectional drawings of simple machine parts	3
3	Drawing of riveted joints and thread fasteners	2
4	Demonstration on computer graphics and computer aided drafting use of standard software	4
5	Computer graphics for food engineering applications	4
6	Practice in the use of basic and drawing commands on auto cad	6
7	Generating simple 2-D drawings with dimensioning using AutoCAD	8
8	Small Projects using CAD/CAM	2
		32

Suggested Readings

1. Higgins L & Morrow LC. 1977. *Maintenance Engineering Hand-Book*. McGraw Hill.
2. Keating FH. 1959. *Chromium-Nickel Austentic Steel*. Butterworths Scientific Publ.
3. Newcomer JL. 1981. *Preventive Maintenance Manual for Dairy Industry*. Venus Trading Co., Anand.
4. Stanier W. 1959. *Plant Engineering Hand-Book*. McGraw Hill.

FPE 502 3(2+1)
Advances in food process engineering
(32 Lectures + 16 Practical)

Unit 1	Engineering properties of biological materials and their significance in equipment design; processing and handling of products.	3
Unit 2	Fluid flow operations: food rheology, mechanical energy balance, piping system, flow measurement and pumping equipment	3
Unit 3	Mechanical processing: Size reduction, size enlargement, mixing and forming, conveying of solids and separations.	4
Unit 4	Heat transfer: coefficients, heat exchangers, electrical/radiation heating and applications	4
Unit 5	Mass transfer: vapour/liquid equilibria, distillations, solvent extraction, gas/liquid absorption, adsorption and ion exchange, crystallization and osmo concentration of food	5
Unit 6	Thermal processing: kinetics of thermal inactivation, heat transfer considerations, equipment, in-container sterilization, continuous-flow sterilization, pasteurization, baking, roasting and frying.	5
Unit 7	Drying: Psychrometrics, drying kinetics, dryer design, drying equipment, energy efficiency in drying	5
Unit 8	Process analysis: spreadsheet applications, heat exchanger problem formulation & solution, psychrometric calculation, fitting curves and statistical quality control	3
		32

List of Practicals

1	Determination of particle density / true density, bulk density and specific gravity of solid grains / fruits and vegetable	1
2	Determination of coefficient of friction, angle of internal friction and aerodynamic property (Terminal Velocity) of grain sample	1
3	Determination of viscosity of food materials	1
4	Study of various types of heat exchangers	1
5	Mixing – determining mixing parameters	1
6	Chemical kinetics in food processing a) Determining rate constants of zero, first order reactions and half-life of reactions	1
7	Microbial destruction in thermal processing of foods a) Determining decimal reduction time from microbial survival data b) Thermal resistance factor, z-value, in thermal processing of foods c) Determining process lethality for conduction heating food with a microorganism with a z-value d) Determining center and mass-averaging sterilizing value for a thermal process	2
8	Mechanical transport of liquid foods a) Measuring viscosity of liquid foods using a capillary tube viscometer b) Rheological properties of power law fluids	2
9	Steady state heat transfer in food processing a) Reducing heat transfer through a wall using insulation b) Selecting insulation to reduce heat loss from cylindrical pipes c) Convective heat transfer coefficient in laminar flow conditions d) Convective heat transfer coefficient in turbulent flow conditions	2
10	Transient heat transfer in food processing a) Predicting temperature in a liquid food heated in a steam jacketed kettle b) Transient heat transfer in spherical shaped foods c) Transient heat transfer in a cube	2
11	Solving simultaneous equations in designing multiple-effect evaporators	2

Suggested Readings

Saravacos G.D. & Maroulis Z.B. 2011. *Food Process Engineering Operations*. CRC Press.

Chandra P.K. & Singh R.P. *Applied Numerical Methods for Food and Agricultural Engineers*. CRC Press.

Singh R.P. *Computer Applications in Food Technology*. Elsevier Science & Technology

FPE 503 3(2+1)

Advances in instrumentation and process control in food industries

(32 Lectures + 16 Practical)

Unit 1	**Process Control**: Dynamic Behavior of first/second order systems, Response of first order systems/first order system in series. Block diagrams and transfer functions, Feedback control, P, PI, PID controllers	4
Unit 2	**Measurement of Electrical and Non Electrical Quantities** **Motion and Displacement Measurement:** Strain gages, Hall effect devices and Proximity sensors, Large displacement measurement using synchros and resolvers, Shaft encoders. **Pressure Measurement:** Mechanical devices like Diaphragm, Bellows, and Bourdon tube, Variable inductance and capacitance transducers, Piezo electric transducers, Low pressure and vacuum pressure measurement using Pirani gauge, McLeod gauge, Ionization gauge **Force and Torque Measurement**: Load cells and their applications, various methods for torque measurement. **Flow Measurement** Differential pressure meter like, Rotameter, Turbine flow meter, Electromagnetic flow meter, hot wire anemometer, Ultrasonic flow meter **Temperature Measurement:** Resistance type temperature sensors – RTD & Thermistor Thermocouples &Thermopiles, Different types of Pyrometers. Humidity measurement and	
	Moisture measurement techniques. **Liquid Level Measurement**: Resistive, inductive and capacitive techniques for level measurement, Ultrasonic and radiation methods, Air purge system (Bubbler method).	8

Unit 3	**Digital Data Acquisition systems & control** Use of signal conditioners, scanners, signal converters, recorders, display devices, A/D & D/A circuits in digital data acquisition. Instrumentation systems. Types of Instrumentation systems. Data– Acquisition system. Multiplexing systems. Modern Digital Data Acquisition system.	3
Unit 4	**Industrial Automation in food industry** **PLC, DCS and SCADA System:** Introduction, Basic parts of a PLC, Operation of a PLC, Basic symbols used in PLC realization, Difference between PLC and Hardwired systems, Difference between PLC and computer, Relay logic to ladder logic, Ladder commands, Examples of PLC ladder diagram realization, PLC timers, PLC counters and examples, Classification of PLCs, History of DCS,DCS concepts, DCS hardware & software, DCS structure, Advantages and disadvantages of DCS, Representative DCS, SCADA, SCADA hardware & software	9
Unit 5	**Image Processing applications in Food Industry** Image Processing Methodology: Images and Image Processing, Shape Analysis, Feature Detection and Object Location, Three-Dimensional Processing Application to Food Industry: Inspection and Inspection Procedures, X-Ray Inspection, Computer Vision Systems, Electronic Nose and Electronic Tongue	6
Unit 6	**Virtual Instrumentation** Introduction to LabVIEW : Virtual Instruments, Parts of VI, Project explorer, Front panel and block diagram window, Creating simple VI	2

List of Practicals

1	Study of various for measurement of pressure ,temperature, flow, level	4
2	Study of PLC and to program a PLC using Ladder programming & PLC based control of Multi process system	3
3	To make Ladder Logicdiagrams and flow sheet diagrams for control logic	3
4	Study of data loggers- computerized data acquisition and data processing	2
5	Programming and making GUI in LABVIEW	2
6	Study of SCADA Application Software/ Computerized Control of PC-PLC Based Multi-Process Control System	2

Suggested Readings

1. Process Control: Principles and Applications by Surekha Bhanot; Oxford University Press.
2. Singh .S.K., 2005. Industrial Instrumentation and Control. Second Edition. Tata McGraw-Hill Publishing Company Limited, New Delhi
3. K. Krishnaswamy and S. Vijayachitra, *Industrial Instrumentation*. New Age International (P) Limited, New Delhi.
4. Instrument Engineers' Handbook (Vol. – II) by B. G. Liptak; Pub: CRC Press
5. Mechanical & Industrial Measurements by R. K. Jain, Khanna Publications
6. Industrial Instrumentation by Rangan, Sharma, Mani
7. Principles of Industrial Instrumentation, D Patranabis, 3rd edition, Mc Graw hill

FPE 504 3(2+1)
Thermal process engineering
(32 Lectures + 16 Practical)

Unit 1	Overview of thermal operations carried out in food processing	1
Unit 2	Measurement and prediction of thermos-physical properties of foods, mass and energy balances and heat transfer considerations for thermal processing of foods	4
Unit 3	Blanching, sterilization, pasteurization and cooking criteria, concentration and evaporation, crystallization and freezing	7
Unit 4	Heat penetration in packaged foods, kinetics of thermal processing and loss of nutrients	3
Unit 5	Equipment used for batch and continuous thermal processing of foods,	8
Unit 6	Measurements for thermal process controls	2
Unit 7	Process evaluation techniques, optimization and validation of thermal processes	5
Unit 8	Thermal processing plant operation and maintenance	2

List of Practicals

1	Measurement of thermal conductivity, thermal diffusivity, emissivity and absorptivity of solid and liquid foods.	2
2	Study of various thermal processing systems i.e. radio frequency heating, microwave heating, infrared heating, instant and high-heat infusion, ohmic heating, dryers, canning line and retorts.	7
3	Use of data loggers to study thermal process.	1
4	Use of different model to optimise thermal processes.	2
5	Using computational fluid dynamics to optimise thermal processes.	1
6	Study of various packaging formats for different thermal processing.	1
7	Visit to thermal processing plants.	2

Suggested Readings

Sun Da-Wen 2006. *Thermal food processing*. CRC Press

Richardson P. 2004. *Improving the thermal processing of foods*. CRC Press

Richardson P. 2001. T*hermal technologies in food processing*. Woodhead Publishing Ltd

Sandeep K.P. 2011. *Thermal Processing of Foods: Control and Automation*. Blackwell Publishing

Holdsworth S.D. & Simpson R. 2007. *Thermal Processing of Packaged Foods*. Springer

FPE 505 3(2+1)
Advances in dairy engineering
(32 Lectures + 16 Practical)

Unit 1	Engineering properties of dairy and food materials and their significance in equipment design; processing and handling of dairy and food products.	2
Unit 2	**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.	4
Unit 3	**Thermal processing of milk and milk products:** Pasteurization; batch, flash and continuous pasteurizer, HTST pasteurizer and design principle and thermal death kinetics, care and maintenance, UHT processing of milk, quality changes during processing of milk and milk products	3
Unit 4	**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. Factors in mixing, types, operation, mixing gas, liquid and solid, heat transfer in mixers, power requirement, transmission, scale-up of models. Separation by gravity and centrifugal force, clarifiers and separators, centrifugal separator and efficiency of separation, flow rate and power consumption.	5
Unit 5	**Evaporation**: Classification, design of multiple-effect evaporator, temperature distribution, boiling point elevation, operation, feeding methods, condensate and air removal, scale formation and removal, heat and mass balance, vapor recompression, design of recovery system, selection and design of auxiliary equipment.	6
Unit 6	**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, Principle s of fluidized bed method, Types of fluidized bed drier, Drying and cooling times in fluidized bed; Freeze drying; Agglomeration, Problems of reconstitution, Methods of Agglomeration, The effect of drying on milk products. Recent advances in drying. Design data, performance and selection and design of dryer.	6
Unit 7	**Material handling**: System and devices, design of screw, belt, flight, apron conveyors, bucket elevators, power requirements, and applications, feeders and feeding mechanism.	4
Unit 8	Dairy plant production planning, operation and maintenances	2

List of Practicals

1	Studying complete set of milk receiving & storage equipments for their constructional, operational and maintenance details.
2	Studying complete set of milk pasteurizing / sterilizing and related equipments.

3	Studying complete set of fat handling equipments.
4	Studying complete set of condensing / drying equipments.
5	Studying complete set of ice-cream and frozen products equipments.
6	Studying complete set of cheese and casein equipments.
7	Detailed study of steam generating systems, their construction, operation & maintenance.
8	Detailed study of steam supply & distribution systems.
9	Detailed study of water treatment equipment, water supply & distribution.
10	Detailed study of electricity supply & distribution.
11	Detailed study of refrigeration plants, chilled water supply & distribution.
12	Detailed study of compressed air generation, supply & distribution.
13	Demonstration of various heat transfer models & equipment.
14	Studying instrumentations of milk processing plants.
15	Design calculations for selected process equipments.
16	Studying material handling equipment, building details & plant layout.

Suggested Readings

1. Das H. 2005. *Food Processing Operations and Analysis*. Asian Books.
2. Fellows PJ. 1988. *Food Processing Technology, Principle & Practices*. Ellis Horwood.
3. Toledo RT. 2007. *Fundamentals of Food Process Engineering*. Springer.
4. Ahmed T. 1997. *Dairy Plant Engineering and Management*. 4th Ed. Kitab Mahal.
5. Gary Krutz, Lester Thompson & Paul Clear. 1984. *Design of Agricultural Machinery*. John Wiley & Sons.
6. Hall CW & Davis DC. 1979. *Processing Equipment for Agricultural Products.* AVI Publ.
7. Higgins L & Morrow LC. 1977. *Maintenance Engineering Hand-Book*. McGraw Hill.
8. Stanier W. 1959. *Plant Engineering Hand-Book*. McGraw Hill.

FPE 506 3(2+1)

Engineering, textural & rheological characteristics of food materials

(32 Lectures + 16 Practical)

Unit 1	Physical characteristics of different food grains, fruits and vegetables; Shape and size, description of shape and size, volume and density, porosity, surface area. Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, methods of determination, steady state and transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, A.C. conductivity and dielectric constant, method of determination, energy absorption from high-frequency electric field.	4
Unit 2	Contact stresses between bodies, Hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of 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 products, drag coefficients, terminal velocity.	4
Unit 3	Rheological classification of Fluid Foods : Shear-rate dependence and time dependence of the flow-curve; Non-Newtonian fluids; thixotropy; Mechanisms and relevant models for non-Newtonian flow; Effect of temperature; Compositional factors affecting flow behaviour; Viscosity of food dispersions – dilute and semi-dilute systems, concentration effects.	4
Unit 4	Rheology of semi-solid and solid food ; Rheological characterization of foods in terms of stress-strain relationship; Viscoelasticity; Transient tests - Creep Compliance and Stress Relaxation Mechanical models for viscoelastic foods: Maxwell, Kelvin, Burgers and generalized models and their application; Dynamic measurement of viscoelasticity.	4
Unit 5	Large Deformations and failure in foods: Definitions of fracture, rupture and other related phenomena; Texture Profile Analysis; Instrumental measurements – Empirical and Fundamental methods; Rheometers and Texture Analyzers; Measurement of Extensional viscosity; Acoustic measurements on crunchy foods.	4
Unit 6	Rheological and textural properties of selected food products: Measurement modes and techniques; Effect of processing and additives (stabilizers and emulsifiers) on food product rheology; Relationship between instrumental and sensory data.	4
Unit 7	Examining food microstructures: history of food microstructure studies, light microscopy,	4

	transmission electron microscopy, scanning electron microscopy, other instrumentation and techniques, image analysis: image acquisition, image processing, measurement analysis.	
Unit 8	Food structuring: traditional food structuring and texture improvement, approaches to food structuring, extrusion and spinning, structuring fat products, structure and stability, gels, gelation mechanisms, mixed gels, the microstructure of gels, structure-property relations in gels.	4

List of Practicals

1. Viscosity measurements of fruit juices using ostwald visometer
2. Viscosity measurements of liquid food products using Brookefield viscometer
3. Development of stress and strain curve and to study viscosity of Newtonian and non Newtonian fluid
4. Determination of thermal conductivity and specific heat using differential scanning colorimetry (DSC)
5. Texture analysis of foods fruits and vegetables
6. Texture analysis of foods baked products (bread/ biscuit)
7. Starch characterization using starch master
8. Dough rehology using doughlab
9. Determination of microstructures in selected foods using light microscopy
10. TEM and SEM, image analysis and image processing techniques
11. Evaluation of phase transition in colloidal systems, evaluation of structure texture function relations

Suggested Readings

1. Barbosa-Canovas GV, Kokini JL, Ma L & Ibarz A. 1997. *Rheology of Semi-liquid foods. Adv. Food & Nutr. Res*., 39:1-69.
2. DeMann JM, Voisey PW, Rasper VF & Stanley DW. 1976. *Rheology and Texture in Food Quality*. AVI Publ.
3. Aguilera JM. 2001. *Micro Structure: Principles of Food ProcessingEngineering.*
4. Bechtel DB. 1983. *New Frontiers in Food Microstructure*. American Association of Cereal Chemists.
5. Moskowitz 1999. *Food Texture.* AVI Publ.

FPE 507 3(2+1)
Advances in food refrigeration and air conditioning
(32 Lectures + 16 Practical)

Unit 1	**Vapour compression refrigeration systems with multiple evaporators and compressors:** System components: compressor, Evaporators, Condensers & Expansion Devices and their functional aspects. Methods for improving COP, multiload system with single compressor, complex systems, dual compression system, system calculations, system balancing & controls, installation charging testing and maintenance of refrigeration and air conditioning	6
Unit 2	**Vapour absorption refrigeration system:** Ammonia-Water system, Li-Br system, Vapour absorption refrigeration cycle and its representation on enthalpy composition diagram; Absorption system calculations.	5
Unit 3	**Heat Pumps:** different 'heat pump circuits', analysis of heat pump cycle, Use of heat pumps in plant for energy conservation.	3
Unit 4	**Non-conventional refrigeration systems:** Steam jet refrigeration, Thermo electric refrigeration, vortex tube, cooling by adiabatic demagnetization, air refrigeration cycles.	3
Unit 5	**Design elements of Refrigeration equipments**: compressor condenser, evaporator, cooling tower, spray pond etc. Balancing of different components.	4
Unit 6	**Design of cold storage and air-conditioning systems**: types of cooling loads and their calculation, design of cold storage for food products, construction of cold storage, equipment selection, insulating materials, vapour barriers, Ice bank tank.	4
Unit 7	**Control and maintenance of a commercial refrigeration plant**: Pressure regulating valves, Thermostatic valves, LP/ HP cutouts, high to low side bypass valve, condenser water regulating valve, capacity control devices, pump down control, defrosting methods, liquid charging; General preventive maintenance of refrigeration plant.	4

Unit 8	**Transport air conditioning system:** Introduction, components of different automobile air conditioning systems	3

List of Practicals

1	To find and compare the theoretical and actual COP of a small refrigeration unit on Refrigeration Tutor.
2	Study and design of refrigeration components of a bulk milk chiller
3	Visit to a commercial refrigeration plant for cold storage/ ice bank unit and calculation of its theoretical COP by making cycle on P-h chart.
4	Calculation of theoretical work and comparing it with actual work for some specified cooling job in a commercial plant.
5	Study of various control and safety devices in a commercial refrigeration plant.
6	Design problems on cold storage for different food/ dairy products.
7	Use of Computer software specific to cold store AC design
8	Study the working of an actual heat pump system.
9	Study the working of an actual cryogenic system.
10	Study and design of space air distribution
11	Study and maintenance of chiller and cooling tower
12	Analysis of complete vapour compression refrigeration systems
13	Study of evaporative, winter and all year air conditioning systems

Suggested Readings

Andrew D Althhouse & Carl H. Turnquist 1958. *Modern Refrigeration and Air-conditioning*. Good Heart Wilcox Co.

Arora CP. 2000. *Refrigeration and Air-conditioning*. Tata McGraw Hill.

Carrier Air-conditioning. 1965. *Handbook of Air-conditioning System Design*. McGraw Hill.

Domkundwar S. 1980. *A Course in Refrigeration and Air-conditioning*. Dhanpat Rai & Sons.

Gunther Raymond C. 1957. *Refrigeration and Air-conditioning and Cold Storage*. Chilton Co.

Jordan RC & Priester GB. 1971. *Refrigeration and Air conditioning*. Prentice Hall of India.

Langley BC. 1978. *Refrigeration and Air-conditioning*. Reston Publ.

New-Comer JL. 1981. *Refrigeration and Air-conditioning*. Venus Trading Co.

Ananta Krishnan CP & Simha NN. 1987. *Technology and Engineering of Dairy Plant Operation*. Luxmi Publ.

FPE 508 3(2+1)

Food industry energy management and auditing

(32 Lectures + 16 Practical)

Unit 1	**General Aspects of Energy Management & Energy Audit:** Energy scenario, basics of energy and its various forma, material and energy balance, monitoring and targeting and financial management	2
Unit 2	**Energy Auditing Basics:** ASHRAE Definitions of Energy Audits, The Audit Process, Pre-Site and Post-Site Work, Audit report.	3
Unit 3	**Energy Accounting and Analysis:** Energy Accounting and Analysis, The Energy Use Index, Conditioned Area, Electricity Costs, Thermal energy costs, Energy-Using Systems, Commercial Energy Use Profiles, Identifying Potential Measures, Industrial Audit Opportunities, Industrial Energy Use Profiles.	10
Unit 4	**Energy economics:** Simple payback, Time value of money, Job simulation experience, Making decisions for alternate investments, Depreciation, taxes and the tax credit, Impact of fuel inflation on life cycle costing	5
Unit 5	**Measurements, Survey Instrumentation, and Data Collection:** General audit instrumentation; CO_2, Temperature, Pressure, Fluid and Fuel flow, Combustion gas composition, Electrical and Light measurement, Measuring building losses, Application of IR thermograph, Infrared radiation and its measurement, Measuring electrical system performance	4
Unit 6	**Energy Conservation Technologies Applied to Food Processing Facilities:** Energy Conservation in Steam Generation and Consumption System, Energy Conservation in Heat Exchangers, Energy Conservation in Compressed Air System, Energy Conservation in Power and Electrical Systems, Waste-Heat Recovery and Thermal Energy Storage in Food Processing Facilities, Building Envelop Audit, Energy Consumption and Saving Opportunities	8

List of Practicals

1	Study and practice with energy assessment and auditing instruments	1
2	Performance assessment of motors and variable speed drives	1
3	Performance assessment of pump, fans and blowers	1
4	Performance assessment of refrigeration system	2
5	Performance assessment of heat exchangers	1
6	Performance assessment of furnace	1
7	Performance assessment of boilers	2
8	Energy conservation in dairy processing facilities	1
9	Energy conservation in grains and oilseeds milling facilities	1
10	Energy conservation in sugar and confectionary processing facilities	1
11	Energy conservation in fruit and vegetable processing facilities	1
12	Energy conservation in bakery processing facilities	1
13	Energy efficiency and conservation in food irradiation	1
14	Energy conservation in meat processing facilities	1
		16

Suggested Readings

1. Wang L. 2009. *Energy Efficiency and Management in Food Processing Facilities*. CRC Press
2. Thumann A., Niehus T. & Younger W.J. 2013. *Handbook of Energy Audits* 9ed. Fairmont Press
3. BEE-NPC Cases studies

FPE 509 2(2+0)
Radiation in food processing
(16 Lectures + 0 Practical)

Unit 1	Radiation physics, sources and units of measurements	2
Unit 2	Interaction of ionising radiation with matter, application in food processing	2
Unit 3	Biological effects of ionising radiation and operational limits	2
Unit 4	Principle of radiation detection, radiation monitoring instruments and measurements	3
Unit 5	Radiation hazards evaluation and control, Safe transport of radioactive sources	2
Unit 6	Safety and regulatory aspects and national/international standards of irradiation facilities	3
Unit 7	Radiation processes and equipment for food products	2
		16

Suggested Readings

1. Gould R.F. 1967. *Radiation Preservation of Foods*. Advances in Chemistry
2. Rosenthal I. 1992. *Electromagnetic Radiations in Food Science*. Springer-Verlag Berlin Heidelberg
3. Miller R.B. 2005. *Electronic Irradiation of Foods*. Springer
4. Fan X and Sommers C.H. 2013. *Food Irradiation Research and Technology*. Institute of Food Technologists Series. Wiley-Blackwell

FPE 510 2(1+1)
Food plant maintenance
(16 Lectures + 16 Practical)

Unit 1	Introduction of course and its relevance, basic concepts of plant maintenance.	1
Unit 2	Elements of preventive maintenance program: Equipment data collection, reporting and recording, principles of lubrication, lubricants and preparation of lubrication schedule.	3
Unit 3	Maintenance organization, development of optimum organization.	3
Unit 4	Planned overhaul and PERT planning, engineering and general stores, workshop facilities in relation to the size and types of dairy plants.	3
Unit 5	Care and maintenance of S.S. surfaces, insulations, rubber and gasket materials, properties, grade and their selection.	3
Unit 6	Care and maintenance of engineering control systems	3
		16

List of Practicals

1	Pipe and pipe fittings	1
2	Maintenance of material conveying system	1
3	Mechanicals seals for pumps	1
4	Method of determining plant performance	2
5	Calibration procedure and set-up for gauges	1
6	Performance evaluation of thermal processing (HTST) and associated components	1
7	Upkeep of electric motors and starters	2
8	Study of IBR	2
9	Fire and explosives safety regulations	1
10	Study of national and international standards for food equipments	1
11	Maintenance organization of experimental plant	1
12	Estimation of the maintenance cost, PERT for overhauling – case study and with group discussion, various records, equipment date card, card file, log books of a plant, specification writing for some select machines & their components.	2

Suggested Readings

1. Higgins L & Morrow LC. 1977. *Maintenance Engineering Hand-Book*. McGraw Hill.
2. Keating FH. 1959. *Chromium-Nickel Austentic Steel*. Butterworths Scientific Publ.
3. Newcomer JL. 1981. *Preventive Maintenance Manual for Dairy Industry*. Venus Trading Co., Anand.
4. Stanier W. 1959. *Plant Engineering Hand-Book*. McGraw Hill.

FPE 511 3(2+1)
Numerical techniques, modelling and simulation in food engineering
(32 Lectures + 16 Practical)

Unit 1	**Modelling and Simulation:** Fundamentals of modeling and simulation; Definition of basic terms like system, entity attribute, activity, state of system, system environment; categories of system, stochastic activities; Different steps for modulation and simulation, Types of models; Advantages of modulation and simulation, disadvantages of modulation; Monte Carlo Method or random simulation, Application areas of simulation	8
Unit 2	**Computer programmes, flow charts and algorithm of some numerical methods:** Numerical methods for solving of transcedental model equations; Iterative convergence method, derivation and algorithm of bisectional method or intermediate value theorem; False position or Regula Falsi method; Newton Raphson method, Convergence of Newton Raphson method, Generalized Newton's method for multiple roots, Secant Method, Convergence of secant method; Iterative or method of successive approximation; Introduction to numerical integration, trapezoidal rule, Simpson's 1/3 rd rule, Truncation error in Trapezodial rule, Simpson's 1/3 rd rule. Solution of Ordinary Differential Equation Model: Picard Method, Taylor's Series method, Euler's method, Modified Euler's method, First order, third and fourth order, Runga Kutta method. Solution of partial differential equations models: Differential Laplace, Poisson, parabolic	10
	and hyperbolic equation, Finite difference method, graphical method, Bender - Schmidt method	
Unit 3	**Optimization:** Introduction, optimization theory, optimization methods, Graphical and numerical methods of optimization, Unconstrained optimization, Constrained optimization, Programming optimization, experimental optimization, Response surface methodology (RSM)	8
Unit 4	**Modelling and simulation of some food engineering operations:** Thermal processing, convection dehydration, osmotic dehydration, spray drying, Freeze Drying, Freezing process; deep fat frying; extrusion process; filtration processes; membrane separation process; distillation and Extraction processes	6
		32

List of Practicals

1	Introduction to various features in different spreadsheet softwares	1
2	Solving problems using functions in spreadsheets	2

3	To use Add-Ins in spread sheet and statistical data analysis using Analysis Tool pack	1
4	Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data. Testing linearity and normality assumption, Testing the goodness of fit of different models; Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, Analysis of variance	3
5	Practice on modelling and simulation softwares i.e. MATLAB, FLUENT, GAMBIT	5
6	Practice on process optimization softwares i.e. SAS, SPSS and Design Expert	4
		16

Suggested Readings

1. Kreyszig E 2005. *Advanced Engineering Mathematics*. John Wiley & Sons publication
2. Das H 2005. Food *Processing Operations Analysis.* Asian Books Private Limited
3. Denn M.M. 1986. *Process Modeling*. Longman
4. Holland C.D. 1975. *Fundamentals and Modeling of Separation Processes*. Prentice Hall.
5. Luyben W. L. 1990. *Process Modeling Simulation and Control for Chemical Engineers* 2ed. McGraw Hill.
6. Najim K. 1990. *Process Modeling and Control in Chemical Engineering*. CRC
7. Aris R. 1999. *Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective (Process System Engineering).* Academic Press.
8. Standard software for modelling, analysis and simulations

FPE 512 3(2+1)
Post harvest management and storage engineering
(32 Lectures + 16 Practical)

Unit 1	Postharvest physiology of fruits and vegetables; Advances in fruits and vegetable selection, grading, sorting, blanching and other pre processing steps in automation of processing line; kinetics of quality changes: physical, chemical, sensory and nutritional changes during handling for processing	5
Unit 2	Packaging materials & its advancement, Mass transfer in packing material, Innovation in food packing(active, passive, intelligent), Package testing. Factors affecting shelf life of agriculture produce as well as products; storage of agricultural produce	4
Unit 3	Storage of grains, biochemical changes during storage, production, distribution and storage capacity estimate models, storage capacity models, ecology, storage factors affecting losses, storage requirements.	5
Unit 4	Bag and bulk storage, godowns, bins and silos, rat proof godowns and rodent control, method of stacking, preventive method, bio-engineering properties of stored products, function, structural and thermal design of structures, aeration system.	5
Unit 5	Grain markets, cold storage, controlled and modified atmosphere storage, effects of nitrogen, oxygen, and carbon dioxide on storage of durable and perishable commodities, irradiation, storage of dehydrated products, food spoilage and preservation, storage pests	8
	and control, BIS/FSSAI standards.	
Unit 6	Physical factors influencing flow characteristics, mechanics of bulk solids, flow through hoppers, openings and ducts; recent advances in handling of food materials	5
		32

List of Practicals

1	Determination of quality and maturity indices of selected foods	2
2	Measurement of respiration of fruits/grains in the laboratory and determination of shelf life	2
3	Determination of effects after different postharvest treatments	2
4	Study of evaporative cooling and cold storage systems for selected fruits and vegetables	2
5	Determination of WVTR & GTR in different packaging materials	2
6	Visits to traditional storage structures, CA storage , cold storage	2
7	Shelf life evaluation of packaged food products	3
8	Storage study in the MAP	1
		16

Suggested Readings

Ramaswamy H.S. 2015. *Post harvest technologies for fruits and vegetables*. DEStech Publications, Inc

Chakraverty A. & Singh R.P. 2014. *Postharvest technology and food process engineering*. CRC Press

Chakraverty A., Mujumdar A.S. & Ramaswamy H.S. 2002. *Handbook of Postharvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices*. CRC Press

Wills R. & Golding J. 2016. *Postharvest: An Introduction to the Physiology and Handling of Fruit and Vegetables*. CABI

FAO. 1984. *Design and Operation of Cold Stores in Developing Countries*. FAO.

Hall CW 1970. *Handling and Storage of Food Grains in Tropical and Sub-tropical Areas*. FAO Publ. Oxford & IBH.

Henderson S & Perry SM. 1976. *Agricultural Process Engineering*. 5th Ed. AVI Publ.

McFarlane Ian. 1983. *Automatic Control of Food Manufacturing Processes*. Applied Science Publ.

Multon JL (Ed). 1989. *Preservation and Storage of Grains, Seeds and their By-products*. CBS.

Ripp BE 1984.*Controlled Atmosphere and Fumigation in Grain Storage*. Elsevier.

Shefelt RL & Prussi SE. 1992. *Post Harvest Handling – A System Approach*. Academic Press.

Shejbal J (Ed). 1980. *Controlled Atmosphere Storage of Grains*. Elsevier.

Vijayaraghavan S. 1993. *Grain Storage Engineering and Technology*. Batra Book Service

FPE 513 2(2+0)
Production and operations management
(32 Lectures + 0 Practical)

Unit 1	**An overview of operations management:** Introduction and overview, historical evolution - changes & challenges; objectives and scope of operations management; Concept of production, production system, classification of production system; productivity, factors affecting productivity	6
Unit 2	**Operations strategy:** Strategic role of operations, strategic planning; product strategy and integrated product development, process strategy; Characteristics of decision and decision methodology; Capacity planning decisions; Facilities location strategies	5
Unit 3	**Product design and process selection:** Product design; process design; process technology and its choices; plant layout, classification of layout; job design and work organization	5
Unit 4	**Planning and managing operations:** Demand Forecasting; value chain and supply chain management; purchasing, vendor selection and material management, inventory management & just-in-time systems; materials requirement, planning and ERP scheduling, sequencing and dispatching; project planning and control	8
Unit 5	**Managing quality:** What is quality and why is it so important?, statistical process control (SPC), measuring and improving performances, failure detection and analysis total quality management, value analysis and value engineering, statistical quality control	5
Unit 6	**Operations challenges:** Why challenges? globalization, corporate social responsibility, environmental responsibility, technology, knowledge management	3
		32

Suggested Readings

1. Chary SN 2004. *Production and Operations Management*. Tata Mc Graw Hill III Edition.
2. Anil Kumar, S and Suresh, N 2009. *Operations Management*. New Age International (P) Ltd., Publishers, New Delhi
3. Slack, N, Chambers, S and Jhonston, R 2007. *Operations Management*. Pearson Education Ltd., Essex, UK
4. Joseph G. Monks 1997. *Operations Management Theory and Problems*. Mc. Graw Hill III Edition

FPE 601 3(2+1)
Transport phenomenon in food engineering
(32 Lectures + 16 Practical)

Unit 1	Introduction to transport phenomena – Molecular transport mechanism, transport properties and their proportionality constants in momentum, energy and mass transfer.	3
Unit 2	Steady-state equations - Momentum transport equations for Newtonian and non-Newtonian fluids, continuity equation in different co-ordinates.	4
Unit 3	Equations of motion - Navier–Stokes equations and their application in viscous fluid flow between parallel plates and through pipes.	4

Unit 4	Turbulent transport mechanism -- Mathematical analysis; eddy viscosity and eddy diffusivity; velocity, temperature and concentration distribution; time smoothing equations. Inter-phase transport in isothermal system - friction factors for various geometries.	5
Unit 5	Mass transfer -- Fick's law of diffusion, diffusion of gases and liquids through solids, equimodal diffusion, isothermal evaporation of water into air, mass transfer coefficients.	5
Unit 6	Dimentional analysis – Buckingham Pi-theorem and matrix method, application to transport phenomena, analysis among mass, heat and momentum transfer, Reynolds' analogy.	6
Unit 7	Boundary layer concept - Theoretical and exact solutions for heat, mass and momentum transfer.	5

List of Practicals

1	Effects of water concentration and water vapor pressure on the water vapor permeability and diffusion of chitosan films	1
2	Mass transfer description of the osmodehydration	1
3	Pretreatment efficiency in osmotic dehydration	2
4	Structural effects of blanching and osmotic dehydration pretreatments on air drying kinetics of fruit tissues	2
5	Thermal processing of particulate foods by steam injection. 1. Heating rate index for diced vegetables 2. Convective surface heat transfer coefficient for steam	2
6	Relating food frying to daily oil abuse. 1. Determination of surface heat transfer coefficients with metal balls 2. A practical approach for evaluating product moisture loss, oil uptake, and heat transfer	2
7	Heat and mass transfer during the frying process	2
8	Influence of liquid water transport on heat and mass transfer during deep-fat frying	2
9	Numerical simulation of transient two-dimensional profiles of temperature, concentration, and flow of liquid food in a can during sterilization	2

Suggested Readings

1. Bird RB. 1994. *Transport Phenomena*. John Wiley & Sons
2. Treybal RE. 1968. *Mass Transfer Operations*. McGraw Hill
3. Yuan SW. 1969. *Foundations of Fluid Mechanics*. Prentice Hall of India.
4. Jorge WC, Jorge F.V.R, Gustavo V.B.C. 2003. *Transport Phenomena in Food Processing*. CRC Press
5. Christie J.Geankoplis 1978. *Transport Process & Unit Operations*. Prentice Hall of India Private Limited.

FPE 602 2(1+1)
Advances in bioprocess and biochemical engineering
(16 Lectures + 16 Practical)

Unit 1	**Introduction:** Interaction of chemical engineering, biochemistry and microbiology, Chemical Reaction kinetics, kinetics of batch and continuous cultures, process variables, biocatalyst and enzyme kinetics, scope and present status in India in relation to food industry.	2
Unit 2	**Fermenter and bioreactors**: Transport phenomenon in microbial systems, types of reactor, working principles, aeration and agitation, sterilization and sanitation, advances in continuous fermentation, developments in solid-state fermentation for food applications.	3
Unit 3	**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)	2
Unit 4	**Production of Single Cell Proteins:** Single cell proteins production: substrates, factors effecting SCP production, composition, uses, economic parameters and constrains including safety aspects	1
Unit 5	**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	2

Unit 6	**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.	2
Unit 7	**Product recovery operations and waste utilization:** Handling of materials in microbial systems, filtration, centrifugation, sedimentation, chromatography, membrane separation (UF and NF) and electrophoresis, separation and disintegration of cells for product recovery operations. Biological waste treatment and inplant sanitation.	2
Unit 8	**Modeling, simulation and scale-up:** Bioprocess modeling and simulation and its application in industrial fermentation, scale-up of fermentation processes, design and analysis of biological fermenter and bioreactors	2
		16

List of Practicals

1	Studying biochemical changes during handling of important food items	1
2	Study of fermenter and fermentation process	1
3	Study of bioprocess instrumentation and control system	1
4	Study of bacterial growth in batch culture	1
5	Production and maintenance of starter culture	1
6	Production of enzyme, extraction and purification	3
7	Production of SCP	1
8	Production of amino acids	2
9	Production of alcohol and alcoholic beverages	2
10	Visit to brewery	1
11	Visit to effluent treatment plant	1
12	Bioprocess modeling and simulation	1
		16

Suggested Readings

1. Schimid. *Advances in Biochemical Engineering*.
2. Olson, J. E. Bailey and David F. Ollis. *Biochemical Engineering Fundamentals*. McGraw-Hill Book Co. Inc., New York
3. Pauline,M. Doran. *Bioprocess Engineering Principles*. Academic Press.
4. Perry R.H. *Chemical Engineering Handbook*. McGraw-Hill
5. Stumbo. *Thermobacteriology in Food Processing*. Academic Press, New York
6. Stanbury. *Principles of Fermentation Technology*.

FPE 603 3(3+0)
Product Monitoring and Process Control
(48 Lectures + 0 Practical)

Unit 1	The concept of Product-Process Monitoring in agro, dairy and food industries: Definition of 'quality'; Optimization paradigm; Quality-prediction model based on quality kinetics and process state equations – Simulation modeling. Process/Product Optimization: Optimization procedures – Search methods, Response surface, Differentiation & Programming methods; Neural Networks; Optimization software.	4
Unit 2	Process Control: Objectives; Control loop – Loop elements and their functions; Modes of process control; Control techniques; control equipment.	2
Unit 3	Real-time Instrumentation : Sensors; their classification based on Proximity, working principle; examples of applications in process control; Requirements of on-line sensors; Biosensors – Construction, types, working principles, applications, merits and limitations; Time-temperature indicators – partial-history & full-history indicators; Commercial devices; Applications and limitations; E-Nose & E-Tongue – Simulation of natural organs; Components & their functions; Applications.	3
Unit 4	Flavour analysis: Flavour bioassays – Gas Chromatography-Olfactometry techniques; Isolation, Separation and detection/Identification of flavour compounds – GC-MS, LC-MS, NMR, FTIR; analysis of chiral compounds.	4

Unit 5	Formation of flavour compounds in food and dairy products during heat processing (including UHT processing, caramelization and extrusion cooking), fermentation and ripening (cultured. products and cheese flavour, with special reference to bitteness) and storage (Maillard browning); Aroma losses/retention during the drying process (in relation to milk powder, cheese powder and dry cultured products); Industrial processes for extraction of desirable and undesirable volatile components from fresh and/or stored products by supercritical fluid (SCF) technique.	5
Unit 6	Monitoring of Food Structure: (a) Application of Thermal Analysis (DTA and DSC vis-a-vis dilatometry) and Pulse Nuclear Magnetic Resonance (PNMR) spectroscopy in determination of solid-fat content (SFC) of butter in relation to various processing and storage aspects; Glass transitions in dairy and food products; Starch gelatinization.	5
Unit 7	Monitoring of Food Structure: (b) Elucidation of crystal characteristics of milk fat in ghee and other fat-rich products by means of X-ray Crystallography with reference to the impact of cooling and storage/handling conditions on the crystal nature and product texture; Process-induced changes in sub-microscopic particulate properties of milk products; structure-texture relationship.	3
Unit 8	Monitoring of Food Structure: (c) Influence of heat processing and freezing treatments on protein denaturation and other conformational as well as aggregation-disaggregation phenomena as monitored through Spectropolarimetry, Circular Dichroism and related techniques.	3
Unit 9	Monitoring of Food Structure: (d) Particle-size analysis: Image analysis; Dynamic light scattering; Laser diffraction; Sieving, and other techniques.	2
Unit 10	Emerging Spectroscopic techniques in assessment of foods : Raman Spectroscopy and Electron Spin Spectroscopy – Working principles and applications - Monitoring of irradiated foods, detection of lipid auto- oxidation, etc.; Microwave & NIR absorption/reflection methods for Compositional analyses – Automated milk analysers; Proximate principles in cheese and milk powder.	4
Unit 11	Ultrasound in product monitoring: Speed- and Attenuation-based measurements of liquid levels, density, mass flow, etc.	2
Unit 12	Monitoring of Chemical Contaminants: Heavy metal quantification by Atomic Absorption Spectrophotometer; Quantification of Agrochemicals by HPLC; Spectrofluorimetric determination of mycotoxins; Detection and quantification of Drug Residues.	5
Unit 13	Colour Characterization : Colour and appearance (gloss and translucence) monitoring through visual colorimeter, tri-stimulus colorimeters and reflectance spectrophotometer, CIE, Hunter-Lab, Munsel and other systems of three-dimensional expression of colour; Colour-based Sorting of foods; Computer Vision – Principles, applications and Benefits.	4
Unit 14	Objective Assessment of Subjective food-quality characteristics - Pitfalls and Promises.	2
		48

Suggested Readings

1. Acree TE & Teranishi R. 1993. *Flavour Science: Sensible Principles and Techniques*. Amer. Chem. Soc., Washington.
2. Bartlett PN, Elliott JM & Gardner JW. 1997. *Electronic Noses and their Application in the Food Industry*. Food Technology: 51 (12) 44-48.
3. Davenel A. 1996. On-line Control and Problems with Sensors. In: *Quality Control for Foods and Agricultural Products.* (J.L. Mutton, Ed.). VCH Publ., London.
4. Kress-Rogers E & Brimelow CJB. (Eds.). 2001. *Instrumentation and Sensors for the Food Industry*. CRC Press, Woodhead Publ. Ltd.
5. Mann CMD & Jones AA. I994. *Shelf-life Evaluation of Foods*. Blackie.
6. Peleg M & Bagley EB. 1983. *Physical Properties of Foods*. AVI Publ.
7. Schartel BJ & Firstenberg ER. 1988. *Biosensors in the Food Industry: Present and Future*. *J. Food Protect*. 51(10): 811-820.

Supporting Courses

Ag.Stat. 531 3(2+1)
Data analysis using statistical packages
(32 Lectures + 16 Practical)

Unit 1	Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.	2
Unit 2	Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, *t* and *F* statistics.	6
Unit 3	Concept of analysis of variance and covariance of data for single factor, multi-factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.	8
Unit 4	Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.	8
Unit 5	Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data; Spatial analysis; Neural networks.	8
		32

List of Practicals

1	Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data.	1
2	Robust Estimation, Testing linearity and normality assumption, Estimation of trimmed means etc., Cross tabulation of data including its statistics, cell display and table format and means for different sub-classifications;	1
3	Fitting and testing the goodness of fit of probability distributions;	1
4	Testing the hypothesis for one sample t -test, two sample t -test, paired t -test, test for large samples - Chi-squares test, F test, One way analysis of variance, contrast and its testing, pairwise comparisons;	1
5	Multiway classified analysis of variance - cross-classification, nested classification, factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components;	2
6	Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets - maximum likelihood, ANOVA, REML, MINQUE;	1
7	Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures;	1
8	Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models - curve estimation models, examination of residuals; Discriminant analysis - fitting of discriminant functions, identification of important variables,	2
9	Factor analysis. Principal component analysis - obtaining principal component, spectral composition;	2
10	Analysis of time series data - fitting of ARIMA models, working out moving averages. Spatial analysis;	2
11	Neural networks	2
		16

Suggested Readings

Anderson CW & Loynes RM. 1987. The Teaching of Practical Statistics . John Wiley.

Atkinson AC. 1985. Plots Transformations and Regression . Oxford University Press.

Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. Graphical Methods for Data Analysis . Wadsworth, Belmount, California.

Chatfield C & Collins AJ. 1980. Introduction to Multivariate Analysis . Chapman & Hall.

Chatfield C. 1983. Statistics for Technology . 3rd Ed. Chapman & Hall.

Chatfield C. 1995. Problem Solving: A Statistician's Guide . Chapman & Hall.

Cleveland WS. 1985. The Elements of Graphing Data . Wadsworth, Belmont, California.

Ehrenberg ASC. 1982. A Primer in Data Reduction . John Wiley.

Erickson BH & Nosanchuk TA. 1992. Understanding Data . 2nd Ed. Open University Press, Milton Keynes.
Snell EJ & Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses . Chapman & Hall.
Sprent P. 1993. Applied Non-parametric Statistical Methods . 2nd Ed. Chapman & Hall.
Tufte ER. 1983. The Visual Display of Quantitative Information . Graphics Press, Cheshire, Conn.
Velleman PF & Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis . Duxbury Press.
Weisberg S. 1985. Applied Linear Regression . John Wiley.
Wetherill GB. 1982. Elementary Statistical Methods . Chapman & Hall.
Wetherill GB.1986. Regression Analysis with Applications . Chapman & Hall.
Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
Course on Experimental design: http://www.stat.sc.edu/~grego/courses/stat706/.
Design Resources Server: www.iasri.res.in/design.
Analysis of Data: Design Resources Server http://www.iasri.res.in/design/Analysis%20of%20data/Analysis%20of%2 Data.html.

FBM 501 3(2+1)
Computer application in food industry
(32 Lectures + 16 Practical)

The industrial use of computer application or Information and Communication Technology (ICT) are now essential in knowledge intensive fields such as quality control, logistics, engineering data management, and product documentation. The application of ICT in industrial processes such as design, engineering, manufacturing, purchasing, physical distribution, production management and supply chain management are common. It also supports in research for integration of business process support, such as in enterprise modelling, ERP, EDM.

Unit 1	Importance of computerization in food industry, operating environments and information systems for various types of food industries, principles of communication	2
Unit 2	**Supervisory Control and Data Acquision (SCADA):** Introduction to SCADA, SCADA systems hardware and firmware, SCADA systems software and protocols, landlines, local area network systems, modems, central site computer facilities	2
Unit 3	**Spreadsheet Applications**: Data entry, interpretation and solving problems; Cells, cell reference, functions, preparation of charts, use of macros to solve engineering problems; use of add-ins, use of solver etc	4
Unit 4	**Web hosting and Webpage Design**: Domain registration, web hosting, webpage design using web publishing software; Introduction to File Transfer Protocol (FTP); Online food process control from centralized server system in processing plant	2
Unit 5	**Use of Matlabs in Food Industry:** Introduction, MATLAB interactive sessions, computing with MATLAB, Script files and editor/debugger; MATLAB help system, problem solving methodologies; Numeric, cell and structure array; Arrays, multidimensional arrays, element by element operations ; Matrix operations, polynomial operations using arrays, cell arrays, structure arrays; Functions and Files in MATLAB: Elementary mathematical functions, user defined functions; Advanced function programming, working with data files; Programming using MATLAB, Program design and development, Relational operators and logical variables, Logical operators and functions, Conditional statements, loops, the switch structure, debugging MATLAB programs, applications to simulations. Plotting and Model Building in MATLAB; XY plotting functions, subplots and overlay plots, special plot types, interactive plotting in MATLAB, function discovery, regression, the basic fitting interface, three dimensional plots; Introduction to Toolboxes useful to Food Industry: Curve fitting toolbox, Fuzzy logic toolbox, Neural Network toolbox, Image processing toolbox, statistical toolbox	10
Unit 6	**Introduction to CFD Applications in Food Industry:** Introduction to Computational Fluid Dynamics (CFD), governing equations of fluid dynamics. Models of flow, substantial derivative, divergence of velocity, continuity, momentum and energy equations. Physical boundary conditions, discretization. Applications of CFD in Food and beverage industry. Introduction to CFD softwares, GAMBIT and Fluent softwares	8

Unit 7	Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.	4
		32

List of Practicals

1	Introduction to various features in different spreadsheet softwares	1
2	Solving problems using functions in spreadsheets	2
3	To use Add-Ins in spread sheet and statistical data analysis using Analysis Tool pack	1
4	Introduction to MATLAB and practice sessions	2
5	To solve problems using Curve fitting toolbox in MATLAB	1
6	To solve problems using Fuzzy logic toolbox in MATLAB	1
7	To solve problems using Neural Network toolbox in MATLAB	1
8	To solve problems using Image processing toolbox in MATLAB	1
9	Introduction to GAMBIT software	1
10	Creation of Geometry for laminar flow through pipe using GAMBIT	1
11	Introduction to FLUENT software	1
12	Import of geometry and application of boundary conditions	1
13	To solve a problem on laminar flow using FLUENT	1
14	Use of software packages for summarization and tabulation of data	1
		16

Suggested Readings

1. David Bailey and Edwin Wright. *Practical SCADA for Industry*. Elsevier
2. William J. Palm. *Introduction to MATLAB 7 for engineers*. McGraw Hill Professional
3. Da Wen Sun. *Computation Fluid Dynamics in Food Processing*. CRC press
4. Jenny Chapman. *Web Design: A Complete Introduction*. John Wiley & Sons
5. Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall.
6. Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
7. Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
8. Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
9. http://www.iasri.res.in/design/Analysis of data/Analysis of Data.html.
10. Fundamentals of Food Process Engineering by R.T.Toledo. Published by Springer
11. Introduction to Web Design Using Microsoft FrontPage by Glencoe/McGraw-Hill Published by Glencoe/McGraw Hill

FBM 503 2(2+0)
Advance mathematics
(32 Lectures + 0 Practical)

Unit 1	**Review of Calculus and Ordinary Differential Equations:** Introduction, First order differential equations, Second order linear differential equations, Higher order linear equations, Series solutions of differential equations, The Laplace transforms, Systems of first order linear equations, Series Solution and special function.
Unit 2	**Partial Differential Equations:** Introduction: PDEs and their solutions; initial and boundary value problems; existence, uniqueness, and well posedness; First order PDEs: method of characteristics, linear and quasi-linear PDEs • Second order linear PDEs: classification; d'Alembert's solution to the wave equation and propagation of discontinuities; Separation of Variables: homogeneous equations, examples from the heat, wave, and Laplace equations; Fourier series and their convergence.
Unit 3	**Complex Variables:** Introduction to complex numbers, complex powers, topology of the complex plane, complex functions and limits, elementary functions, analyticity and the Cauchy Riemann relations; Complex Integration: contour integration and Cauchy's theorem, harmonic functions; **Series representation of analytic functions** convergent series of analytic functions, Laurent and Taylor series, zeroes and singularities ; **Calculus of residues:** calculation of residues, residue theorem.

Unit 4	**Calculus of Variations Integral Equation:** Introduction, Variational problems with the fixed boundaries, Variational problems with moving boundaries, Sufficiency conditions, Fredholm's Integral equations, Voltera Integral equations, FRedholm's theory - HilbertSchmidt theorem, Fredholm and Volterra Integro-Differential equation

Suggested Readings

1. W. A. Strauss. Partial Differential Equations: An Introduction 2ed
2. Y. Pinchover and J. Rubinstein. An Introduction to Partial Differential Equations
3. Kreyszig E. Advanced Engineering Mathematics. Wiley
4. E. Zauderer. Partial Differential Equations of Applied Mathematics
5. R. B. Guenther and J. W. Lee. Partial Differential Equations of Mathematical Physics and Integral Equations
6. Heath M.T. Scientific Comuting. McGraw-Hill

FBM 504 3(2+1)

Advances in statistical methods in food processing

(32 Lectures + 16 Practical)

Unit 1	Applications of statistical procedures in food processing, Descriptive statistics, Analysis of differences, Types of significance test, Association, correlation and regression and Experimental design
Unit 2	**Sensory and consumer data**: Introduction, The quality and nature of sensory and consumer data, Experimental design issues, Consumer data (sensory and survey), Trained panel sensory data, Analysis of relationships
Unit 3	**Instrumental data:** Introduction, Quality and nature of instrumental data, Sampling and replication, Experimental design issues, Statistical analysis of instrumental data, Chemical analysis applications, Analysis of relationships
Unit 4	**Food product formulation:** Introduction, Design application in food product development, Single ingredient effects, Two or more ingredients, Screening of many ingredients, Formulation by constraints
Unit 5	**Statistical quality control:** Introduction, Types of statistical quality control, Sampling procedures, Control charts, Acceptance sampling
Unit 6	**Multivariate applications:** Introduction, Multivariate methods and their characteristics, Multivariate modes, Relationship of consumer preference with sensory measures
Unit 7	Principal component analysis, Chemometrics, Partial least square, Response surface methodology, Mixture design, Fractal analysis, Cluster analysis, ANN and Fuzzy logic

List of Practicals

1. Applications of dimensionality reduction and discriminant function analysis
2. Nonparametric tests.
3. Analysis of qualitative data
4. Analysis of data having random effects using Linear mixed effects models
5. Classification and prediction using artificial neural networks
6. Analysis of data with missing observations
7. Multiple linear regression analysis
8. Partial regression coefficients
9. Residuals and their applications in outlier detection
10. Study on robust parameter design and process robustness
11. Practice with Statistical Softwares

Suggested Readings

1. John A. Bower 2013. *Statistical Methods for Food Science: Introductory Procedures for the Food Practitioner 2ed* Wiley Blackwell.
2. Barnsley M.F.1988. *Fractals Everywhere*. Academic Press, Boston.
3. Montgomery D.C. 1997. *Design and Analysis of Experiments 4ed*. Wiley
4. Everitt BS & Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.
5. Geisser S. 1993. *Predictive Inference: An Introduction*. Chapman & Hall.
6. Gentle JE, Härdle W & Mori Y. 2004. *Handbook of Computational Statistics -Concepts and Methods*. Springer.
7. Simonoff JS. 1996. *Smoothing Methods in Statistics*. Springer.

8. Thisted RA. 1988. *Elements of Statistical Computing*. Chapman & Hall.
9. Khuri AI & Cornell JA. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.
10. Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
11. Design Resources Server: www.iasri.res.in.
12. SAS Online Doc 9.1.3:
13. http://support.sas.com/onlinedoc/913/docMainpage.jsp

FBM 505 2(2+0)
Operation Research
(32 Lectures + 0 Practical)

Unit	Topics
Unit 1	Introduction to operations research
	Elementary concepts and objectives of Operations Research
	Applications of Operations Research in decision making
Unit 2	Linear programming problem
	Mathematical formulation of the linear programming problem and its graphical solution
	Simplex Method
Unit 3	Transportation problem
	Definition and mathematical formulation
	Initial basic feasible solution
	Optimal solution
Unit 4	Introduction and mathematical formulation
	Solution of Assignment problem
Unit 5	Inventory control
	Introduction and general notations
	Economic lot size models with known demand
Unit 6	Replacement theory
	Introduction and elementary concepts
	Replacement of items deteriorating with time
Unit 7	Sequencing problem
	Introduction and general notations
	Solution of a Sequencing problem
Unit 8	Queuing theory
	Introduction and classification of queues
	Solution of Queuing models
Unit 9	Project planning and network analysis
	Introduction and basic definitions in Network Analysis
	Rules for drawing Network Analysis
	Critical Path Method (CPM)
	Project Evaluation and Review Technique (PERT)

Suggested Readings

1. Ackoff R. K. and Sassioni, M.W. 1978. Fundamentals of Operations Research. Wiley Eastern, New Delhi
2. Wagner, H.M. 1978. Principles of Operations Research, with Applications to Management Decisions. Prentice Hall of India, New Delhi
3. Taha, H. A. 2007. Operations Research: An Introduction. Pearson Prentice Hall, New Jersey
4. Goel, B. S. and Mittal, S. K. 1985. Operations Research. Pragati Prakashan, Meerut

FBM 506 2(2+0)
Business analysis for engineers
(32 Lectures + 0 Practical)

Business Analysis for Engineers provides an opportunity for engineering students to understand the language of business both in financial and strategic dimensions. At the end of the course, a student will be able to gain knowledge on concepts of accounting & costing, introductory economics, various corporate strategy tools and organizational behaviour.

Unit 1	**Introduction to Economy**: Macro and Microeconomics fundamentals, Demand & Supply, Pricing, Types of Markets, Macro/Micro economic indicators, Indian Budget - Overview	7
Unit 2	**Introduction to Costing**: Introduction to financial statements, Fundamental Accounting concepts – Dual entry concept and other accounting entries, Preparation of financial statements – B/S, I/S and Cash Flow, Analysis of financial statements, Types of costs – Economies of scale – Variances – Need for cost competitiveness – case studies for discussions.	11
Unit 3	**Business and Organization:** Business functions, Role of each function, Organizations – Organizational structures, Types of organizations, Issues in handling complexities.	3
Unit 4	**Introduction to Strategy:** What is strategy? Need for Strategy, Vision and Mission, Porter's Diamond framework, Porter's 5–forces, McKinsey's 7S Model, BCG Matrix, Value chain analysis, Case studies and discussions	11

Suggested Readings

1. Robert Anthony & James Reece 2001. *Accounting Principles*. IR WIN
2. Michael E.P. *Competitive Strategy Techniques for Analysing Industries and Competitors*. Free Press.
3. Michael E.P. *Competitive Advantage of Nations*. Free Press
4. Romulo Neri 2001. *Economics & Public Policy*. AIM Publications

FQA 501 3(1+2)
Advances in Analytical Techniques
(16 Lectures + 32 Practical)

Unit 1	Introduction to Food Analysis: Introduction to food and its components, Sampling, Sample preservation, Extraction, Proximate analysis
Unit 2	Spectroscopic Techniques: Introduction & theory of spectroscopic techniques, - Principle, Instrumentation, application of each technique. UV-Visible, IR, Raman, & Mass spectroscopy – Principle, Instrumentation, application of each technique. Fluorescence, Turbidoimetric techniques – Principle, Instrumentation, application of each technique. AAS – Principle, Instrumentation, applications. NMR/ESR spectroscopy – Principle, Instrumentation, application.
Unit 3	Chromatographic Techniques: Introduction, HPLC, GC, Paper chromatography, TLC/HPTLC, Ion chromatography, Flash chromatography – Principle, Instrumentation, applications of each technique.
Unit 4	Biological Techniques: Electrophoresis, PCR/RTPCR, Immunoassays - Principle, Instrumentation, applications of each technique
Unit 5	Recent Techniques: Rheology, DSC/DTA/TGA/TMA, XRD/XRF, Electron microscopy, Refractivity, Polarimetry - Principle, Instrumentation, applications of each technique

Practical

1	Determination of moisture by Karl Fischer method
2	Determination of carotenes (spectrophotometric)
3	Determination of Vitamin C (spectrophotometric)
4	Determination of gingerol by HPLC
5	Determination of minerals by AAS
6	Fatty acid profile in lipids by GC
7	Determination of Chloride content by Ion Chromatography
8	Determination of thermal properties using DSC
9	Determination of rancidity using Rancimat
10	Determination of sugar concentration and solids using Refractometer
11	Separation of amino acids using TLC/HPTLC
12	Separation of food colors using TLC/HPTLC
13	Demonstration of PCR for Gene amplification
14	Agarose Gel Electrophoresis
15	Demonstration of ELISA test

Suggested Readings

1. Food Analysis: Theory and Practice, 1994. Y. Pomeranz and C.E. Meloan. 3rd edn., Conn. (USA): AVI Publ. Co.
2. Stewart, K.K. and Whitaker, J.R. (1984). Modern Methods of Food Analysis. Conn: AVI Publ. Co.
3. James, CS. (1995). Analytical Chemistry of Foods. Blackie Academic and Professional, UK
4. Methods of analysis of food components and additives by Semih Otle, Published in 2005 by CRC Press

FQA 502 2(2+0)

Food Legislations, Standards and Food Safety Management Systems

(32 Lectures + 0 Practical)

Unit 1	Introduction to food - its nutritional, technological and safety aspects. Introduction to Indian legal system, an overview of food regulations in India. Food safety and standards act and role of FSSAI. Various food plant inspection bodies and legislations.
Unit 2	International Standards: Codex Alimentarius: Structure of organization, standards related to Indian foods.
Unit 3	Introduction to food safety: definition, food safety issues, factors affecting food safety, importance of safe foods. Shelf life of food products: factors affecting shelf life and methods to check the shelf life.
Unit 4	Food contaminants of natural origin- seafood toxins, toxic amino acids and others. Indirect additives: pesticides, pesticide residues, metallic contamination, radionuclides, other adulterants.
Unit 5	Good Hygienic Practices (GHP), Good Manufacturing Practices (GMP), Food Safety Plan, Food Safety Management Risk Analysis. Traceability, food product recall.
Unit 6	Food safety Management Systems: ISO 22000: Importance of implementing a HACCP system and how it can be applied to various products, develop a HACCP plan including a HACCP team, produce product workflow diagrams for a range of products and their verification processes etc. Audits: Introduction, objectives, documentation, responsibilities, management review, audit citification and its importance etc.
Unit 7	ISO 14000: Introduction, various standards among 14000 series, certification and its importance, various clauses of 14001. ISO 17025 - General requirements for the competence off testing and calibration laboratories.
Unit 8	Good agricultural practices for crops, land animals, human beings, finished goods etc. Good manufacturing practices: Concept, current problems in food industry and solutions using good manufacturing practices.
Unit 9	World Trade Organization (WTO), Sanitary and Phytosanitary Measures and Technical Barriers to Trade, Food and Agriculture Organization (FAO), World Health Organization (WHO), World Animal Health Organization, International Plant Protection Convention (IPPC) Export – Import of Food.

Suggested Readings

1. FSSAI (2011). Food safety and standards (Food product standards and Food Additives) regulation.
2. Neal D. Fortin. 2009. Food regulation, Wiley Publishers.
3. Naomi Rees. David Watson. 2000. International standards for food safety, Aspen Publications.
4. Assuring food safety and quality. 2012. FAO Food and Nutrition Manual., FAO publications, Rome.

FQA 512 3(2+1)
Advances in Food Microbiology
(32 Lectures + 16 Practical)

Unit 1	History, scope and importance of food microbiology
Unit 2	Microorganisms and food: Their primary sources of microorganisms in foods: Airborne bacteria and fungi, Microorganisms found in soil, Microorganisms in water, Normal flora of skin, nose, throat, GI tract
Unit 3	Factors affecting the survival and growth of microorganisms in food: Intrinsic factors for growth,Moisture, pH & acidity, Nutrient content, Biological structure, Redox Potential, Naturally occurring and added antimicrobials, Competitive micro flora, Extrinsic factors for growth, Types of packaging/atmospheres, Effect of time/temperature conditions on microbial growth, Storage/holding conditions, Processing steps
Unit 4	Microbiological examination- Methods of Isolation and detection of microorganisms or their products in food. - Conventional methods - Rapid methods (Newer techniques) – Immunological methods: Fluorescent, antibody, Radio immunoassay, ELISA etc. - Chemical methods PCR (Polymers chain reactions), RT PCR, Microchip based techniques
Unit 5	Microflora of Fresh Food: Meat, Poultry, Eggs, Fruits and vegetable, Shellfish and Finish, Milk, Microbial Spoilage of Food, Fresh Foods, Fresh Milk, Canned Foods
Unit 6	Food Preservation and application to different types of foods: Physical methods –, Drying, freeze-,drying cold storage,, heat treatments(pasteurization), TDT, TDP, Irradiation (UV, microwave, ionization), high pressure processing, Aseptic packaging, modified atmosphere, Chemical preservatives and Natural antimicrobial compounds. Biologically based preservation systems
Unit 7	Food borne infections and diseases: Significance to public health Food hazards and risk factors, Bacterial, and viral food-borne disorders, Food-borne important animal parasites, Mycotoxins. - Bacillus, Campylobacter, Brucella, Staphylococcus, Clostridium, *E.coli*, Aeromonas, *Vibrio cholerae*, Listeria, Mycobacterium, Salmonella, Shigella
Unit 8	Quality Control/Quality Assurance Legislation for food safety – national and international Criteria, sampling schemes, records, risk analysis QC- microbial source, code Indicators of food safety and quality: Microbiological criteria of foods and their significance.
Unit 9	The H A C C P system and food safety used in controlling microbiological hazards.

Practical

1	Preparation of common laboratory media and special media for cultivation of bacteria, yeast & molds.
2	Staining of Bacteria: Gram's staining, acid -fast, spore, capsule, Motility of bacteria, Staining of yeast and molds.
3	Isolation of microorganisms: Different methods and maintenance of cultures of microorganisms.
4	Bacteriological analysis of Foods using conventional methods
5	Coli forms analysis of milk and water samples
6	To perform various biochemical tests used in identification of commonly found bacteria in foods: IMVIC urease, H_{2S}, Catalase, coagulase, gelatin and fermentation (Acid/gas)
7	Determination of thermal death characteristics of bacteria
8	Demonstration of available rapid methods and diagnostic kits used in identification of microorganisms or their products.
9	Visits (at least two) to food processing unit or any other organization dealing with advanced methods in food microbiology.

Suggested Readings

1. Pelzer, M.I. and Reid, R.D. (1993) Microbiology McGraw Hill Book Company, New York, 5 th Edition.
2. Atlas, M. Ronald (1995) Principles of Microbiology, 1 st Edition, Mosby-Year Book, Inc, Missouri, U.S.A.

3. Topley and Wilson's (1983) Principles of Bacteriology, Virology and Immunity, Edited by S.G. Wilson, A. Miles and M.T. Parkar, Vol. I: General Microbiology and Immunity, II: Systematic Bacteriology. 7 th Edition. Edward Arnold Publisher.
4. Frazier, W.C. (1988) Food Microbiology, McGraw Hill Inc. 4 th Edition,
5. Jay, James, M. (2000) Modern Food Microbiology, 6 th Edition. Aspen publishers, Inc., Maryland.
6. Banwart, G. (1989) Basic Food Microbiology, 2 nd Edition. CBS Publisher.
7. Doyle, P. Benehat, L.R. and Mantville, T.J. (1997): Food Microbiology, Fundamentals and Frontiers, ASM Press, Washington DC.
8. Adams, M.R and M.G. Moss (1995): Food Microbiology, 1st Edition, New Age International (P) Ltd.

BE 501 3(2+1)
Non- conventional Sources of Energy
(32 Lectures + 16 Practical)

Unit 1	Classification of energy sources; Introduction to renewable energy sources and technologies, their importance for sustainable development and environmental protection, production and potential.	3
Unit 2	Solar radiation, measurement of solar radiation, types of solar collectors and their uses, solar thermal energy conversion and storage	5
Unit 3	Solar PV cells, modules, arrays, conversion process of solar energy into electricity, applications.	5
Unit 4	Wind energy, potential & process of conversion, types of wind energy conversion systems	5
Unit 5	Characterization of biomass; briquetting of biomass, biomass combustion, pyrolysis, gasification, types and uses of gasifiers,.	5
Unit 6	Importance of biogas technology, production mechanism, types of biogas plants, uses of biogas, handling & utilization of digested slurry.	5
Unit 7	Brief introduction to geothermal energy, wave energy, ocean thermal energy conversion,	4
		32

List of Practicals

1	Demonstration of solar cooker.	1
2	Demonstration of solar water heater	1
3	Demonstration of solar dryer	1
4	Demonstration of solar still	1
5	Demonstration of solar radiation measuring instruments	1
6	Demonstration of solar PV system	1
7	Demonstration of wind measuring instruments	1
8	Study of wind mill	1
9	Estimation of moisture content of biomass	1
10	Determination of calorific value of biomass	1
11	Estimation of ash content of biomass	1
12	Estimation of fixed carbon and volatile matter of biomass	1
13	Demonstration of up draft gasifier	1
14	Demonstration of down draft gasifier	1
15	Demonstration of working of a fixed dome type biogas plants	1
16	Demonstration of working of a floating drum type biogas plants	1
		16

Suggested Readings

1. Rai, G.D. 2013. Non-Conventional Energy Sources, Khanna Publishers, Delhi.
2. Rai, G.D., Solar Energy Utilization, Khanna Publishers, Delhi.
3. Khandelwal, K.C. & S. S. Mahdi. 1990. Biogas Technology- A Practical Handbook.
4. Rathore N. S., Kurchania A. K., Panwar N. L. 2007. Non Conventional Energy Sources, Himanshu Publications.
5. Tiwari, G.N. and Ghoshal, M.K. 2005. Renewable Energy Resources: Basic Principles and Applications. Narosa Pub. House. Delhi.
6. Rathore N. S., Kurchania A. K., Panwar N. L. 2007. Renewable Energy, Theory and Practice, Himanshu Publications.

BE 502 3(2+1)
Environmental Engineering
(32 Lectures + 16 Practical)

Unit 1	Introduction, earth's environment, ecology and various ecosystems.	3
Unit 2	Bio-geochemical cycle, hydrological cycle, carbon cycle, nitrogen cycle, sulphur cycle, energy flow in ecosystem, food chains & food webs, ecological pyramids, major ecosystems, bio-diversity	6
Unit 3	Natural Resources, water resources - surface & ground water sources, uses & overuses of water resources, problems due to overexploitation of water resources.	5
Unit 4	Water pollution: water quality standards, sources of water pollution, classification & effects of water pollutants, effluent treatment plant, working, waste management in food processing industry, BOD, COD, air pollution & its control.	5
Unit 5	Food behavior and spoilage in storage, economical aspects of fruit and vegetable storage, modified atmospheric storage and control of its environment, storage sanitation.	5
Unit 6	Storage of grains, moisture and temperature changes in stored grains; conditioning of environment inside storage, drying, grain storage structures, silo and control of environment inside silo.	5
Unit 7	Introduction to green house, type's classification and its applications.	3
		32

List of Practicals

1	Study of the Earth's atmosphere and hydrosphere	1
2	Study of Lithosphere & biosphere	1
3	Study of major ecosystems of the earth	1
4	Study of energy resources	1
5	Determination of pH of a given sample.	1
6	Determination of electric conductivity of a given sample	1
7	Determination of total solids of a given sample	1
8	Determination of total dissolves solids of a given sample.	1
9	Determination of hardness of a given water sample.	1
10	Determination of total settable solids of a given sample	1
11	Estimation of BOD exerted by the given waste water sample	1
12	Estimation of COD exerted by the given waste water sample	1
13	Visit of an effluent treatment plant in a food processing industry	2
14	Study of types of storage systems for fruits & vegetables	1
15	Study of various types of greenhouses and its environmental control	1
		16

Suggested Readings

1. Gilbert M. Masters and Wendell P. Ela. 2013. Introduction to Environmental Engineering and Science. Pearson Education Limited, NY, USA.
2. Suresh K. Dhameja. 2009. Environmental Engineering and Management. S. K. Kataria & Sons, New Delhi.
3. Bernard J. Nebel and Richard T. Wright. 1993. Environmental Science: The Way the World Works. Prentice-Hall Professional, New Delhi.

ANNEXURE- I (C)

Post graduate Program
(M. Tech. & Ph. D.)

in

FOOD TECHNOLOGY

Specialization in

Food Safety and Quality Assurance

FACULTY OF FOOD PROCESSING TECHNOLOGY & BIO-ENERGY
ANAND AGRICULTURAL UNIVERSITY
ANAND - 388110

March – 2017

Minimum Credit Requirements

Subject	Masters	Doctoral
Major	**20**	**15**
Minor	**09**	**08**
Supporting	**05**	**05**
Seminar	**01**	**02**
Research	**20**	**45**
Total Credits	**55**	**75**

Compulsory Non- Credit Courses

Code	Course Title	Credits
PGS 501	Library and Information Services	0+1
PGS 502	Technical Writing and Communication Skills	0+1
PGS 503 (e course)	Intellectual Property and its management in Agriculture	1+0
PGS 504	Basic concepts in Laboratory Techniques	0+1
PGS 505 (e course)	Agricultural Research, Research ethics and Rural Development Programs	1+0
PGS 506 (e course)	Disaster Management	1+0

Food Safety and Quality Assurance

S. No.	Course No.	Course Title	Credits
A MAJOR COURSES			
1.	FQA 501	Advances in Analytical Techniques	3(1+2)
2.	FQA 502	Food Legislations, Standards and Food Safety Management Systems	2(2+0)
3	FQA 503	Food Safety and Risk Analysis	2(2+0)
4	FQA 504	Advances in Food Chemistry and Nutrition	3(2+1)
5	FQA 505	Food Toxicology	2(2+0)
6	FQA 506	Advances in Carbohydrate Chemistry	3(2+1)
7	FQA 507	Advances in Protein Chemistry	3(2+1)
8	FQA 508	Advances in Lipid Chemistry	3(2+1)
9	FQA 509	Advances in Food Additives & Preservatives	3(2+1)
10	FQA 510	Advances in Enzyme Technology	3(2+1)
11	FQA 511	Advances in Fermentation Technology	4(2+2)
12	FQA 512	Advances in Food Microbiology	3(2+1)
13	FQA 513	Starter Cultures and Fermented Dairy Products	3(2+1)
14	FQA 514	Microbiology of Food-Borne Pathogens	3(3+0)
15	FQA 515	Environmental Microbiology	3(2+1)
16	FQA 516	Advances in Food Biotechnology	3(2+1)
17	FQA 597	Special Problem	2(0+2)
18	FQA 598	In-Plant Training	2(0+2)

B1. MINOR COURSES: Food Processing Technology			
1.	FPT 501	Advances in Food Packaging Technology	3(2+1)
2.	FPT 502	Advances in Food Processing Technology	3(2+1)
3.	FPT 511	Management of by-products and Wastes	2(2+0)
4.	FPT 512	Membrane Technology in Food Processing	2(2+0)
5.	FPT 515	Technology for RTE/RTC Food Products	3(2+1)
6.	FPT 516	Technology of Food Emulsions, Foams and Gels	3(2+1)
7.	FPT 517	Technology of Frozen Foods	2 (2+0)
8.	FPT 518	Traditional Value added Food Products	3(2+1)

B2. MINOR COURSES : Food Engineering			
1.	FPE 501	Computer aided design of food plant, machinery and equipment	3(1+2)
2.	FPE 502	Advances in food process engineering	3(2+1)
3.	FPE 503	Advances in instrumentation & process control in food industry	3(2+1)
4.	FPE 504	Thermal process engineering	3(2+1)
5.	FPE 505	Advances in dairy engineering	3(2+1)
6.	FPE 509	Radiation in food processing	3(2+1)
7	FPE 510	Food plant maintenance	2(1+1)
8	FPE 602	Advances in bioprocess and biochemical engineering	2(1+1)

C. Supporting Courses			
1.	FBM 501	Computer Application in Food Industry	3(2+1)
2.	FBM 502	Operations Management	2(2+0)
3.	FBM 503	Advance Mathematics	2(2+0)
4.	FBM 504	Advances in statistical methods in food processing	3(2+1)
5.	FBM 505	Operation Research	2(2+0)
6	AG. STAT 512	Experimental Designs	3(2+1)
7	BE 501	Non- conventional Sources of Energy	3(2+1)
8	BE 502	Environmental Engineering	3(2+1)

D Seminar			
1.	FQA 599	Masters seminar	1+0
2.	FQA 998	Doctoral Seminar (Minor)	1+0
3	FQA 999	Doctoral Seminar (Major)	1+0

E Research (Thesis)			
1.		Masters Research	20
2.		Doctoral Research	45

FQA 501 3(1+2)
Advances in Analytical Techniques
(16 Lectures + 32 Practical)

Unit 1	Introduction to Food Analysis: Introduction to food and its components, Sampling, Sample preservation, Extraction, Proximate analysis
Unit 2	Spectroscopic Techniques: Introduction & theory of spectroscopic techniques, - Principle, Instrumentation, application of each technique. UV-Visible, IR, Raman, & Mass spectroscopy – Principle, Instrumentation, application of each technique. Fluorescence, Turbidoimetric techniques – Principle, Instrumentation, application of each technique. AAS – Principle, Instrumentation, applications. NMR/ESR spectroscopy – Principle, Instrumentation, application.
Unit 3	Chromatographic Techniques: Introduction, HPLC, GC, Paper chromatography, TLC/HPTLC, Ion chromatography, Flash chromatography – Principle, Instrumentation, applications of each technique.
Unit 4	Biological Techniques: Electrophoresis, PCR/RTPCR, Immunoassays - Principle, Instrumentation, applications of each technique
Unit 5	Recent Techniques: Rheology, DSC/DTA/TGA/TMA, XRD/XRF, Electron microscopy, Refractivity, Polarimetry - Principle, Instrumentation, applications of each technique

Practical

1	Determination of moisture by Karl Fischer method
2	Determination of carotenes (spectrophotometric)
3	Determination of Vitamin C (spectrophotometric)
4	Determination of gingerol by HPLC
5	Determination of minerals by AAS
6	Fatty acid profile in lipids by GC
7	Determination of Chloride content by Ion Chromatography
8	Determination of thermal properties using DSC
9	Determination of rancidity using Rancimat
10	Determination of sugar concentration and solids using Refractometer
11	Separation of amino acids using TLC/HPTLC
12	Separation of food colors using TLC/HPTLC
13	Demonstration of PCR for Gene amplification
14	Agarose Gel Electrophoresis
15	Demonstration of ELISA test

Suggested Readings

1. Food Analysis: Theory and Practice, 1994. Y. Pomeranz and C.E. Meloan. 3rd edn., Conn. (USA): AVI Publ. Co.
2. Stewart, K.K. and Whitaker, J.R. (1984). Modern Methods of Food Analysis. Conn: AVI Publ. Co.
3. James, CS. (1995). Analytical Chemistry of Foods. Blackie Academic and Professional, UK
4. Methods of analysis of food components and additives by Semih Otle, Published in 2005 by CRC Press

FQA 502 2(2+0)
Food Legislations, Standards and Food Safety Management Systems
(32 Lectures + 0 Practical)

Unit 1	Introduction to food - its nutritional, technological and safety aspects. Introduction to Indian legal system, an overview of food regulations in India. Food safety and standards act and role of FSSAI. Various food plant inspection bodies and legislations.
Unit 2	International Standards: Codex Alimentarius: Structure of organization, standards related to Indian foods.
Unit 3	Introduction to food safety: definition, food safety issues, factors affecting food safety, importance of safe foods. Shelf life of food products: factors affecting shelf life and methods to check the shelf life.

Unit 4	Food contaminants of natural origin- seafood toxins, toxic amino acids and others. Indirect additives: pesticides, pesticide residues, metallic contamination, radionuclides, other adulterants.
Unit 5	Good Hygienic Practices (GHP), Good Manufacturing Practices (GMP), Food Safety Plan, Food Safety Management Risk Analysis. Traceability, food product recall.
Unit 6	Food safety Management Systems: ISO 22000: Importance of implementing a HACCP system and how it can be applied to various products, develop a HACCP plan including a HACCP team, produce product workflow diagrams for a range of products and their verification processes etc. Audits: Introduction, objectives, documentation, responsibilities, management review, audit citification and its importance etc.
Unit 7	ISO 14000: Introduction, various standards among 14000 series, certification and its importance, various clauses of 14001. ISO 17025 - General requirements for the competence off testing and calibration laboratories.
Unit 8	Good agricultural practices for crops, land animals, human beings, finished goods etc. Good manufacturing practices: Concept, current problems in food industry and solutions using good manufacturing practices.
Unit 9	World Trade Organization (WTO), Sanitary and Phytosanitary Measures and Technical Barriers to Trade, Food and Agriculture Organization (FAO), World Health Organization (WHO), World Animal Health Organization, International Plant Protection Convention (IPPC) Export – Import of Food.

Suggested Readings

1. FSSAI (2011). Food safety and standards (Food product standards and Food Additives) regulation.
2. Neal D. Fortin. 2009. Food regulation, Wiley Publishers.
3. Naomi Rees. David Watson. 2000. International standards for food safety, Aspen Publications.
4. Assuring food safety and quality. 2012. FAO Food and Nutrition Manual., FAO publications, Rome.

FQA 503 2 (2+0)
Food Safety and Risk Analysis
(32 Lectures + 0 Practical)

Unit 1	Overview of food safety
	The importance of food safety, how food borne illness affects consumers and retailers, how poor safety practices affect food products, Food hazards, The food business, The responsibilities of the managers, Penalties applicable to poor food handlers, Enforcement officers, Basic rules regarding personal hygiene, good manufacturing and hygiene practices at various sectors of food processing.
Unit 2	Introduction to Risk Analysis
	Introduction, Changing International Environment, Increasing Demand for "Safe and Wholesale Food", Risk Analysis Definitions related to Food Safety, Risk Analysis: Structure of Risk Analysis, Carrying out Risk Analysis, Risk Analysis at International and National Levels. Challenges and benefits in the application of risk analysis.
Unit 3	Risk Management
	Introduction, Definitions of key Risk Management Terms, General principles of Food Safety Risk Management, General Risk Management Framework: Preliminary Risk management activities, selection of risk management options, implementation of risk management decisions, monitoring and review. Role of food chain professionals in Risk Management: Self-monitoring and company Laboratory Accreditation, Guides to good hygiene practices, the development of company certification, product standardization, contribution to product traceability
Unit 4	Risk Assessment
	Introduction, Definitions related to risk assessment, principles of Food safety risk assessment, scientific approaches for assessing risks, responsibilities of risk managers in commissioning and guiding a risk assessment, general criteria of risk assessment, risk assessment methodology, risk assessment for chemical hazards, risk assessment for biological hazards, Biotechnology risk assessment, sensitivity analysis, validation, establishment of 'Targets' in the food chain as Regulatory standards
Unit 5	Risk Communication

	Introduction, Understanding risk communication, the goals of risk communication, key communication stages during food safety risk analysis, role and responsibilities for risk communication, principles of risk communication, some practical aspects of risk communication.

Suggested Readings:

1. A practical Guide for Food Industry, Yasmine Motarjemi Huub Lelieveld, Academic Press, 2013
2. Managing Food Safety Risks in Agri Food Industries, Jan Mei Soon and Richard Baines, CRC Press 2013
3. Food Safety, Researching the Hazard in Hazardous Foods, Edited by Barbara Almanza Richard Ghiselli, Apple Academic Press 2014

FQA 504 3(2+1)
Advances in Food Chemistry and Nutrition
(32 Lectures + 16 Practical)

Unit 1	Physical and chemical properties of water: structure and chemical properties, solute effects on water, state of water in foods, kinetic principles; water activity: principles, measurement, control, effects, related concepts; acid-base chemistry of foods and common additives
Unit 2	Proteins: physical properties of proteins in relation to protein structure, analytical methods; basic properties: hydration, ionization, colloidal behaviour; functional properties; effects of food processing: changes occurring in chemical, functional & nutritional properties of proteins; nitrite function, chemistry and nitrosamine formation. Protein as nutrient, protein quality, role in human body.
Unit 3	Lipids: Content and role in foods, analytical methods, chemical, nutritional and physical properties, processing of fats and oils, degradation reactions
Unit 4	Carbohydrates: simple sugars, sugar derivatives and oligosaccharides, basic chemistry, conformation, anomeric forms, equilibrium, reactivity, sweetness; sugar derivatives: sugar alcohols, glycosides, etc.; browning and related reactions; case studies – acrylamide and furan formation in foods; polysaccharides: basic structures and properties, starches, celluloses, gums, modification techniques; dietary fiber: components, properties, analysis. Nutritional importance.
Unit 5	Vitamins: structure and properties of vitamins, distribution and morphology of vitamins in foods, changes of vitamins in food processing and storage, Regulation and control of vitamins in foods, relationship of vitamins and food quality. Deficiency of vitamins and metabolic disorders.
Unit 6	Minerals: structure and properties of minerals, distribution and morphology of minerals in foods and processed goods, changes of minerals in food processing and storage, regulation and control of minerals in foods, relationship of minerals and food quality
Unit 7	Role of protein, carbohydrate and lipid in nutrition, water, minerals and vitamins in nutrition: Functions, food sources, storage in body, deficiency, bioavailability etc.
Unit 8	Effect of cooking and heat processing on nutritive value of food. Processed supplementary foods. Use of food in body: digestion, absorption transportation and utilization. Nutrition and its relation to obesity. Energy calculations form foods and formulation of balanced diet.

Practical

1	Estimation of moisture content in food sample
2	Estimation of reducing sugars
3	Estimation of crude fibre content
4	Estimation of protein by Kjeldahl's method
5	Estimation of total ash, water soluble and acid soluble ash
6	Extraction of fat
7	Estimation of free fatty acids
8	Estimation of peroxide value
9	Estimation of iodine value
10	Estimation of saponification value
11	Refractive index of fats and oils
12	Specific gravity of fats and oils

13	Water activity
14	Calculation of normal diet
15	Calculation of liquid diet
16	Calculation of high and low calorie diet

Suggested Readings

1. Fennema's Food Chemistry, Fourth Edition (Food Science and Technology) Srinivasan Damodaran, Kirk L. Parkin, Owen R. Fennema
2. Belitz, H. D. and Grosch, W. Food Chemistry. Second Edition. New Yolk: Springer verlag, Berlin Heidelberg, 1999
3. Medeiros, D., & Wildman, R. (2011). Advanced Human Nutrition: Jones & Bartlett Learning.

FQA 505 2(2+0)
Food Toxicology
(32 Lectures + 00 Practical)

Unit 1	Introduction: history, definition of toxin, various classes of toxins i.e. chemical and biological origin, effects of excess intake of nutrients, acceptable daily intake, ease of food processing and nutrition. Molecular mechanism behind the chemical-induced toxicities.
Unit 2	Food additives, their safety, legal framework, unintended contamination form packaging materials and methods to avoid it. Nanomaterial and risk associated with it. Toxins generated during processing i.e. heating, irradiation, storage etc.
Unit 3	Biological techniques in toxicology: suspension cell culture, monolayer cell culture, indicators of toxicology in cell cultures, molecular cloning, cDNA and genomic libraries, northern and southern blot analysis, PCR, immunochemical techniques.
Unit 4	Pollutants: air pollutants: types, sources; water and soil pollutants: types and examples; occupational toxicants: sources and regulations
Unit 5	Metal toxins: mercury, lead, cadmium, chromium, arsenic etc. Effects on health. Their sources and prevention. Analysis of metal toxins.
Unit 6	Carcinogens in Food: Introduction, common carcinogens found in food, effect on health, their sources and levels of exposure, approaches to minimize carcinogens in food, assessment of carcinogenic safety of food.
Unit 7	Toxicological Testing: LD50 and LC50 oral dermal and inhaled, feeding trials, in vitro tests for toxicology, analysis of food toxins by gas chromatography, HPLC, mass spectrometry
Unit 8	Pesticides: introduction, organochlorine, organophosphorus, carbamate, pyrethroid, herbicides, fungicides, rodenticides, fumigants etc. Methods to reduce food contamination with pesticides.
Unit 9	Biological Toxins: mycotoxin, algal toxins, plant toxins and anti-nutrients, toxic animals used as food sources, dietary estrogens and antiestrogens, safety of genetically engineered foods.
Unit 10	Statistical methods used in toxicological studies.

Suggested Readings

1. Introduction to Food Toxicology (2nd Ed 2009). T. Shibamato and L. Bjeldanes Academic Press, Inc. San Diego, CA. ISBN 0-12640025-3
2. Essentials of Environmental Toxicology. W. William Hughes. Taylor & Francis, Philadelphia, PA. ISBN 1-56032-470-4
3. A Textbook of Modern Toxicology (3rd Ed 2004). Ernest Hodgson (Ed.), USA, Wiley & Sons. ISBN 0-471-26508-X
4. Food Toxicology. W. Helferich and C. K. Winter (Ed.), CRC Press, London. ISBN 0-8493-2760-1

FQA 506 3(2+1)
Advances in Carbohydrate Chemistry
(32 Lectures + 16 Practical)

Unit 1	Monosaccharides: structure, configuration and conformation. Physical Properties: hygroscopicity and solubility, optical rotation, mutarotation. Sensory Properties.

Unit 2	Chemical reactions: Reduction to sugar alcohols, oxidation to aldonic, dicarboxylic and uronic acids, reaction with acids and alkalies, caramalization, Millard reaction. Derivatives: esters, ethers.
Unit 3	Oligosaccharides: Structure and nomenclature, properties and reactions, production, importance in human health, prebiotic oligosaccharides, low calorie sweeteners.
Unit 4	Polysaccharides Classification, structure, conformation, properties. Important polysaccharides - Structures, properties and utilization: Agar, Alginates, Carrageenans, Furcellaran, Gum Arabic, Karaya Gum, Guaran Gum, Locust Bean Gum, Tamarind Flour, Pectin, Dextrins, Inulin and Oligofructose.
Unit 5	Enzymatic Degradation of Polysaccharides α-Amylase β –Amylase, Pectinolytic Enzymes, Cellulases, Hemicellulases etc.
Unit 6	Dietary fibers and their role in human health. The role of dietary fiber in the prevention of lipid metabolism disorders. Polydextrose as soluble fiber and complex carbohydrate to reduce calorie intake. Complex carbohydrates as fat mimetics.
Unit 7	Starch granules, granule gelatinization and pasting. Modification of starches: cold-water-soluble (pre-gelatinized) starch, cold-water-swelling starch, resistant starch. Retrogradation and staling of starch, starch complexes, hydrolysis of starch.
Unit 8	Cellulose: occurrence, isolation, structure, properties, utilization. Cellulose Derivatives : alkyl cellulose, hydroxyalkyl cellulose, carboxymethyl cellulose etc.
Unit 9	Analysis of carbohydrates. High Performance Anion Exchange Chromatography with Pulsed Amperometric Detection (HPAE-PAD): for the Analysis of Dietary Fiber and Complex Carbohydrates, NIR Analysis of Dietary Fiber, Estimation of psyllium content in ready-to-eat cereals, analysis of resistant starch etc.

Practical

1	Tests for reducing sugars by rapid tasters
2	Estimation of total sugars in foods
3	Tests for starch
4	Gelatinization of starches form various food sources
5	Estimation of amylase enzymes in food
6	Estimation of dietary fibres in given food sample
7	Modification of starch
8	NIR analysis of dietary fibre
9	Analysis of resistant starches
10	HPAE – PAD analysis of carbohydrates
11	Sensory evaluation of various sweeteners
12	Estimation of psyllium content in ready-to-eat cereals
13	Estimation of various carbohydrates forms ready to eat foods
14	Preparation of bread optimizing properties of carbohydrates

Suggested Readings

1. Damodaran, S., Parkin, K. L., and Fennema, O.R. (2008) Fennema's Food Chemistry 4th Edition, CRC Press
2. Belitz, H-D., Grosch, W. & Schieberle, P. (2004) Food Chemistry 3rd Ed. (translation of fifth German edition), Springer
3. Atkins, P. (1997) The Elements of Physical Chemistry, W.H. Freeman & Co.

FQA 507 3(2+1)
Advances in Protein Chemistry
(32 Lectures + 16 Practical)

Unit 1	Survey of protein availability and world's protein need. Present status of proteins in food industry.
Unit 2	Characteristics of proteins from plant, animal and microbial origins. Isolation techniques from conventional and non-conventional sources including single cell protein, leaf protein, seed protein and proteinoids.
Unit 3	Denaturation of proteins: effect of processing parameters on denaturation. Effect of denaturation on the physicochemical and biological properties of proteins in food systems.

Unit 4	Protein interactions with food constituents: protein-protein interactions, protein-lipid interactions, protein-polysaccharide interactions and protein- ion interactions.
Unit 5	Protein Nutrition: Recent concepts in protein nutrition in human. Effect of processing on nutritive value of proteins. Mass and institutional feeding programs: amino acid fortification of foods and concepts in protein supplementation and complementation. Allergic reactions to proteins and remedies. Legume proximate compositions and anti-nutritional factors: trypsin inhibitors etc. Treatments to enhance protein quality.
Unit 6	Protein hydrolysates – production and processing, de-bittering of protein products. Bioactive peptides: production and properties.
Unit 7	Recent Technologies: augmentation of world resources for protein foods: protein from plants, animals and microorganisms. Simulated protein foods.
Unit 8	Textured vegetable proteins and spun fiber technology. Tenderization of proteins.
Unit 9	Recent advances in the physical, chemical and microbiological aspects of separation, processing, characterization and utilization of food proteins.
Unit 10	Estimation of protein quality and quantity.

Practical

1	Estimation of protein content in various food samples by Kjeldahl method
2	Estimation of protein content in food samples using spectroscopic methods
3	Study of effect of heat on protein denaturation using enzymes
4	Study of effect of various salt solutions on solubility of proteins
5	Separation of milk proteins by salting out method
6	Separation of proteins using chromatographic methods
7	Preparation of protein hydro-lysates with different degree of hydrolysis
8	Study various methods of estimating protein efficiency in biological systems
9	Determination of molecular weight of protein with gel electrophoresis
10	Study effect of protein type, concentration etc. on rheological properties of protein
11	Study heat stability of proteins using heat coagulation time
12	Using protein as emulsifier to prepare food products
13	Understanding algorithms to sequence proteins
14	Sequence small protein fragments using mass spectrometry

Suggested Readings

1. Introduction to Protein Structure: Second Edition by Carl Branden and John Tooze
2. Proteins: Structures and Molecular Properties by Thomas E. Creighton
3. Physical Biochemistry by K.E.van Holde, C. Johnson, P. S. Ho

FQA 508 3(2+1)
Advances in Lipid Chemistry
(32 Lectures + 16 Practical)

Unit 1	Current trends in the fats & oil industry in India and abroad: sources and utilization of vegetable, animal and marine fats/oils.
Unit 2	Basic chemistry structure aspects of fats and oils, in relation to their processing, properties, utilization and significance in human diet. Rancidity development in oils: hydrolytic and oxidative. Antioxidants-science, technology and applications.
Unit 3	Physico-chemical properties of oils & fats, polymorphism, fat crystal networks, crystallization kinetics.
Unit 4	The changing concepts in the role of edible fats and oils in human nutrition and health: PUFA, MUFA, CLA, ω - fatty acids, trans fatty acids, phytosterol, etc.
Unit 5	Sources and classification of commercial edible fats and oils: Innovations in the production and processing of oils and fats from different sources, e.g. plant, animal, marine and microbial lipids for utilization in the food products. Non-conventional fats/oils for edible purpose – rice bran oil, microbial lipids.
Unit 6	Advances in refining including degumming, bleaching and deodorization of oils and fats: Existing technologies and new developments - application of membrane techniques, winterization.

Unit 7	Modification of fats and oils: physical modification – fractionation, chemical modification – hydrogenation and inter esterification, enzymatic/microbial modification of fats/oils – cholesterol reducing treatments.
Unit 8	Applications of fats and oils: margarine and low-fat table spreads, bakery and confectionery fats, coatings, shortenings, salad dressings, technology of cooking oils, frying process and systems, changes in fats and oils during frying, snack foods - processing systems, modified fats and oils for use in bakery and confectionery products, shortenings and spreads.
Unit 9	Fat replacers, technological developments in low calories spreads and other fat-based products.
Unit 10	Advances in technologies for production of plasticizers, emulsifiers and protective coatings.
Unit 11	Analytical techniques including rheological measurements and flavor evaluations.

Practical

1	Measurement of rancidity of oil/fat samples using rancimet
2	Estimation of various antioxidants in frying oils
3	Judging quality of frying oil by estimating polar compounds
4	Judging quality of frying oil by estimating free fatty acids
5	Sensory evaluation of various oils and ranking them on scorecards
6	Hydrogenation of vegetable oils in batch type equpmnet
7	Inter esterification of vegetable oils on laboratory scale
8	Comparing physical properties of oils after and before hydrogenation
9	Comparing physical properties of oils after and before inter esterification
10	Estimation of cholesterol in oil or fat sample
11	Removing cholesterol from oil/fat samples by various methods
12	Solvent and dry fractionation of oil samples
13	Preparation of butter and margarine form oil/fat samples
14	Estimation of various quality parameters of oils

Suggested Readings

1. Food Chemistry, O.R. Fennema, Ed., 2008. Marcel and Dekker, Inc., New York, NY.
2. Bailey's Industrial Oil & Fats Products, Ed. by Y.H. Hui, John Wiley & Sons, Inc

FQA 509 3(2+1)
Advances in Food Additives and Preservatives
(32 Lectures + 16 Practical)

Unit 1	Introduction- what are food additives, role of food additives in food processing , functions, classification, intentional and unintentional food additives, toxicology and safety evaluation of food additives, beneficial effects of food additives/toxic effects, food additives generally recognized as safe (GRAS), tolerance levels and toxic levels in foods-LD 50 values of food additives
Unit 2	Naturally occurring food additives, classification, role in food processing, health implications, food colors, natural and synthetic food colors, types , their chemical nature and their impact on health
Unit 3	Preservatives, what are preservatives, natural preservation, chemical preservatives, their chemical action on foods and human system, Antioxidants and chelating agents, their role in foods, types of antioxidants – natural and synthetic, chelating agents, their mode of action in foods with examples
Unit 4	Surface active agents, their mode of action in foods with examples, stabilizers and thickners with examples and their role in food processing, bleaching and maturing agents, examples of bleaching agents, what is maturing, examples of maturing agents and their role in food processing
Unit 5	Starch modifiers, chemical nature, their role in food processing, buffers- acids and alkalis, examples, types, their role in food processing, Sweeteners, what are artificial sweeteners and non nutritive sweeteners, their health implications, role in food processing
Unit 6	Flavoring agents, natural and synthetic flavors, examples and their chemical nature, role of flavoring agents in food processing, Anti-caking agents, their role in food processing, Humectants- definition, their role in food processing

Unit 7	Clarifying agents- definition, examples, their role in food processing

Practical

1	Determination of benzoic acid in food samples
2	Estimation of sulphur dioxide in food samples
3	Estimation of sorbic acid in cheese and yoghurt
4	Determination of nitrate and nitrites in foods
5	Detection and determination of aspartame by thin layer chromatography
6	Liquid chromatographic determination of caffeine, benzoate and saccharin in soda beverage
7	Identification of natural colours
8	Isolation, identification and estimation of synthetic food colours
9	TLC detection of antioxidants in fats and oils
10	TLC detection of emulsifiers
11	Detection of alginates in foods (chocolate, ice cream)
12	GC determination of menthol in mentholated pan masala

Suggested Readings

1. Baren, A. F. *et al* (2001). Food additives, 2nd edition,Marcel Dekker.
2. George, A. B. (1991). Encyclopaedia of food and colour additives, Vol III, CRC Press.
3. Nakai, S. and Modler, H. W. (2000). Food proteins: processing applications, Wiley

FQA 510 3(2+1)
Advances in Enzyme Technology
(32 Lectures + 16 Practical)

Unit I	Introduction The Nature of Enzymatic Reactions, Sources of Enzymes, General Characteristics of Enzymes, Classes and Nomenclature of Enzymes, Factors affecting enzyme activity, Enzyme Kinetic, Enzyme Inhibition
Unit II	Production of Commercial Enzymes, Selection of sources of enzyme, Sources of enzymes, Advantages of microbial enzymes, Problems of scale up, Enzyme extraction, Enzyme Purification
Unit III	Enzyme Applications, Introduction, Immobilization, Whole cell as catalysts, rDNA in enzyme engineering
Unit IV	Applications of enzyme in food Processing, Milling and baking, Starch, starch syrups and dextrose, Fruit, fruit products and wine, Meat and Other Proteinaceous Foods, Candy, Cacao, Chocolate, Coffee, Flavors and other applications
Unit V	Health and Legal Aspects of the, Use of Enzymes, Immunochemical Reactions, General Health Aspects, Legal Aspects

Practical

1	To investigate some of the kinetic properties of invertase
2	To study time course of the reaction catalysed by alkaline phosphatase.
3	To investigate the thermal stability of horseradish peroxidase
4	Quantitative estimation of endoglucanase
5	Quantitative estimation of exoglucanase
6	Quantitative estimation of β galactosidase
7	Quantitative estimation of Pectinase
8	Quantitative estimation of Protease
9	Quantitative estimation of Lipase
10	Immobilization of amylase by sodium alginate and comparative evaluation with native enzyme
11	To immobilize yeast cells and demonstrate its biological activity by invertase assay
12	To carry out amylase fermentation fermentation
13	To carry out protease fermentation fermentation
14	To carry out lipase fermentation fermentation

Suggested readings

1. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry. Trevor Palmer, Horwood Publishing Chichester, England.
2. Enzymes and Immobilized Cells in Biotechnology. Allen I. Laskin, The Benjamin/Cummings Publishing Company, INC., California.
3. Fermentation Microbiology and Biotechnology. Mansi El-Mansi & Charlie Bryce, Taylor & Francis Ltd, London.
4. Industrial Biotechnology. S. N. Jogdand, Himalaya Publishing House, Mumbai.
5. Biotechnology. Keshav Trehan, New Age International Publishers, New Delhi.
6. Fundamentals of Enzymology: Nicholes C. Price and Lewis Stevens, Oxford Univ. Press.
7. Enzymes in Food Processing. Gerald Reed, academic press New York and London

FQA 511 4(2+2)
Advances in Fermentation Technology
(32 Lectures + 32 Practical)

Unit 1	Introduction Fermentation- historical development; fermented food products of India; worldwide fermented food products; classification of fermented food products.
Unit 2	Fermentation- Basic Concepts Basic principles involved in fermentation; types of fermentation; starter culture; preparation and maintenance of bacterial, yeast and mold cultures for food fermentations.
Unit 3	Fermented Milk Products Processing, manufacture, storage and packaging of acidophilus milk, cultured butter-milk and other fermented milk; bio-chemical changes occurring during manufacture of fermented milks; factors affecting these changes and effects of these changes on the quality of finished products.
Unit 4	Fermented Vegetables Products Technological aspects of pickled vegetables, sauerkraut, cucumbers; mushrooms-cultivation and preservation
Unit 5	Fermented cereal and Pulse Products Fermented soy sauce; microbiology and biochemistry; soy sauce manufacturing methods; miso fermentation- raw materials and microorganism for fermentation; comparison of Indigenous and modern processing; spoilage microbes; tempeh- production and consumption, raw material used, essential steps of fermentation; indigenous fermented product-idli, dosa, dhokla etc.
Unit 6	Fermented Fish and Meats Product Fermented fish and fish products- fish sauces, fermented fish pastes; fermented sausages- process for manufacture of fermented sausage biochemical and microbiological changes during sausage ripening.
Unit 7	Alcoholic Fermentation Products Technology for processing oh wine, cider, beer etc.; microbiological and biochemical aspects
Unit 8	Other Fermented Products Methods of manufacture for acetic acid/vinegar, baker's yeast, microbial protein, lactic acid etc. Traditional fermented Foods of India: Dahi, lassi, Butter Milk, Jalebi, Khaman, Dhokla, Idli, Wada etc. Future of Fermented Foods: Advances in microbiology, role of intestinal bacteria in human health in future, regulation and health claims for fermented foods.

Practical

1	Preparation of fermented cereal products
2	Preparation of fermented pickles
3	Preparation of Dahi and Lassi
4	Freeze drying of starter culture
5	Preparation of Cheese and analysis
6	Preparation of yoghurt
7	Study of bacteriophages in starter culture
8	Preparation of Traditional fermented food of India
9	Preparation of Tempeh

10	Preparation of alcoholic products
11	Study of Probiotic bacteria
12	Preparation of symbiotic food
13	Industrial Visits

Suggested Readings

1. Microbiology of fermented foods by B. J. B. Wood, Springer
2. Microbiology and Technology of Fermented Foods by Robert W. Hutkins, IFT Press
3. Handbook of Indigenous Fermented Foods by K. H. Steinkrauss, CRC Press
4. Outlines of Dairy Technology by Sukumar De, Oxford University Press

FQA 512 3(2+1)
Advances in Food Microbiology
(32 Lectures + 16 Practical)

Unit 1	History, scope and importance of food microbiology
Unit 2	Microorganisms and food: Their primary sources of microorganisms in foods: Airborne bacteria and fungi, Microorganisms found in soil, Microorganisms in water, Normal flora of skin, nose, throat, GI tract
Unit 3	Factors affecting the survival and growth of microorganisms in food: Intrinsic factors for growth,Moisture, pH & acidity, Nutrient content, Biological structure, Redox Potential, Naturally occurring and added antimicrobials, Competitive micro flora, Extrinsic factors for growth, Types of packaging/atmospheres, Effect of time/temperature conditions on microbial growth, Storage/holding conditions, Processing steps
Unit 4	Microbiological examination- Methods of Isolation and detection of microorganisms or their products in food. - Conventional methods - Rapid methods (Newer techniques) – Immunological methods: Fluorescent, antibody, Radio immunoassay, ELISA etc. - Chemical methods PCR (Polymers chain reactions), RT PCR, Microchip based techniques
Unit 5	Microflora of Fresh Food: Meat, Poultry, Eggs, Fruits and vegetable, Shellfish and Finish, Milk, Microbial Spoilage of Food, Fresh Foods, Fresh Milk, Canned Foods
Unit 6	Food Preservation and application to different types of foods: Physical methods –, Drying, freeze-,drying cold storage,, heat treatments(pasteurization), TDT, TDP, Irradiation (UV, microwave, ionization), high pressure processing, Aseptic packaging, modified atmosphere, Chemical preservatives and Natural antimicrobial compounds. Biologically based preservation systems
Unit 7	Food borne infections and diseases: Significance to public health Food hazards and risk factors, Bacterial, and viral food-borne disorders, Food-borne important animal parasites, Mycotoxins. - Bacillus, Campylobacter,
	Brucella, Staphylococcus, Clostridium, *E.coli*, Aeromonas, *Vibrio cholerae*, Listeria, Mycobacterium, Salmonella, Shigella
Unit 8	Quality Control/Quality Assurance Legislation for food safety – national and international Criteria, sampling schemes, records, risk analysis QC- microbial source, code Indicators of food safety and quality: Microbiological criteria of foods and their significance.
Unit 9	The H A C C P system and food safety used in controlling microbiological hazards.

Practical

1	Preparation of common laboratory media and special media for cultivation of bacteria, yeast & molds.
2	Staining of Bacteria: Gram's staining, acid -fast, spore, capsule, Motility of bacteria, Staining of yeast and molds.
3	Isolation of microorganisms: Different methods and maintenance of cultures of microorganisms.
4	Bacteriological analysis of Foods using conventional methods
5	Coli forms analysis of milk and water samples
6	To perform various biochemical tests used in identification of commonly found bacteria in foods: IMVIC urease, H_{2S}, Catalase, coagulase, gelatin and fermentation (Acid/gas)

7	Determination of thermal death characteristics of bacteria
8	Demonstration of available rapid methods and diagnostic kits used in identification of microorganisms or their products.
9	Visits (at least two) to food processing unit or any other organization dealing with advanced methods in food microbiology.

Suggested Readings

1. Pelczar, M.I. and Reid, R.D. (1993) Microbiology McGraw Hill Book Company, New York, 5 th Edition.
2. Atlas, M. Ronald (1995) Principles of Microbiology, 1 st Edition, Mosby-Year Book, Inc, Missouri, U.S.A.
3. Topley and Wilson's (1983) Principles of Bacteriology, Virology and Immunity, Edited by S.G. Wilson, A. Miles and M.T. Parkar, Vol. I: General Microbiology and Immunity, II: Systematic Bacteriology. 7 th Edition. Edward Arnold Publisher.
4. Frazier, W.C. (1988) Food Microbiology, McGraw Hill Inc. 4 th Edition,
5. Jay, James, M. (2000) Modern Food Microbiology, 6 th Edition. Aspen publishers, Inc., Maryland.
6. Banwart, G. (1989) Basic Food Microbiology, 2 nd Edition. CBS Publisher.
7. Doyle, P. Benehat, L.R. and Mantville, T.J. (1997): Food Microbiology, Fundamentals and Frontiers, ASM Press, Washington DC.
8. Adams, M.R and M.G. Moss (1995): Food Microbiology, 1 st Edition, New Age International (P) Ltd.

FQA 513 3 (2+1)
Starter Cultures and Fermented Dairy Products
(32 Lectures + 16 Practical)

Unit 1	Introduction to starter cultures; History and taxonomy of starter cultures; Classification of starter organisms: The genus Lactococcus; The genus Leuconostoc; The genus Streptococcus; The genus Pediococcus, The genus Lactobacillus.
Unit 2	Adjunct starter organisms; Bifidobacterium, Enterococcus, Propionibacterium, Brevibacterium, miscellaneous microorganisms, Yeasts and Molds.
Unit 3	Metabolism of starter organisms: biochemical characterization of lactic acid bacteria; carbohydrate, citrate and protein metabolism. Genetics of starter cultures: plasmids and plasmid instability; industrially significant genes, genetic modification of lactic acid bacteria through transduction; conjugation; protoplast transformation; electroporation and chromosomal integration, transposons and insertion sequences.
Unit 4	Types of starters: single, mixed and multiple strain starter cultures; propagation and preservation of starter cultures; commercial starter preparations: concentrated and super-concentrated starters
Unit 5	Growth inhibition of lactic acid bacteria by antibiotics, bacteriocins; immunoglobulins and bacteriophage: sources, types and characteristics of phages associated with starters, phage control during starter handling and growth, mechanisms of phage resistance in LAB.
Unit 6	Probiotic cultures, health and nutritional benefits, requirements for ability to survive and grow in the intestine, control of intestinal infections.
Unit 7	Introduction and history of probioitcs and fermented dairy products. Factors influencing the quality and storage stability of fermented milks.
Unit 8	Methods used in their manufacture, evaluation and quality control Microbiology of yoghurt and related products. Microbiology of acidophilus products, dahi, cultured butter milk, shrikhand, yakult, and milk based products containing probiotic cultures.

Practical

1	• Isolation of lactococcal cultures from fermented milks
2	Examination of purity and activity of starter cultures.
3	Preservation of starter cultures by freeze drying and other methods.
4	Preparation of concentrated starters and quality evaluation.
5	Inhibition of starters by antibiotic residues and other inhibitors

6	Plasmid profiles of some lactococcal cultures
7	Identification of lactic starters by molecular biology techniques
8	Production of bacteriocins by LAB.
9	Manufacture of different fermented milks and their microbiological and chemical analysis
10	Study of shelf life of fermented milks using different methods of preservation
11	Microbiological assay of vitamins or amino acids in fermented milk

Suggested Readings

1. Cogan TM & Accolas JP. 1995. Dairy Starter Cultures. VCH Publ.
2. Law BA. 1997. Microbiology and Biochemistry of Cheese and Fermented Milks. 2nd Ed. Blackie.
3. Marth EM & Steele JL.1998. Applied Dairy Microbiology. Marcel Dekker.
4. Robinson RK. 1998. Developments in Food Microbiology. Vol. IV Elsevier.
5. Salminen S & Wright AV. 1998. Lactic Acid Bacteria. Marcel Dekker.
6. Wood BJ & Warner PJ. (Eds.). 2003. Genetics of Lactic Acid Bacteria. Springer- Verlag.
7. Cogan TM & Accolas JP. 1995. Dairy Starter Cultures. VCH Publ.
8. Law BA. 1997. Microbiology and Biochemistry of Cheese and Fermented Milks. 2nd Ed. Blackie.
9. Marth EM & Steele JL.1998. Applied Dairy Microbiology. Marcel Dekker.
10. Robinson RK. 1998. Developments in Food Microbiology. Vol. IV. Elsevier.

FQA 514 3(3+0)
MICROBIOLOGY OF FOOD-BORNE PATHOGENS
(48 Lectures + 0 Practical)

Unit 1	Foodborne Pathogens: Host Invasion; Pathogenesis; Molecular approaches for detection, identification, typing and analysis of foodborne pathogens; Biosensor –based detection of foodborne pathogens
Unit 2	Staphylococcal Gastroenteritis: Incidence in Foods, Staphylococcal Enterotoxins: Types and Incidence, The Gastroenteritis Syndrome, Prevention of Staphylococcal and other Food-Poisoning Syndromes
Unit 3	Botulism: Analysis of Dairy Products for C. botulinum and Botulinal Toxin, Clinical Manifestations, Outbreaks, Prevention; Bacillus Cereus food poisoning: Analysis of Dairy Products for B. cereus and Toxin, clinical manifestation, outbreaks, prevention.
Unit 4	Brucellosis: Clinical Manifestations, Outbreaks, Prevention; Foodborne Listeriosis, Clinical Manifestations, Thermal Properties, Virulence Properties, Animal Models and Infectious Dose, Listeriosis Syndromes, Prevention.
Unit 5	Salmonellosis: Isolation and Detection Methods, Clinical Manifestations, Outbreaks, Prevention

Suggested Readings

1. Doyle MP, Beuchat LR & Montville TJ. 2001. Food Microbiology:
2. Fundamentals and Frontiers. 2nd Ed. ASM Press.
3. Food and Drug Administration. Food-borne Pathogenic Microorganisms and Natural Toxins Handbook: The Bad Bug Book.
4. Fratamico PM, Bhunia AK & Smith JL. 2005. Food-borne Pathogens: Microbiology and Molecular Biology. Caister Academic Press.
5. Hocking AD. et al. 2003. Food-borne Microorganisms of Public Health Significance. 6th Ed. AIFST (NSW Branch) Food Microbiology Group, Sydney.
6. Jay JM. 2000. Modern Food Microbiology. 6th Ed. Aspen Publ.
7. Labbe RG & Garcia S. 2001. Guide to Food-borne Pathogens. John Wiley & Sons.
8. Marth EH & Steele JM. 2001. Applied Dairy Microbiology. 2nd Ed. Marcel Dekker.
9. Robinson RK, Batt CA & Patel PD. 2000. Encyclopedia of Food Microbiology. Vols.I-III. Academic Press.

FQA 515 3 (2+1)
ENVIRONMENTAL MICROBIOLOGY
(32 Lectures + 16 Practical)

Unit 1	Introduction to Environmental Microbiology: Environmental Microbiology as a Discipline; Microbial Influences on our, Daily Lives, Microorganisms Found in the Environment:Classification of Organisms; Prokaryotes, Eukaryotes, Viruses, Other Biological Entities, Waste and Pollutants:Sources of Wastes and pollution, Hazards from waste and

	pollution,Global environmental problems:Ozone depletion, UV-B, greenhouse effect and acid rain, their impact and biotechnological approaches for management, Containment of acid mine drainage applying biomining, Issues concerning release of genetically engineered microorganisms in environment; impact assessment and ethical issues.
Unit 2	Waste Treatment, Biofilters, Treatment of liquid wastes, Treatment of solid wastes, Contribution of biotechnology to waste
Unit 3	Landfill, Cell Emplacement method, Trench Method, Uses of Landfill sites, Hazards of Landfill
Unit 4	Aerobic waste water treatment, Measurement of levels of pollution, Process of waste water treatment: Preliminary, Primary, Secondary, Tertiary and sludge treatment, Aerobic Reactors and Digesters: Fixed Film; Trickling Filter, Rotating Biological Contactors, Dispersed Growth, Digesters, Microorganisms used:
Unit 6	Anaerobic Treatment of Waste water, Microorganisms used, Sludge Treatment
Unit 7	Microbial toxicants and pollutants and their Biodegradation; Organic pollutants and their degradation, Biodegradation of plastics and polymers, Bioremediation of Xenobiotics, Microbiology of degradation of xenobiotics in the environment, ecological considerations, decay behaviour, bio-magnification and degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants and pesticides

Practical

1	Determination of BOD in Dairy industrial wastes
2	Determination of BOD in Fruit pulp industrial wastes
3	Determination of COD in Dairy industrial wastes
4	Determination of COD in Fruit pulp industrial wastes
5	Determination of composite micro-flora of selected environmental samples
6	Detection of low levels of xenobiotics
7	Detection of Microbial toxins in environmental samples
8	Detection of residual antibiotics in environmental samples
9	Isolation of bacteria capable of degrading organic and microbial pollutants from environmental samples
10	Isolation of bio-indicators from environmental samples
11	Characterization of bio-indicators from environmental samples
12	Visit to a Effluent treatment plant

Suggested Readings

1. Bitton G. 1994. Waste-water Microbiology. John Wiley & Sons.
2. Hurst CJ, Crawford RL, Garland JL, Lipson DA & Mills AL. 2007. Manual of Environmental Microbiology. 3rd Ed. ASM Press.
3. Maier RM, Pepper IL & Gerba CP. 2000. Environmental Microbiology. Elsevier.
4. Mitchell R. 1995. Introduction to Environmental Microbiology. 8th Ed. Prentice-Hall of India.
5. Pepper IL & Gerba CP. 2004. Environmental Microbiology: A Laboratory Manual. 2nd Ed. Elsevier.
6. Singh BD, 2010, Biotechnology: Expanding Horizons Third edition. Kalyani Publisher

FQA 516 3(2+1)
Advances in Food Biotechnology
(32 Lectures + 16 Practical)

Unit 1	History of biotechnology, status of biotechnology in India, primary and secondary screening, introduction to primary and secondary metabolites. Introduction to control of metabolic pathways. Techniques for isolation and screening of microorganisms.
Unit 2	Strain improvement, fermentation process of enzyme, fermentation processes of alcohol and organic acids, fermentation processes of antibiotics.
Unit 3	Food applications of enzymes; amylases, proteases, lipase, pectinase, celluloses, glucose oxidase. Microencapsulation of enzyme/probiotics.
Unit 4	Genetic improvement of starter cultures to improve technological features of starter cultures such as acid, flavor, EPS production etc.
Unit 5	Recombinant DNA technology for production of protease, lipase, chimosin, immunoglobulins etc.

Unit 6	Functional and nutraceuticals, supplementation/fortification of bioactive peptides and other functional ingredients, nutrigenomics.
Unit 7	Application of molecular tools, biosensors etc. for the detection of pathogens.
Unit 8	Molecular tools for study of biodiversity. Regulatory standards for GMO and GM foods.

Practical

1	Demonstration of fermenter
2	To carry out fermentation of amylase enzyme
3	Introduction to enzyme purification techniques
4	To carry out quantitative estimation of amylase
5	To carry out enzyme assay of invertase
6	Demonstration of enzyme immobilization
7	Determination of stability of enzyme at different temperature, pH
8	Extraction and clarification of juices using enzymes
9	Introduction to microbial isolation techniques
10	Detection of food borne pathogen by conventional microbiological method
11	Microencapsulation of probiotics and study of their viability
12	Isolation of genomic DNA
13	Agarose gel electrophoresis
14	DNA amplification by using PCR
15	RT PCR for pathogen detection
16	Gene cloning

Suggested Readings

1. Principles of Fermentation Technology by Stanbury and Whittaker: 2nd Edition
2. Industrial Microbiology: L.E. Casida, Willey Eastern Ltd., 1989
3. Bioprocess Engineering – Basic concepts by M. L. Schuler & F. Kargi, Entice Hall;1992
4. Biotechnology - a handbook of industrial microbiology: W. Crueger and A. Crueger
5. Basic Biotechnology by Colin Ratledge and Bjorn Kristiansen: 2nd Edition, Cambridge University Press

SUPPORTING COURSES

FBM 501 3(2+1)
Computer application in food industry
(32 Lectures + 16 Practical)

Unit 1	Importance of computerization in food industry, operating environments and information systems for various types of food industries, principles of communication	2
Unit 2	Supervisory Control and Data Acquision (SCADA): Introduction to SCADA, SCADA systems hardware and firmware, SCADA systems software and protocols, landlines, local area network systems, modems, central site computer facilities	2
Unit 3	Spreadsheet Applications: Data entry, interpretation and solving problems; Cells, cell reference, functions, preparation of charts, use of macros to solve engineering problems; use of add-ins, use of solver etc	4
Unit 4	Web hosting and Webpage Design: Domain registration, web hosting, webpage design using web publishing software; Introduction to File Transfer Protocol (FTP); Online food process control from centralized server system in processing plant	2

Unit 5	Use of Matlabs in Food Industry: Introduction, MATLAB interactive sessions, computing with MATLAB, Script files and editor/debugger; MATLAB help system, problem solving methodologies; Numeric, cell and structure array; Arrays, multidimensional arrays, element by element operations ; Matrix operations, polynomial operations using arrays, cell arrays, structure arrays; Functions and Files in MATLAB: Elementary mathematical functions, user defined functions; Advanced function programming, working with data files; Programming using MATLAB, Program design and development, Relational operators and logical variables, Logical operators and functions, Conditional statements, loops, the switch structure, debugging MATLAB programs, applications to simulations. Plotting and Model Building in MATLAB; XY plotting functions, subplots and overlay plots, special plot types, interactive plotting in MATLAB, function discovery, regression, the basic fitting interface, three dimensional plots; Introduction to Toolboxes useful to Food Industry: Curve fitting toolbox, Fuzzy logic toolbox, Neural Network toolbox, Image processing toolbox, statistical toolbox	10
Unit 6	Introduction to CFD Applications in Food Industry: Introduction to Computational Fluid Dynamics (CFD), governing equations of fluid dynamics. Models of flow, substantial derivative, divergence of velocity, continuity, momentum and energy equations. Physical boundary conditions, discretization. Applications of CFD in Food and beverage industry. Introduction to CFD softwares, GAMBIT and Fluent softwares	8
Unit 7	Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.	4
		32

List of Practical

1	Introduction to various features in different spreadsheet softwares	1
2	Solving problems using functions in spreadsheets	2
3	To use Add-Ins in spread sheet and statistical data analysis using Analysis Tool pack	1
4	Introduction to MATLAB and practice sessions	2
5	To solve problems using Curve fitting toolbox in MATLAB	1
6	To solve problems using Fuzzy logic toolbox in MATLAB	1
7	To solve problems using Neural Network toolbox in MATLAB	1
8	To solve problems using Image processing toolbox in MATLAB	1
9	Introduction to GAMBIT software	1
10	Creation of Geometry for laminar flow through pipe using GAMBIT	1
11	Introduction to FLUENT software	1
12	Import of geometry and application of boundary conditions	1
13	To solve a problem on laminar flow using FLUENT	1
14	Use of software packages for summarization and tabulation of data	1
		16

Suggested Readings

1. David Bailey and Edwin Wright. *Practical SCADA for Industry*. Elsevier
2. William J. Palm. *Introduction to MATLAB 7 for engineers*. McGraw Hill Professional
3. Da Wen Sun. *Computation Fluid Dynamics in Food Processing*. CRC press
4. Jenny Chapman. *Web Design: A Complete Introduction*. John Wiley & Sons
5. Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall.
6. Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
7. Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
8. Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
9. http://www.iasri.res.in/design/Analysis of data/Analysis of Data.html.
10. Fundamentals of Food Process Engineering by R.T.Toledo. Published by Springer
11. Introduction to Web Design Using Microsoft FrontPage by Glencoe/McGraw-Hill Published by Glencoe/McGraw Hill

FBM 502 2(2+0)
Operations Management
(32 Lectures)

Unit	Topics	No. of Lecture
Unit 1	An overview of Operations Management: Operations Management: Introduction and Overview, Historical Evolution - Changes & Challenges	2
	Concept of Production, Production System, Classification of Production System	2
	Objectives and Scope of Operations Management	1
	Productivity, Factors Affecting Productivity	1
Unit 2	Operations Strategy: Strategic Role of Operations, Strategic Planning	1
	Product Strategy and integrated product development, Process Strategy	1
	Characteristics of decision and decision methodology	1
	Capacity Planning Decisions	1
	Facilities Location Strategies	1
Unit 3	Product Design and Process Selection: Product design	1
	Process design	1
	Process technology and its choices	1
	Plant Layout, Classification of layout	1
	Job design and work organization	1
Unit 4	Planning and managing operations: Demand Forecasting	2
	Value chain and Supply chain Management	2
	Purchasing, vendor selection and material management, Inventory Management & Just-in-Time Systems	2
	Materials Requirement, Planning and ERP Scheduling, sequencing and dispatching	1
	Project planning and control	1
Unit 5	Managing Quality: What is quality and why is it so important?	1
	Statistical process control (SPC), Measuring and improving performances, Failure detection and analysis	2
	Total Quality management, Value analysis and Value Engineering	1
	Statistical Quality Control	1
Unit 6	The Operations Challenges: Why challenges? Globalization, Corporate social responsibility, Environmental responsibility, Technology, Knowledge management	3

Suggested Readings

1. Chary SN (2004), Production and Operations Management, Tata Mc Graw Hill III Edition.
2. Anil Kumar, S and Suresh, N (2009), Operations Management, New Age International (P) Ltd., Publishers, New Delhi
3. Slack, N, Chambers, S and Jhonston, R (2007) Operations Management, Pearson Education Ltd., Essex, UK
4. Joseph G. Monks(1997), Operations Management Theory and Problems, Mc. Graw Hill III Edition

FBM 503 2(2+0)
Advance Mathematics
(32 Lectures + 0 Practical)

Unit 1	Review of Calculus and Ordinary Differential Equations: Introduction, First order differential equations, Second order linear differential equations, Higher order linear equations, Series solutions of differential equations, The Laplace transforms, Systems of first order linear equations, Series Solution and special function.
Unit 2	Partial Differential Equations: Introduction: PDEs and their solutions; initial and boundary value problems; existence, uniqueness, and well posedness; First order PDEs: method of characteristics, linear and quasi-linear PDEs • Second order linear PDEs: classification; d'Alembert's solution to the wave equation and propagation of discontinuities; Separation of Variables: homogeneous equations, examples from the heat, wave, and Laplace equations; Fourier series and their convergence.

Unit 3	Complex Variables: Introduction to complex numbers, complex powers, topology of the complex plane, complex functions and limits, elementary functions, analyticity and the Cauchy Riemann relations; Complex Integration: contour integration and Cauchy's theorem, harmonic functions; **Series representation of analytic functions** convergent series of analytic functions, Laurent and Taylor series, zeroes and singularities ; **Calculus of residues:** calculation of residues, residue theorem.
Unit 4	Calculus of Variations Integral Equation: Introduction, Variational problems with the fixed boundaries, Variational problems with moving boundaries, Sufficiency conditions, Fredholm's Integral equations, Voltera Integral equations, FRedholm's theory - HilbertSchmidt theorem, Fredholm and Volterra Integro-Differential equation

Suggested Readings

1. W. A. Strauss. Partial Differential Equations: An Introduction 2ed
2. Y. Pinchover and J. Rubinstein. An Introduction to Partial Differential Equations
3. Kreyszig E. Advanced Engineering Mathematics. Wiley
4. E. Zauderer. Partial Differential Equations of Applied Mathematics
5. R. B. Guenther and J. W. Lee. Partial Differential Equations of Mathematical Physics and Integral Equations
6. Heath M.T. Scientific Comuting. McGraw-Hill

FBM 504 3(2+1)
Advances in statistical methods in food processing
(32 Lectures + 16 Practical)

Unit 1	Applications of statistical procedures in food processing, Descriptive statistics, Analysis of differences, Types of significance test, Association, correlation and regression and Experimental design
Unit 2	Sensory and consumer data: Introduction, The quality and nature of sensory and consumer data, Experimental design issues, Consumer data (sensory and survey), Trained panel sensory data, Analysis of relationships
Unit 3	Instrumental data: Introduction, Quality and nature of instrumental data, Sampling and replication, Experimental design issues, Statistical analysis of instrumental data, Chemical analysis applications, Analysis of relationships
Unit 4	Food product formulation: Introduction, Design application in food product development, Single ingredient effects, Two or more ingredients, Screening of many ingredients, Formulation by constraints
Unit 5	Statistical quality control: Introduction, Types of statistical quality control, Sampling procedures, Control charts, Acceptance sampling
Unit 6	Multivariate applications: Introduction, Multivariate methods and their characteristics, Multivariate modes, Relationship of consumer preference with sensory measures
Unit 7	Principal component analysis, Chemometrics, Partial least square, Response surface methodology, Mixture design, Fractal analysis, Cluster analysis, ANN and Fuzzy logic

List of Practical

1. Applications of dimensionality reduction and discriminant function analysis
2. Nonparametric tests.
3. Analysis of qualitative data
4. Analysis of data having random effects using Linear mixed effects models
5. Classification and prediction using artificial neural networks
6. Analysis of data with missing observations
7. Multiple linear regression analysis
8. Partial regression coefficients
9. Residuals and their applications in outlier detection
10. Study on robust parameter design and process robustness
11. Practice with Statistical Softwares

Suggested Readings

John A. Bower 2013. *Statistical Methods for Food Science: Introductory Procedures for the Food Practitioner 2ed* Wiley Blackwell.

Barnsley M.F.1988. *Fractals Everywhere*. Academic Press, Boston.

Montgomery D.C. 1997. *Design and Analysis of Experiments 4ed*. Wiley

Everitt BS & Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.

Geisser S. 1993. *Predictive Inference: An Introduction*. Chapman & Hall.

Gentle JE, Härdle W & Mori Y. 2004. *Handbook of Computational Statistics -Concepts and Methods*. Springer.

Simonoff JS. 1996. *Smoothing Methods in Statistics*. Springer.

Thisted RA. 1988. *Elements of Statistical Computing*. Chapman & Hall.

Khuri AI & Cornell JA. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.

Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.

Design Resources Server: www.iasri.res.in.

SAS Online Doc 9.1.3:

FBM 505 2(2+0)
Operation Research
(32 Lectures)

Unit	Topics
Unit 1	Introduction to operations research
	Elementary concepts and objectives of Operations Research
	Applications of Operations Research in decision making
Unit 2	Linear programming problem
	Mathematical formulation of the linear programming problem and its graphical solution
	Simplex Method
Unit 3	Transportation problem
	Definition and mathematical formulation
	Initial basic feasible solution
	Optimal solution
Unit 4	Introduction and mathematical formulation
	Solution of Assignment problem
Unit 5	Inventory control
	Introduction and general notations
	Economic lot size models with known demand
Unit 6	Replacement theory
	Introduction and elementary concepts
	Replacement of items deteriorating with time
Unit 7	Sequencing problem
	Introduction and general notations
	Solution of a Sequencing problem
Unit 8	Queuing theory
	Introduction and classification of queues
	Solution of Queuing models
Unit 9	Project planning and network analysis
	Introduction and basic definitions in Network Analysis
	Rules for drawing Network Analysis
	Critical Path Method (CPM)
	Project Evaluation and Review Technique (PERT)

Suggested Readings

1. Ackoff R. K. and Sassioni, M.W. 1978. Fundamentals of Operations Research. Wiley Eastern, New Delhi

2. Wagner, H.M. 1978. Principles of Operations Research, with Applications to Management Decisions. Prentice Hall of India, New Delhi

3. Taha, H. A. 2007. Operations Research: An Introduction. Pearson Prentice Hall, New Jersey

4. Goel, B. S. and Mittal, S. K. 1985. Operations Research. Pragati Prakashan, Meerut

AG. STAT- 512 3(2+1)
Design of experiments
(32 Lectures + 16 Practical)

Unit 1	Basic principles of Design of experiments.
Unit 2	Uniformity trials – shape & size of plots and blocks.
Unit 3	Elements of Linear estimation. Analysis of variance and Co-variance. CRD, RCBD and LSD. Factorial experiments, Confounding in 1^n, 2^n and 3^n experiments.
Unit 4	Split plot & Strip plot design. BIBD (general properties). Analysis of BIBD with recovery of inter block information, construction of BIBD.
Unit 5	Variance stabilizing transformations, sampling in field experiments.
Unit 6	Analysis of group of experiments. Switch over design – experimental on cultivator speed.

Practical:

1	Application of CRD technique to specific problems
2	Application of RCBD technique to specific problems
3	Application of LSD technique to specific problems
4	Application of CRD, RCBD and LSD techniques to specific problems
5	Problems related to confounding
6	Problems related to variance and co-variance
7	Problems related to BIBD
8	Problems related to Switch over design

BE – 501 3 (2+1)
Non- conventional Sources of Energy
(32 Lectures + 16 Practical)

S. No.	Topics of Lectures
Unit 1	Classification of energy sources; Introduction to renewable energy sources and technologies, their importance for sustainable development and environmental protection, production and potential.
Unit 2	Solar radiation, measurement of solar radiation, types of solar collectors and their uses, solar thermal energy conversion and storage
Unit 3	Solar PV cells, modules, arrays, conversion process of solar energy into electricity, applications.
Unit 4	Wind energy, potential & process of conversion, types of wind energy conversion systems
Unit 5	Characterization of biomass; briquetting of biomass, biomass combustion, pyrolysis, gasification, types and uses of gasifiers,.
Unit 6	Importance of biogas technology, production mechanism, types of biogas plants, uses of biogas, handling & utilization of digested slurry.
Unit 7	Brief introduction to geothermal energy, wave energy, ocean thermal energy conversion,
	Total lectures

Practical	Title
1	Demonstration of solar cooker.
2	Demonstration of solar water heater
3	Demonstration of solar dryer
4	Demonstration of solar still
5	Demonstration of solar radiation measuring instruments
6	Demonstration of solar PV system
7	Demonstration of wind measuring instruments
8	Study of wind mill
9	Estimation of moisture content of biomass
10	Determination of calorific value of biomass
11	Estimation of ash content of biomass
12	Estimation of fixed carbon and volatile matter of biomass
13	Demonstration of up draft gasifier
14	Demonstration of down draft gasifier
15	Demonstration of working of a fixed dome type biogas plants
16	Demonstration of working of a floating drum type biogas plants

Suggested Readings

Rai, G.D. 2013. Non-Conventional Energy Sources, Khanna Publishers, Delhi.
Rai, G.D., Solar Energy Utilization, Khanna Publishers, Delhi.
Khandelwal, K.C. & S. S. Mahdi. 1990. Biogas Technology- A Practical Handbook.
Rathore N. S., Kurchania A. K., Panwar N. L. 2007. Non Conventional Energy Sources, Himanshu Publications.
Tiwari, G.N. and Ghoshal, M.K. 2005. Renewable Energy Resources: Basic Principles and Applications. Narosa Pub. House. Delhi.
Rathore N. S., Kurchania A. K., Panwar N. L. 2007. Renewable Energy, Theory and Practice, Himanshu Publications.

BE – 502 3 (2+1)
Environmental Engineering
(32 Lectures + 16 Practical)

S. No.	Topics of Lectures
Unit 1	Introduction, earth's environment, ecology and various ecosystems.
Unit 2	Bio-geochemical cycle, hydrological cycle, carbon cycle, nitrogen cycle, sulphur cycle, energy flow in ecosystem, food chains & food webs, ecological pyramids, major ecosystems, bio-diversity
Unit 3	Natural Resources, water resources - surface & ground water sources, uses & overuses of water resources, problems due to overexploitation of water resources.
Unit 4	Water pollution: water quality standards, sources of water pollution, classification & effects of water pollutants, effluent treatment plant, working, waste management in food processing industry, BOD, COD, air pollution & its control.
Unit 5	Food behavior and spoilage in storage, economical aspects of fruit and vegetable storage, modified atmospheric storage and control of its environment, storage sanitation.
Unit 6	Storage of grains, moisture and temperature changes in stored grains; conditioning of environment inside storage, drying, grain storage structures, silo and control of environment inside silo.
Unit 7	Introduction to green house, type's classification and its applications.

Practical	Title
1	Study of the Earth's atmosphere and hydrosphere
2	Study of Lithosphere & biosphere
3	Study of major ecosystems of the earth
4	Study of energy resources
5	Determination of pH of a given sample.
6	Determination of electric conductivity of a given sample
7	Determination of total solids of a given sample
8	Determination of total dissolves solids of a given sample.
9	Determination of hardness of a given water sample.
10.	Determination of total settable solids of a given sample
11.	Estimation of BOD exerted by the given waste water sample
12	Estimation of COD exerted by the given waste water sample
13-14	Visit of an effluent treatment plant in a food processing industry
15	Study of types of storage systems for fruits & vegetables
16	Study of various types of greenhouses and its environmental control

Suggested Readings

Gilbert M. Masters and Wendell P. Ela. 2013. Introduction to Environmental Engineering and Science. Pearson Education Limited, NY, USA.
Suresh K. Dhameja. 2009. Environmental Engineering and Management. S. K. Kataria & Sons, New Delhi.
Bernard J. Nebel and Richard T. Wright. 1993. Environmental Science: The Way the World Works. Prentice-Hall Professional, New Delhi.