NAVSARI AGRICULTURAL UNIVERSITY

AAU

ICAR

Restructured and Revised Syllabi of Post-graduate Programmes

Food Technology

Year 2022

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NAVSARI AGRICULTURAL UNIVERSITY

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Food Technology

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NAVSARI AGRICULTURAL UNIVERSITY

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Foreword

Presently we are at the dawn of an age of unprecedented technological change. Every day the technologies are astonishing through innovation, refinement and refurbishment. If we will not keep ourselves updated with the pace of refinement of the technologies, we may expel out of the development. Being a pillar of higher education and research in the field of agriculture and allied sciences, our responsibilities are double. Our education system needs to be rejuvenated instantaneously to develop competency and fundamental principles of the society. In anticipation of this, central government introduced National Education Policy-2020 which is more flexible, holistic and multi-disciplinary. The ICAR is sensible enough and has striving best to bring necessary reforms in agricultural education through constituting National Core Group (NCG) and BSMA Committees for revision and restructuring of Post-graduate and Doctoral syllabi of agriculture and allied sciences. The committee has thoroughly restructured the syllabus of Masters' and Doctoral programmes in 79 disciplines, introduced new courses under the dynamic leadership of stalwarts of agricultural sciences Dr. T. Mohapatra (DG ICAR & Secretary DARE, New Delhi), Dr Arvind Kumar (Chairman, NCG), Dr R.C. Agrawal (DDG Agri. Edn) and to his predecessor Dr N. S. Rathore, Dr. G. Venkateshwarlu (Member-Secretary, NCG and former ADG, EQR) and Dr. P. S. Pandey (ADG, EP & HS). To restructure and articulate the entire syllabi of agriculture and allied sciences, 19 different BSMA Committees performed outstanding job in many marathon meetings and brain storming sessions.

Since the syllabi was restructured and articulated considering national significance, there would have been few topics which does not fetch national attention, however, are indispensible from the Gujarat agriculture point of view. Therefore, to implement these recommendations in all the SAUs of Gujarat *viz*., Navsari Agricultural University, Navsari, Junagadh Agricultural University, Junagadh, Anand Agricultural University and Sardarkrushinagar Dantiwada Agricultural University, Dantiwada we reviewed and added certain topics without imposing much stress in the semester. We have not compromised with any of the content prepared by the expert team so that our student does not remain deprived of any opportunity in national level competition. I personally thanks all my colleges Vice Chancellors of SAUs of Gujarat Dr. K. B. Kathiria (AAU, Anand), Dr. R. M. Chauhan (SDAU, Dantiwada), Dr. N. K. Gontia (JAU, Junagadh) for showing faith in NAU, Navsari and bestowing the responsibilities of Nodal University for the finalizing the same. All the faculty members of all the SAUs of Gujarat has done marvelous work of reviewing these and provided their suggestion to make it more relevant to Gujarat state in the close coordination of Dr. T.R. Ahlawat, Nodal Director of Research & Dean PGS, NAU, Navsari. I acknowledge their contribution and congratulate them for coming out with this excellent document.

Jay Jawan, Jai Kisan, Jay Jay Garvi Gujarat

Date : 20-07-2022
Navsari

(Z. P. Patel)

Prof. (Dr.) Naredra Kumar Gontia
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Message

Indian Agriculture is evolving and advancing adopt against a variety of challenges and problems. The scientists of one of the world's largest National Agricultural Research System (NARS) including ICAR institutes and State Agricultural Universities (SAUs) are working hard to ensure the sustainable growth of the Indian agriculture despite these challenges. The Indian Council of Agricultural Research (ICAR) constituted 19 BSMA (broad subject matter area) committees with eminent agricultural scientists, academics, and subject matter specialists and revised the Post Graduate syllabus of Agriculture, and allied sciences in India so that the students can equip themselves with knowledge of recent developments and future technologies. According to the Ancient Indian Vedic Education System "The basic aim of all training, whether literary or vocational, should be to make the student fit to become a useful member of society". The State Agricultural Universities of Gujarat are always working on the same concept by leading in the country to take the challenge to implement the modern education system as well as syllabus. I am glad to know that the publication on "BSMA syllabus for SAUs of Gujarat" has been prepared for revision and restructuring of Post-graduate and Doctoral syllabi as per recommendation of ICAR-BSMA along with consideration of local need. The adoption of BSMA syllabus will make the competent PG students of SAUs of Gujarat to fall into step with knowledge of modern and emerging technologies. I convey my gratitude to all the members of various BSMA committees for SAUs of Gujarat for their fruitful inputs. I complement the efforts of Director of Research and Dean, PG Studies of Navsari Agricultural University, Navsari for compilation of this report to ensure timely implementation of BSMA in SAUs of Gujarat and also to his counter parts at JAU, AAU and SDAU.

Date : 23-07-2022
Junagadh

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Dr. K.B. Kathiria
Vice Chancellor

Message

Review and revision in curriculum are imperative means not only to modify the program, but also enable teachers to espouse the ways curriculum interacts with learners in a real education milieu. It becomes more valued for post graduate programs in agricultural streams, as it takes care of interests/abilities of both the learners and teachers. The key paybacks remain elimination of needless contents, introduction of latest/updated smart methods of teaching, newer content/knowledge/practices, better connectiveness across students' theory courses and learning practices, and object-based learning experiences with recent technological impacts.

ICAR and SAUs are incessantly striving to fetch essential reforms in this direction for quality assurance in higher agricultural education. Based upon rigorous efforts from National Core Group and 19 Broad Subject Matter Area (BSMA) Committees (casing 79 disciplines), revision and restructuring of Post-graduate and Doctoral syllabi has been successfully attained by having fruitful consultation with all the stakeholders to harness opportunities across various disciplines of agriculture and allied sciences. It will certainly cater the need of paradigm shift in academic regulations to comply with various provisions of recently implemented National Education Policy-2020. It looks very pleasing to realize that the respective Committees have taken due care by adhering towards core functional elements of NEP-2020; namely flexibility, multi-disciplinary/holistic approach, better options on elective courses, online courses, internship /entrepreneurship elements. Added attractive ingredients are the teaching-assistantship for Ph.D. scholars, equipping students to attain skillful knowledge & employability with global competitiveness.

I wish to extend my heartful complement and best wishes for ICAR authorities as well as expert faculty members involved with different BSMA committees for their useful efforts. It is certainly going to be a path providing document for guiding demand driven quality PG education across various agricultural and allied disciplines in ICAR-SAU system. My specific and deep sense of gratitude goes to the Vice Chancellors of other 3 SAUs as well as Deans, Directors, Professors, Heads, faculty members and students at four SAUs of Gujarat who contributed nicely by their effective participation and interaction.

Date : 25-07-2022
Anand

(K. B. Kathiria)

NAVSARI AGRICULTURAL UNIVERSITY

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Preface

It is indeed awesome that our agriculture and allied education system has been in the coziest hand since its instigation. The resonance of this is well echoed through the series of incredible revolutions in agriculture which have been true architecture of economic and social structure of the nation. Looking at the burgeoning population and multiple challenges to the society, we need to stretch out to a greater strength to ensure perpetual prosperity. Recently government introduced National Education Policy-2020 which shall usher in a paradigm shift in the education system. Accordingly, ICAR, New Delhi constituted a National Core Group (NCG) and 19 Broad Subject Matter Area (BSMA) Committees for restructuring of Master's and Ph.D. curriculum, syllabi and academic regulations for the disciplines under agricultural sciences. SAUs of Gujarat are passionate to bring necessary reforms to assure the admirable education to their apprentices and aspirants.

We are indeed fortunate that Navsari Agricultural University, Navsari got a chance to serve as Nodal Institute to coordinate the implementation of various recommendations of the recommendation of BASMA in all the disciplines of SAUs under the dynamic leadership of Hon Vice Chancellor Dr. Z.P. Patel. We had three tiers system for the refinement of the same, where in the first subject specialists of all the SAUs in the chairmanship of identified convener thoroughly studied and recommended suggestions, which were further discussed at the university level and recommended. Finally we had a meeting at NAU, Navsari and finalized all the suggestions in the presence of all the Vice Chancellors, Director of Research & Dean PGS, Deans and Principals of various faculties of all the SAUs. I am indeed very much grateful to the all the Hon Vice Chancellors, Dr. Z. P. Patel (NAU, Navsari), Dr. K. B. Kathiria (AAU, Anand), Dr. R. M. Chauhan (SDAU, Dantiwada), Dr. N. K. Gontia (JAU, Junagadh) for showing confidence in me and my predecessor Dr. S. R. Chaudhary. I sincerely admire the help and guidance received from my counterparts Dr. M. K. Jhala (AAU, Anand), Dr. B. S. Deora (SDAU, Dantiwada) and Dr. D. R. Mehta (JAU, Junagadh) for their superb support. I am also thankful to all the staff members of the office of Director of Research & Dean PGS for their wonderful support in various activities of coordinating and compiling.

The commitment and cooperation of all the conveners, Deans & Principals, Registrars of all the SAUs of Gujarat is sincerely acknowledged.

I hope these curriculum, syllabi and academic regulations would come out true to its anticipated benefits to various provisions of National Education Policy-2020.

Date : 22-07-2022
Navsari

(T. R. Ahlawat)


कृषिमूला सृष्टिः
NAVSARI AGRICULTURAL UNIVERSITY


कृषिमित् कृषस्व


॥ कृषिमूलम जगत् सर्वम् ॥


AAU
कृणवन्तो राष्ट्रं कृषि संपन्नम्


भाकृअनुप
ICAR

Contents

Food Processing Technology

Course Title with Credit load M. Tech. in Food Processing Technology

1. Minimum Credit Hours

i Course Work	
Major Courses	20
Minor Courses	08
Supporting Courses	06
Common Course	05
Seminar	01
ii **Thesis Research**	30
Total	70

i. Course Work

Major Courses

S. No.	Course Title	Course No	Credits
1	Emerging Technologies in Food Processing*	FPT 501	3(2+1)
2	Emerging Technologies in Food Packaging*	FPT 502	3(2+1)
3	Industrial Manufacturing of Food and Beverages*	FPT 503	3(2+1)
4	Food Material and Product Properties	FPT 504	3(2+1)
5	Cocoa and Chocolate Processing Technologies	FPT 505	3(2+1)
6	Spices, Herbs and Condiments	FPT 506	2(2+0)
7	Meat, Poultry, Fish and Egg Processing	FPT 507	3(2+1)
8	Nutraceuticals and Specialty Foods	FPT 508	3(2+1)
9	Frozen and Concentrated Foods	FPT 509	2(1+1)
10	Aseptic Processing and Packaging	FPT 510	3(2+1)
11	Traditional Foods	FPT 511	3(2+1)
12	Technologies of Convenience Foods	FPT 512	3(2+1)
13	Food Powders and Premixes	FPT 513	3(2+1)
14	Food Ingredients and Additives	FPT 514	3(2+1)
15	Flavour Chemistry and Technology	FPT 515	3(2+1)
16	Bioprocessing and Separation Technology	FPT 516	3(2+1)
17	Enzymes in Food Processing	FPT 517	3(2+1)
18	Food Process Automation and Modelling	FPT 518	2(2+0)
19	Zero Waste Processing	FPT 519	2(2+0)
20	Special Problem / Summer Internship	FPT 520	2(0+2)

* Compulsory

Rest of the courses will be decided by the students advisory committee keeping the minimum limits set for award of degree

Minor Courses

S. No.	Title	Course No.	Credits
1	Engineering Properties of Food Materials	FPE 502	3(2+1)
2	Bioprocessing and Down Stream Engineering	FPE 504	3(2+1)
3	Numerical Technique and Stimulation	FPE 506	2(1+1)
4	Food Safety and Storage Engineering	FPE 508	3(2+1)
5	Advanced Food Chemistry	FSQ 503	3(2+1)
6	Global Food Laws and Regulations	FSQ 504	2(2+0)
7	Process and Products Monitoring for Quality Assurance	FSQ 506	2(2+0)
8	Management of Food By-products and Waste	FSQ 508	3(2+1)

Supporting Courses

1	Research Methodology	BSH 501	2(2+0)
2	Food Informatics	BSH 502	2(2+0)
3	Post-Harvest Management	FBM 501	3(2+1)
4	Food Business Management	FBM 502	2(2+0)
5	Food Processing Entrepreneurship and Start up	FBM 503	2(1+1)
6	Energy Management and Auditing in Food Industry	FPE 505	3(2+1)
7	Food Safety Management Systems and Certification	FSQ 505	2(2+0)
8	Quality Concepts and Chain Traceability	FSQ 507	2(2+0)
9	Operation Research	FPE 510	3(2+1)

Common Courses

S. No.	Course Title	Credits
1	Library and Information Services	1
2	Technical Writing and Communications Skills	1
3	Intellectual Property and its Management in Agriculture	1
4	Basic Concepts in Laboratory Techniques	1
5	Agricultural Research, Research Ethics and Rural Development Programmes	1
These courses are available in the form of e-courses/MOOCs. The students may be allowed to register these courses/similar courses on these aspects, if available online on SWAYAM or anyother platform. If a student has already completed any of these courses during UG, he/she may be permitted to register for other related courses with the prior approval of the HoD/BoS.		

Seminar

S. No.	Course Title	Course No.	Credits
1	Seminar	FPT 599	1(1+0)

ii Thesis Research

S. No.	Course Title	Course No.	Credits
1	Masters Research	FPT 555	30(0+30)

Course Contents

FPT 501 Emerging Technologies in Food Processing 3 (2+1)

Theory

UNIT I

Membrane technology: Pressure activated membrane processes: MF, UF, NF and RO and their industrial application. Membrane distillation

Supercritical fluid extraction: Concept, property of super critical fluids SCF, extraction methods, application in food processing

UNIT II

Microwave and radio frequency processing: Advantages, mechanism of heat generation, application in food processing: microwave blanching, sterilization and finish drying

Hurdle technology: Concept and Principle, Preservation techniques as hurdles and their principles, hurdle tech foods.

UNIT III

High pressure processing: Concept, equipment for HPP treatment, mechanism of microbial and enzyme inactivation and its application in food processing, effect on food constituents.

Ultrasonic processing: Properties of ultrasonic, types of equipment, application of ultrasonic as processing technique.

UNIT IV

Newer techniques in food processing: Principle and application of high intensity light, Pulse electric field, Ohmic heating, IR heating, Inductive heating, Cold plasma, and Pulsed X-rays in food processing and preservation, Cryo-processing of foods.

Nanotechnology: Principles and applications in foods.

Practical

- To evaluate the characteristics of treated water using RO system
- To study production and characteristics of treated water using, microfiltration, UF, NF and RO system
- To study the effect of ultrafiltration process on fruit juices quality
- To study suitability and production of fruit juices using ultrafiltration
- To study the effect of microfiltration process on milk quality
- To study super critical fluid extraction system and to carry out extraction of bioactive compound from selected samples
- To carry out extraction of lycopene from tomato using SCFE system
- To study microwave system and to evaluate the effect of different power on drying characteristics of selected vegetable products
- To study microwave blanching of vegetable and determination of blanching efficacy
- To study the effect of different drying techniques/ hybrid drying techniques on fruits and vegetables
- To study the ultrasonicator and evaluate the effect of ultrasonication on micro-organism insample

- To study the ultrasonicator and to evaluate the effect of ultrasonication on extracted juice yield from fruit pomace
- To evaluate the different pre-treatment on oil yield from oil seed cake
- To prepare nano emulsion and study of their characteristics
- To study ohmic heating system and to study the processing of fruit pup using ohmic heatingsystem
- To visit food industries utilizing advance food processing techniques

Suggested Readings

1. Gould G W, 2000. New Methods of Food Preservation, CRC Press.
2. Barbosa-Canovas, 2002. Novel Food Processing Technologies, CRC Press.
3. Dutta AK & Anantheswaran RC. 1999. Hand Book of Microwave Technology for Food Applications, CRC Press.
4. Sun DW, 2015. Emerging Technologies for Food Processing, Elsevier Ltd.
5. Kudra T and Mujumdar AS, 2009. Advanced Drying Technologies, CRC Press.
6. Nema PK, Kaur BP and Mujumdar AS, 2018. Drying Technologies for Foods: Fundamentals and Applications, CRC Press

FPT 502 Emerging Technologies in Food Packaging 3 (2+1)

Theory

UNIT I

Active and Intelligent Packaging: Packaging techniques- Definition, Concept, Types, current use of novel packaging techniques. Novel packaging- oxygen, ethylene and other scavengers: Oxygen scavenging technology, selecting right types of oxygen scavenger, ethylene scavenging technology, carbon dioxide and other scavengers.

Antimicrobial food packaging: Antimicrobial agents, constructing/ designing antimicrobial packaging systems, factors affecting the effectiveness of antimicrobial packaging.

UNIT II

Non-migratory bioactive polymers (NMBP): Advantages of NMBP, Inherently bioactive synthetic polymers: types and application, Polymers with immobilized bioactive compounds and their applications.

Time temperature indicators (TTIs) and labels: Defining and classifying TTIs, Requirements for TTIs, Development of TTIs, Maximizing the effectiveness of TTIs, Application of TTIs- to monitorshelf-life, and optimization of distribution and stock rotation, leakage indicators, oxygen indicators, micro indicators etc.

Freshness indicator in packaging: Compounds indicating the quality of packaged food products, freshness indicators, pathogen indicators, other methods for spoilage detection.

Self-heating /rehydrating packages.

UNIT III

Packaging-flavour interaction: Factors affecting flavor absorption, role of food matrix, role of different packaging materials, flavour modification and sensory quality, Study of packaging materials compatibility with foods.

Developments in modified atmosphere packaging (MAP): Permeability properties of polymer packaging, measurement of permeability – water and gases. Selection criteria of packaging films, Novel MAP gas, testing novel MAP applications, applying high oxygen MAP.
Recycling packaging materials: Recyclability of packaging plastics, improving the recyclability ofplastics packaging, testing safety and quality of recycled materials, uses of recycled plastics in packaging.

UNIT IV

Green plastics for food packaging: Problems of plastic packaging wastes, range of biopolymers, developing novel biodegradable materials.
Edible Films and Coatings: Properties, types, sources, applications, advantages, disadvantages,theories of plasticization, challenges and opportunities.
PFS machine, seal and closures.
Safety and legislative aspects of packaging: Regulatory considerations, plastic, metal, paper and glass packaging.

Practical

- Determination of WVTR in different packaging materials
- Determination of GTR in different packaging materials.
- Study of different ethylene scavengers and their analysis
- Study of different oxygen scavengers systems and their analysis
- Application of anti-microbial packaging for moisture sensitive foods
- Evaluation of chemical residue migration from package to food
- Application of MAP packaging in selected foods
- Study of TTI label, leakage indicators etc.
- Determination of oxidative changes in packaged foods
- Comparative evaluation of flexible and rigid packages for fragile foods
- Packaging of foods under inert atmosphere.
- To study textural characteristics of selected fruit/ vegetable under MAP storage
- Shelf life evaluation of packaged food product.
- Determination of oil and grease resistant test for packaging films
- Determination of respiration rate in fresh fruits and vegetables
- Determination of shelf life of fresh fruits and vegetables by using edible coating and films.
- Effect of edible coating and films on respiration behaviour, chemical, physical and sensory characteristics of fresh fruits and vegetables.
- Visit to food packaging material manufacturing industry

Suggested Readings

1. Ahvenainen R, 2001. Novel Food Packaging Techniques, CRC Press.
2. Robertson GL, 2012. Food Packaging, CRC Press.
3. Hanlon, J F, Kelsey R J & Forcinio H. 1998. Handbook of Package Engineering, CRC Press.
4. Paine FA, 1992. A Handbook of Food Packaging, Blackie.
5. Rooney ML, 1988. Active Food Packaging, Chapman & Hall.
6. Coles R & Kirwan M, 2011. Food and Beverage Packaging Technology, Wiley -Blackwell.
7. Han J and Han J, 2005. Innovations in Food Packaging, Academic Press.
8. Yam K & Lee D, 2012. Emerging Food Packaging Technologies, Woodhead Publishing.

FPT 503 Industrial Manufacturing of Food and Beverages 3 (2+1)

Theory

UNIT I

Grain products: Industrial manufacturing of grain based products: formulation, processes, machinery and material balance of baked, rolled, shredded, puffed, flaked, roasted products.

Extrusion technology: Importance and applications of extrusion in food processing; Pre and post extrusion treatments; Manufacturing process of extruded products; Changes in functional properties of food components during extrusion. Breakfast cereals, RTE/RTC foods, instant premixes, functional foods.

UNIT II

Fruit and vegetable products: Industrial manufacturing of fruit and vegetable based products: formulation, processes, machinery and material balance of minimally processed, Retorted products, Intermediate Moisture Food (IMF), high moisture stable foods, IQF: Machines and equipment for batch and continuous processing of fruit and vegetable products.

UNIT III

Chocolates and candies: Coating or enrobing of chocolate (including pan-coating); Maintenance, safety and hygiene of bakery plants.

Fats and oils processing: Technology of refined oil, winterized oil, hydrogenated fat, texturized fat, by-products of fat/oil processing industries – oil seed protein isolates; Quality standards of fats and fatty foods; Antioxidants and its mechanism of application.

UNIT IV

Beverages: Production technology of beer and wine

Non – alcoholic beverages: Carbonated beverages: carbonation equipment, ingredients, preparation of syrups, Filling system-packaging containers and closures. Non-carbonated beverage: Coffee bean preparation, processing, brewing, decaffeination, instant coffee; Tea types-black, green, Fruit juices and beverages, Flash pasteurization, Aseptic packaging of beverages, Tea/coffee and cocoa beverages, Grain based and malted beverages.

Packaged drinking water: types, manufacturing processes, quality evaluation of raw and processed water, methods of water treatment, BIS quality standards of bottled water; mineral water, natural spring water, flavoured water, carbonated water.

Practical

- Preparation of cereals based fried snack foods
- Preparation of cereal, pulses based ready-to-eat snack food by extrusion cooking their quality evaluation
- Preparation of cereal grain based puffed products
- Development of instant food premixes

- Preparation of cereal and legume based roasted snack
- Preparation of flaked rice product
- To study the effect of roasting time and temperature on quality of pop-corn
- Determination of shelf-life and packaging requirements of snack food products
- Preparation of fruits/vegetable based ready to serve beverages and quality evaluation
- Heat classification of milk powders
- Determination of degree of browning-chemical/physical methods
- Determination of quality of packaged drinking water
- Preparation of wine and beer
- Preparation of soy milk
- Determination of quality of canned food

Suggested Readings

1. Edmund WL, 2001. Snack Foods Processing, CRC Press.
2. Gordon BR, 1990. Snack Food, Springer US.
3. Frame ND, 1994. Technology of Extrusion Cooking, Springer US
4. O'Brien RD, 2008. Fats and Oils: Formulating and Processing for Application, CRC Press.
5. Davis B, Lockwood A, Alcott P & Pantelidis L, 2012. Food and Beverage Management, CRCPress.
6. Kunze W, 2010. Technology: Brewing and Malting, VLB.
7. Dhillon PS and Verma S, 2012. Food and Beverage: Production Management for Hospitality Industry, Abhijeet Publications.
8. Bamforth CW, 2006. Brewing: New Technologies, Woodhead Pub.

FPT 504 Food Material and Product Properties 3 (2+1)

Theory

UNIT I

Introduction: Biomaterials and their properties in relation to processing and product development.

Physico-chemical characteristics: Shape, sphericity, size, volume, microstructure, density, porosity, surface area, coefficients of friction and angle of repose and influence of constituents on processing.

UNIT II

Mechanical & rheological properties: Flow behaviour of granular and powdered food materials, rheological models, creep phenomenon, stress–strain - time effects & relationships, and techniques of model fitting, Elastic vs. textural characteristics and textural profile analysis of food products.

UNIT III

Thermal, electrical and optical properties: Specific heat, thermal conductivity, phase transition, Thermodynamics-basic principles and laws, Thermodynamic properties of moist air, kinetics of water absorption, heat capacity, thermal diffusivity, electrical resistance and conductance, dielectric constant, reflectivity, transmittivity and absorptivity of incident rays.

Food microstructure: Methods and systems for food microstructure, determination of food quality by light microscopy, transmission electron microscopy, scanning electron microscopy, other instrumentation and techniques, Image analysis: image acquisition, image processing, measurement analysis.

UNIT IV

Functional properties: Dextrinization, gelatinisation, crystallisation, gelation, foaming, coagulation, denaturation and syneresis, emulsification.

Sensory attributes: Sensory properties and correlation with objective indices, microstructure and its relation to texture from their mechanical models and its examination.

Sorption behaviour of food: sorption isotherm, modelling.

Practical

- To determine physical dimension and shape for suitability of processing and packaging of food materials
- To determine bulk, true density and porosity of samples
- To determine the angle of repose using rough and smooth surface
- Analysis of powder characteristics using powder flow analyser
- To determine the mixing and strength characteristics of wheat flour using faringograph/mixograph / mixolab/ doughlab/ texture analyser
- To determine the amylolytic activity using falling number of wheat flour
- Development of stress and strain curve and to study viscosity of Newtonian and non-Newtonian fluid
- Effect of temperature on viscosity profile of a food sample
- Texture profile analysis of foods samples
- Effect of temperature on textural profile of food
- Determination of thermal properties of foods using DSC
- To estimate dielectric constant of foods
- Organoleptic evaluation of food materials
- TEM and SEM, image analysis and image processing techniques
- To determine water activity of food
- To determine colour value of food viz. Lab, whiteness index, yellowness index, browning index

Suggested Readings

1. Rao M A and Rizvi S S H, 1986. Engineering Properties of Foods, Marcel Dekker.
2. Aguilera J M & Stanley D W, 1999. Microstructural principles of food processing and Engineering, Springer.
3. Mohsenin N N, 1986. Physical properties of Plant and Animal Materials, Gordon & BreachScience.
4. Bourne M C, 1981. Food Texture and Viscosity; Concept and Measurement, Academic Press.
5. Steffe J F, 1992. Rheological Methods in Food Process Engineering, Freeman Press.
6. Aguilera J M, 1999. Micro Structure: Principles of Food Processing Engineering, Springer.
7. Rahman M S, 2009. Food Properties Handbook, CRC Press.
8. Serpil S & Sumnu S G, 2006. Physical Properties of Foods, Springer-Verlag.
9. Pomeranz Y, 1991. Functional Properties of Food Components, Academic Press

FPT 505 Cocoa and Chocolate Processing Technologies 3 (2+1)

Theory

UNIT I

Introduction: Cocoa-occurrence, chemistry of the cocoa bean, analysis of cocoa beans, processing of raw bean, changes taking place during fermentation of cocoa bean

Cocoa processing: Processing of cocoa bean- cleaning, roasting, alkalization, cracking and fanning; Nib grinding for cocoa liquor, cocoa butter and cocoa powder; Processing of roast bean; chemical changes during various stages of processing

UNIT II

Chocolates: Types, ingredients, Chemistry of chocolate manufacture, Mixing, refining, conching, tempering, moulding etc. to obtain chocolate slabs, chocolate bars. Dark, milk and white chocolate and their manufacturing processes

UNIT III

Enrobed and other confectionary products: Compound coatings and candy bars, Tempering technology, Chocolate hollow figures, Chocolate shells, Enrobing technology, Manufacture of candy bars, Application of vegetable fats, Production of chocolate mass

UNIT IV

Packaging, quality and storage of chocolates

Practical

- Anatomical structure of cocoa beans
- Effect of fermentation on cocoa beans
- Roasting of cocoa beans
- Effect of roasting on cocoa beans
- Effect of packaging on quality of cocoa beans
- Production of cocoa liquor
- Production of cocoa butter
- Effect of conching on chocolate
- Effect of tempering on chocolate
- Fat expulsion during chocolate storage
- Production of milk chocolate
- Production of dark chocolate
- Effect of packaging on quality of chocolate
- Effect of storage temperature on chocolate quality

Suggested Readings

1. Minifie, BW, 1999. Chocolate, Cocoa and Confectionery Technology. Springer Science & Business Media.

FPT 506 Spices, Herbs and Condiments 2 (2+0)

Theory

UNIT I

Introduction: Status and scope of spice processing industries in India; Spices, herbs and seasonings: Sources, production, selection criteria, classification on the basis of origin, physical characteristic.

Major spices: Post-Harvest Technology- Composition, processed products of following spices (1) Ginger (2) Chilli (3) Turmeric (4) Onion and garlic (5) Pepper (6) Cardamom

UNIT II

Minor spices, herbs and leafy vegetables: All spice, Annie seed, sweet Basil, Caraway seed, Cassia, Cinnamon, Clove, Coriander, Cumin, Dill seed, Nutmeg, Mint, Rose merry, Saffron, Sage

Processing technology of spices: Chemical composition, processing methods, equipment used; Recent developments in processing

UNIT III

Processing effect on spice quality: Effect of processing on spice quality, contamination of spices with micro-organisms and insects

UNIT IV

Spice Essential Oils: methods of extraction, isolation, and encapsulation

Spice Oleoresins: method of extraction, isolation, separation equipment

Spices quality evaluation: Criteria for assessment of spice quality

Suggested Readings

1. Reineccius G, 2005. Flavour Chemistry and Technology. CRC Press.
2. Heath HB, 1986. Flavour chemistry and technology. AVI Publ.
3. Piggott JR and Paterson A, 1994. Understanding Natural Flavours. Springer US

FPT 507 Meat, Poultry, Fish and Egg Processing 3 (2+1)

Theory

UNIT I

Meat Industry: Meat and meat products in India-An industrial profile. Meat production and trade practices. Prospects and problems in production of fresh meat in India, Research and development activities on meat, fish and poultry products Gross and microstructure of muscle, Mechanism of muscle contraction and relaxation: Organization of skeletal muscle from gross structure to molecular level, Muscle communication (sarcolemma, sarcoplasmic reticulum, innervation), Muscle metabolism, Different types of connective tissues and their relevance to properties of meat, Myofilament proteins and their major functions, Nervous tissue, nerves and the nature of stimuli, membrane potential in nerve and muscle, Events that occur during relaxation and contraction

UNIT II

Cattle and beef, sheep and mutton, pig and pork and their fabrication: Breeds, Pre-slaughter care, ante and post mortem, Slaughter, handling of offal (edible and inedible), Cuts of beef, pork and mutton.

Meat inspection and grading: Elements of inspection (sanitation, antemortem inspection, post-mortem inspection, condemnation, product inspection, laboratory inspection, labelling). Identification of inspected products, product inspection, types of grades, factors used to establish quality grades, conformation, fleshing and finish. Application and enforcement of inspection laws

UNIT III

Properties of fresh meat: Perception of tenderness, Factors effecting tenderness, connective tissue, collagen, sarcomere contractile state, Myofibrillar tenderness, marbling, Methods to improve tenderness (Electrical stimulation, aging), Meat colour, Pigments associated with colour, Chemical state of pigments, methods to improve meat colour. Water holding capacity (Net charge effect andstearic effect), Molecular techniques in meat products, cultured meat etc.

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

Egg and egg processing: Egg quality, egg preservation, egg powder production

UNIT IV

Meat analogues and restructured meat products: Textured plant proteins, processesfor preparation of meat analogues and restructured meat products.

Fish processing and fish products: Chemical/nutritional composition of fish, Fish in human diet: protein, carbohydrates, lipids, vitamins etc. Selection of raw material for processing of streaking and filleting of fish; Production of fish paste, fish oils, sauce, fish protein concentrates. Irradiation of fish and fisheries products, Packaging of fish products, Quality control and quality assurance, Allergens, toxins and infectious diseases from meat, poultry and fish products

Practical

- To study the effect of low and high oxygen atmosphere on meat colour
- To study the chemistry of myoglobin as it relates to the colour of the molecule
- To understand and compare the action of two meat tenderizing enzymes by applying the technique of electrophoresis
- To study the structure of the muscle under compound microscope
- Perform the slaughtering of the poultry birds
- Identification of different internal organs of poultry birds and their utilization for product preparation
- Dressing of fish
- Determination of total volatile acids in fish
- Determination of buffering capacity of fish muscle
- Rapid estimation of hypoxanthine concentration in chill stored fish
- Determination of glycine in fish muscle
- Determination of protein fractions in fresh fish
- Cut out test for canned fishery products
- Determination of glycogen in fish muscle
- Industrial visit to meat industry

Suggested Readings

1. Henricksons, 1978. Meat poultry and Sea Food Technology, Prentice Hall
2. Robert RJ, 2012. Fish Technology, Wiley -Blackwell
3. Mountney, GJ, 1988. Poultry Meat and Egg Production, Springer, Netherlands
4. Kerry Joseph and Kerry John, 2002. Meat Processing, Woodhead Publishing and David Ledwood
5. Levie A, 1979. Meat Hand Book, AVI Publisher
6. Weiss GH, 1971. Poultry Processing. Noyes Data Corporation
7. Wheaton FW and Lawson TB, 1985. Processing of Aquatic Food Products John Wiley & Sons.
8. Mead G, 2004. Poultry meat processing and quality, Woodhead Publishing
9. Sinha R, 2017. HACCP in Meat, Poultry and Fish Processing, Random Publications
10. Sahoo J and Chatli MK, 2015 Textbook on Meat, Poultry and Fish Technology, Daya Pub. House
11. Badapanda KC, 2012. Basics of Fisheries Science, Narendra Publishing House
12. Sahoo J, Sharma DK, Chatli MK. 2016. Practical Handbook on Meat Science and Technology, Daya Pub. House

FPT 508 Nutraceuticals and Specialty Foods 3 (2+1)

Theory

UNIT I

Introduction: Defining nutraceuticals and functional foods. Nature, type and scope of nutraceutical and functional foods. Nutraceutical and functional food applications and their health benefits. Nutraceutical compounds and their classification based on chemical and biochemical nature, Innovations in functional food industry for health and wellness, Development of biomarkers to indicate efficacy of functional ingredients

Nutraceuticals and Functional foods: Nutraceuticals / food components for specific disease such as cancer, heart disease, diabetes, obesity, anti-aging, arthritis, Prebiotics and probiotics; Bioactive compounds- Omega 3 and omega 6 fatty acids, isoflavones, phenolic compounds, catechins, lycopene, glucosinolates.

UNIT II

Specialty Foods: Design of food for infants, children and old age

Functional Beverage: Selection of ingredients, health benefits and production

Extraction and delivery system: Non-thermal techniques, bioprocessing techniques, dehydration techniques, effect on bioactive ingredients. Delivery system and controlled release of nutraceuticals

UNIT III

Packaging, storage, labelling: Packaging requirements, storage and storage kinetics on quality of nutraceuticals, interactions of various environmental factors

Marketing and safety aspects: Marketing and safety and regulatory issues for functional foods and nutraceuticals

UNIT IV

Nutrigenomics : concept of personalized medicine, Use of nanotechnology in functional food industry Biological functionality of cruciferous vegetables, tropical, subtropical and temperate fruits, herbs and spices

Practical

- Determination of antioxidant activity of given food sample by different techniques viz. DPPH,FRAP, ABTS, FRAP
- Determination of total phenolic content of given food sample
- Estimation of dietary fibres of given food sample
- Estimation of soluble/insoluble fibres of given food sample
- Estimation of lycopene in tomato
- Estimation of carotenoids of given food sample
- Determination of total flavonoid content of given food sample
- Effect of heat processing on ascorbic acid
- Determination of vitamins A
- Estimation of pectic substances in plant sample
- Determination of beta carotene of given food sample
- To determine gas chromatography for bioactive components analysis
- To study the effect of drying on bioactive components of food sample
- To study the packaging requirement of functional foods
- Determination and qualifications of some nutraceutical and functional food compounds byHPLC
- Estimation of â- glucan
- To study the storage kinetics of nutraceutical

Suggested Readings

1. Chadwick R Henson S and Moseley B, 2003. Functional Foods, Springer-Verlag.
2. Jeffrey Hurst W, 2008. Methods of Analysis for Functional Foods and Nutraceuticals, CRCPress.
3. Shi J, Mazza G and Maguer M, 2002. Functional Foods, CRC Press.
4. Wildman R E C, 2006. Handbook of Nutraceuticals and Functional Foods, CRC Press.
5. Vattem DA and Maitin V, 2016. Functional Foods, Nutraceuticals and Natural Products, DEStech Publications.
6. Grumezescu AM, 2016. Nutraceuticals: Nanotechnology in the Agri-Food Industry, Elsevier Inc
7. Rizvi SSH, 2010. Separation, extraction and concentration processes in the food, beverage and nutraceutical Industries, Woodhead Publishing.
8. Tomar SK, 2011. Functional Dairy Foods Concepts and Applications, Satish Serial PublishingHouse.
9. Gupta RK, Bansal S & Mangal M, 2012. Health Food Concept, Technology and Scope,Biotech Books.

FPT 509 Frozen and Concentrated Foods 2 (1+1)

Theory

UNIT I

Freezing: Glass transitions in frozen foods and biomaterials, Microbiology of frozen foods, Thermo-physical properties of frozen foods, Freezing loads and Freezing time calculation, Innovations in freezing process, freezing methods and equipment

Facilities for the Cold Chain: Cold store design and maintenance, Transportation and storage of frozen foods, Retail display equipment and management

UNIT II

Quality and safety of frozen foods: Quality and safety of frozen meat and meat product, poultry and poultry products, eggs and egg products, fish and shellfish, and related products, frozen vegetables and fruits, frozen dairy products, frozen ready meals and confectioners

UNIT III

Packaging of frozen foods: Selection of packaging materials, Plastic and paper packaging of frozen foods, Shelf-life prediction of frozen foods

UNIT IV

Concentrated milk: Production and quality of evaporated and condensed milk

Concentrated juice products: Production and quality of fruits and vegetable juice concentrate, puree and paste, tomato juice concentrates, mango pulp etc.

Practical

- Measure the glass transition temperature of food
- Calculate freezing load of food sample
- Calculate freezing time of a frozen foods
- Effect of cold chain on quality of fruits and vegetables
- Effect of cooling on egg quality
- Effect of chilling on meat quality
- Effect of freezing on meat quality
- Production of concentrated milk and check its quality
- Production of evaporated milk and check its quality
- Effect of clarification on juice quality
- Effect of juice concentration on juice concentrate
- Effect of cold and hot break on tomato pulp quality
- Production tomato puree and paste and check its quality

Suggested Readings

1. Erickson MC and Hung Y C, 1997. Quality in Frozen Foods, Springer.
2. Hui YH, Legarretta IG, Lim, MH, Murrell KD and Nip WK, 2004. Handbook of Frozen Foods, CRC Press.
3. Kennedy CJ, 2000. Managing Frozen Foods, Elsevier.

FPT 510 Aseptic Processing and Packaging 3 (2+1)

Theory

UNIT I

Introduction: Present and future of aseptic processing, Advantages and disadvantages, Processing of semi-solid and fluid and particulate foods

Aseptic processing operations: Pre-sterilization, loss of sterility, water-to-product and product-to-water separation, cleaning, control, cleaning in place (CIP).

UNIT II

Quality Assurance: Effect of aseptic processing on nutrients, microorganisms, in-process and post-process assurance, HACCP, regulatory aspects of processing and packaging, Shelf life modules.

UNIT III

Sanitary design and equipment requirements: Pumps, Heat exchangers, homogenizers, aseptic process and packaging system for retail and institutional packages.

UNIT IV

Packaging of aseptic processed foods: Packaging materials characteristics, aseptic filling, sterilization of packaging materials, package design, aseptic packaging system, type of pack and equipment: Fill and seal; Form, fill and seal; Erect, fill and seal; Thermoform- fill, sealed, Blow mold- fill, seal, Seal- geometry, materials and size of retail and bulk package, seal and closures.

Practical

- Effect of aseptic processing on microbial quality of juice-based beverage
- Effect of aseptic processing on vitamins in selected foods
- Effect of aseptic processing on minerals in selected foods
- Effect of aseptic processing on colour pigments in selected foods
- Effect of aseptic processing on browning of milk
- Effect of aseptic processing on viscosity of milk
- Effect of aseptic processing on proteins in selected foods
- Effect of different chemical sterilant on microbial quality of packaging material
- To estimate chemical sterilant residue on packaging materials
- Estimation of package integrity and leakage
- Shelf life models and prediction

Suggested Readings

1. Robertson GL, 2012. Food Packaging: Principles and Practices, CRC Press.
2. David JRD, Graves RH and Szemplenski T, 2016. Handbook of Aseptic Processing and Packaging, CRC Press.
3. Reuter H, 1993. Aseptic Processing of Foods, CRC Press.
4. Willhoft E M, 1993. Aseptic Processing and Packaging of Particulate Foods, Springer.

FPT 511 Traditional Foods 3 (2+1)

Theory

UNIT I

Present status of traditional food products, Globalization of traditional food products; Plans and policies of the Government and developmental agencies

Overview of heat-desiccated, coagulated, fried, fermented traditional food Products Process technology for Indian bread (chapatti), paratha, stuffed paratha, panipoori. Process technology for Indian fried foods-poori, samosa, sev, fafda, chorafali, jalebi

Process technology for fermented traditional food and its improvement- pickle, idli, khaman, nan, dahi, dhokla, spiced buttermilk etc).
Process improvement in production of Indian sweets (Halwasan, kajukatli, carrothalwa, Rabdi,chocolate burfi, Chikki etc).
Process improvement in production of puffed cereals and grains by microwave technique

UNIT II

New products based on fruits, vegetables and cereals
Application of membrane technology, microwave heating, steaming, extrusion for industrial production of traditional food products (Shrikhand, Dhokla, Wadi, Murukku/Chakri, Patra, Khandvi)
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, Wada mix, Gotamix)
Process technology for convenience traditional food products (ready to eat and serve - Curried vegetables, pulses and legumes), chutneys, paste
Use of natural and permitted synthetic preservatives and new packaging systems for traditional food products

UNIT III

Techno-economic aspects for establishing commercial units for traditional products
Introduction to traditional foods of India, composition and nutritive values, microbial and biochemical diversity, quality and food safety challenges Processing & Preservation methods of Sweets & Desserts**:** kulfi, falooda, kheer, khurchan, khoa/mawa, rabri, jalebi, imarti, Gulab jamun, peda, petha, rewdi, gajak, milk cake, balushahi, bal mithai, singori, rasmalayi, gulqand, ghevar, rasgolla, chamcham, son halwa, son papri, several varieties of halwa, laddu, barfi & rasgolla.

UNIT IV

Traditional fermented foods: Dosa, Vada, Dahi (Curd), Srikhand. Processing and preservation methods of snacks**:** Gujiya, kachauri, samosa, mirchibada, kofta, potato chips, banana-chips, mathri, bhujiya, fried dhals, bhujia, shakarpara, pakora, vada.
Processing and preservation methods of baked and fried products: Biscuits, Toast, Candies, Cookies, Breads, Roti, Naan, Tandoori Roti, Parantha, Kulcha, Puri, Bhatura.
Processing and preservation methods of preserves and beverages: Murabba, Sharbat, Panna, Aampapad, Coconut water, Milk (khas, rose), Alcoholic Beverages
Industrialization, Socioeconomic conditions and sustainability of traditional foods

Practical

- To study the effect of different combination of salt and oil in quality of traditional fermented food product (pickle)
- To study the effect of different starter culture on taste and texture of idli
- To evaluate the shelf life of stuffed paratha under different storage conditions
- To study the effect of time and temperature on quality of fried food products (poori/ panipoorietc.
- To study effect of sugar and Artificial sweeteners in the preparation of kajukatli
- To study the microwave heating in drying of khaman/ dhokla

- To study the effect of cold extrusion on mixing of vermicelli
- To prepare instant carrot halwa mix
- To study the effect of different packaging material on shelf life of traditional Indian food products
- To study the effect of different natural food preservatives in traditional sweets
- Preparation of spiced buttermilk
- Preparation of puffed cereals and grains
- Preparation and quality evaluation of Instant Premixes (Puranmix)
- Preparation of quality evaluation of dried malted moth bean powder
- Preparation of Indian traditional confections (chikki)
- Visit to ethnic food industry (Instant mixes/Pickle making)

Suggested Readings

1. Steinkrus KH, 1995. Handbook of Indigenous Fermented Foods. CRC Press
2. Wickramasinghe P, 2007. The Food of India, OM Book Service
3. Aneja RP, Mathur, BN, Chandan, RC and Banerjee AK, 2002. Technology of Indian Milk Products, India Year Book Publications
4. Mangal R, 2013. Fundamentals of Indian Cooking: Theory and Practice

FPT 512 Technologies of Convenience Foods 3 (2+1)

Theory

UNIT I

Overview of grain-based snacks: whole grains – roasted, toasted, puffed, popped and flakes Coated grains-salted, spiced and sweetened

Flour based snack– batter and dough-based products; *savoury* and *farsans*; formulated chips and wafers, papads

Fruit and vegetable-based snacks: chips, wafers, papads etc.

Coated nuts – salted, spiced and sweetened products- *chikkis, fried groundnut pakora*

UNIT II

Technology of ready- to- eat baked food products, drying, toasting, roasting and flaking, coating, chipping

Extruded snack foods: Formulation and processing technology, flavouring and packaging

UNIT III

Ready-to-cook food products- different puddings and curried, Vegetables, meat and meat food products etc.

Technology of instant cooked rice, carrot and other cereals-based food products,Technology of ready to eat instant premixes based on cereals, pulses etc.

Technology for RTE puffed snack- sand puffing, hot air puffing, explosion puffing, gun puffing etc.

UNIT IV

Equipment for frying, baking and drying, toasting, roasting and flaking, popping, blending, coating, chipping

Practical

- Preparation of cereals based fried snack foods
- Preparation of legume based fried snack foods
- Preparation of cereal, pulses based ready-to-eat snack food by extrusion cooking and theirquality evaluation
- Preparation of cereal grain based puffed products
- To study the effect of frying time and temperature on potato chips
- Development of instant food premixes
- Preparation of cereal and legume based roasted snack
- Preparation of flaked rice product
- To study the effect of roasting time and temperature on quality of pop-corn
- Determination of shelf-life and packaging requirements of snack food products
- Preparation of cereal and legume based roasted snack foods by vacuum frying
- Visit to industries manufacturing snack foods.

Suggested Readings

1. Edmund WL 2001 Snack Foods Processing. CRC Press
2. Frame ND 1994 Technology of Extrusion Cooking, Blackie Academic.
3. Gordon BR 1997 Snack Food AVI Publ.
4. Samuel AM. 1976 Snack Food Technology. AVI Publ.
5. Duncan Manley 2000 Technology of Biscuits, Crackersand Cookies CRC Press
6. Deny AV and Dobraszczyk BJ 2001 Cereals and Cereal Products, Aspen Publishers
7. Ram S and Mishra B. 2010 Cereals: Processing and nutritional quality, New India Publishers

FPT 513 Food Powders and Premixes 3 (2+1)

Theory

UNIT I

Food powder properties: Particle- size, shape, density and size distribution, Powders- Crystalline and amorphous microstructure, Cohesive and adhesive forces, Surface energies, Stickiness, Surface structure, Fluidity, Compressibility, Mixing property, Segregation, Flow and packing properties

Handling of food powders: Basic flow patterns in storage vessels, storage vessel design, mass-flow operation, the Jenike silo design method, the flow-no flow criterion, Powder conveying: Belt, screw, chain, pneumatic

UNIT II

Size reduction and enlargement: Principles, equipment, criteria for selecting comminution process, aggregation and agglomeration, instantization

Encapsulation: Principles, methods of encapsulation viz. spray drying, coacervation, extrusion, co-crystallization

UNIT III

Powder Production: Spray, drum and freeze-drying process and equipment

Undesirable properties: Attrition, segregation, caking, dust explosion hazards, laboratory testing to assess explosion characteristics of dust clouds, safety from dust cloud explosion hazards

Food powder rehydration: Principles, wettability and sink ability, dispersibility, solubility, improvement of rehydration properties

Surface composition of food powders: Microscopy and spectroscopy techniques food powder surface analysis, factors affecting food powder surface composition, impact of powder surface composition on powder functionality.

UNIT IV

Packaging and Storage: Packaging requirements, design of package, effect of environmentalfactors on quality of food powders, shelf life test and prediction

Food Premix: Formulation, processing and packaging of vitamin premix, mineral premix, fibres premix for food supplements

Practical

- Estimation of bulk properties: bulk density, true density, porosity
- Estimation of reconstitution powder properties: wettability, dispersibility, solubility
- Effect of moisture on lump formation and caking
- Estimate flowability of food powders
- Estimate hygroscopicity of powder
- Estimate glass transition and sticky point temperature of food powder
- Effect of bulk properties on packaging
- Measurement of particle size using particle size analyser
- Measurement of surface properties of food powder using SEM
- Packaging of food powders
- Effect of storage on quality of food powders
- Production of various vitamin premix and its application
- Production of various mineral premix and its application

Suggested Readings

1. Hong Yan, 2005. Food powders: Physical properties, processing, and functionality, Springer US
2. Bhandari BS, Bansal N, Zang M, Schuck P, 2013. Handbook of food powders-process and properties Woodhead Publishing
3. Yasuo Arai, 1996. Chemistry of powder production. Springer Netherlands
4. Masuda H, Higashitani K, and Yoshida H, 2006. Powder technology: fundamentals of particles, powder beds, and particle generation. CRC Press

FPT 514 **Food Ingredients and Additives** **3 (2+1)**

Theory

UNIT I

Introduction: Role of food ingredients and additives in food processing, functions, classification, intentional and unintentional food additives, toxicology and safety evaluation of food additives, beneficial effects of food additives, food additives generally recognized as safe (GRAS), tolerance levels and toxic levels in foods-LD 50 values of food additives

Preservatives: General mechanism of action; basis of selection; classes; Chemical preservatives: characteristics, antimicrobial spectrum, mechanism of action, toxicology, regulations, applicationin food

UNIT II

Antioxidants: Characteristics, types/classes/groups, mechanism of action/ working of antioxidants, functions, sources, application in food, limits and toxic effects of synthetic antioxidants, synergisticeffects of antioxidants, role of free radicals in human body

Flavouring agents: Flavour functions, selection; forms; sources; process of flavour creation; natural and synthetic flavouring; extractions methods; production process; application in food

Emulsifiers and Stabilizers: Characteristics/ functional properties; functions; basis of selection; types; mechanism of emulsion formation; mechanisms of emulsion stabilization and destabilization; application in food

UNIT III

Hydrocolloids: Definition; function and functional properties; sources; application in food

Sweeteners: Characteristics; classification/types; applications in food; Limits and toxicology of non-nutritive sweeteners

Colouring agents: Properties; functions; classification; sources of natural and synthetic colours: extraction; applications in food, levels of use, misbranded colours, colour stabilization

UNIT IV

Starch, protein, and lipids, fibres and fructo-oligosaccharides: As functional ingredients; their isolation, modification, specifications, functional properties and applications in foods

Humectants, Clarifying agents, Stabilizers and thickeners, Bleaching and maturing agents, Sequestrants / chelating agents, Anti-caking agents, Buffering agents, Acidulants: definition; characteristics; sources; functions and their application in food processing

Practical

- Determination of benzoic acid in food samples
- Estimation of sulphur dioxide in food samples
- Estimation of sorbic acid in cheese and yoghurt
- Determination of nitrate and nitrites in foods
- Detection and determination of aspartame by thin layer chromatography
- Liquid chromatographic determination of caffeine, benzoate and saccharin in soda beverage
- Identification of natural colours
- Isolation, identification and estimation of synthetic food colours
- TLC detection of antioxidants in fats and oils

- TLC detection of emulsifiers
- Detection of alginates in foods (chocolate, ice cream)
- GC determination of menthol in mentholated pan masala
- Isolation and modifications of protein, starch, lipids, fibres from the raw and processed food
- Estimation of various additives mentioned in unit IV

Suggested Readings

1. Branen AL, Davidson PM and Salminen S, 2001. Food Additives, Marcel Dekker.
2. George AB, 1996. Encyclopaedia of Food and Colour Additives, CRC Press.
3. Nakai S and Modler HW, 2000. Food Proteins: Processing Applications, Wiley VCH.
4. Gerorge AB, 2004. Fenaroli's Handbook of Flavour Ingredients, CRC Press.
5. Branen AL, Davidson PM, Salminen S and Thorngate JH, 2001. Food Additives, MarcelDekker.
6. Madhavi DL, Deshpande SS and Salunkhe DK, 1996. Antioxidants: Technological, Toxicological and Health Perspective, Marcel Dekker.
7. Stephen AM, 2006. Food Polysaccharides and Their Applications, CRC Press.
8. Smith J and Shum LH, 2011. Food Additives Data Book, Wiley-Blackwell.
9. Baines D and Seal R, 2012. Natural Food Additives, Ingredients and Flavorings, Woodhead Publishing.

FPT 515 Flavour Chemistry and Technology 3 (2+1)

Theory

UNIT I

Introduction: Classification of food flavour, chemical compounds responsible for flavours, difficulties of flavour chemistry research. Anatomy of chemical senses. Chemical compounds classes and their flavour response

Flavour intensifiers: Flavour intensifiers and their effects, Chemistry and technology of various flavour intensifiers

Flavour Extraction: Methods of flavour extraction, isolation, separation and equipment

UNIT II

Flavour development during biogenesis: Flavour compounds from carbohydrates and proteins, Lipid oxidation

Flavour formulation: Creating and formulating flavour, Synthetic flavours, Blended flavouring, Flavour creation for new products, Delivery of flavours from food matrices

Flavouring compounds during food processing: Volatile and non-volatile flavouring compounds, non-enzymatic browning reactions

UNIT III

Flavour analysis: Sensory evaluation, discrimination analysis, descriptive analysis, Instrumental analysis (Absorption spectroscopy (UV/VIS), chromatography, mass spectrometry)

Food flavours in different food products: Principal components and properties, baked products, cheese, milk, meat, fish, wine, coffee, tea, chocolate, fruit and vegetable products and fermented foods

UNIT IV

Flavour encapsulation and stabilization: Principles and techniques of flavour encapsulation, types of encapsulation, factors affecting stabilization of encapsulated flavour and their applications in food industry, Packaging and flavour compounds interaction, packaging and storage

Practical

- Qualitative identification of different flavouring compounds
- Extraction of essential oil/ flavouring compound of basil leave by hydro distillation
- Extraction of essential oil/ flavouring compound of basil leave by SCFE
- Comparison of the quality of flavouring component obtained by hydro distillation and SCFE
- Extraction of essential oil/ flavouring compound of ginger by SCFE
- Effect of storage conditions on flavouring compound of ginger
- Preparation of flavour emulsions and their stability
- To study effects of staling on food flavours and its adverse effects
- Separation, purification and identification of some flavouring compounds by GC/MS.
- Sensory evaluation of different flavours
- To check effect of cooking on flavour of food sample
- To check effect of fermentation on food flavour
- To study sugar caramelization reaction for flavour development
- Development of blended food flavour-based products
- To study effects of storage conditions on food flavour
- Encapsulation of flavouring compounds
- To study effects of overdoses of flavours
- To study flavour development on roasting/ baking

Suggested Readings

1. Reineccius G, 2005. Flavour Chemistry and Technology. CRC Press
2. Heath, HB, 1986. Flavour Chemistry and Rechnology. AVI Publ.
3. Piggott, JR and Paterson A, 1994. Understanding Natural Flavours. Springer US
4. Morton, ID and Macleod AJ, 1990. Food Flavour. Elsevier Science
5. Ashurst PR, 1994. Food Flavourings, Blackie
6. Taylor AJ and Linforth RST, 2010. Food Flavour Technology. Blackwell Publishing Ltd.
7. Hui YH, 2010. Handbook of Fruit and Vegetable Flavours. Wiley & Sons, Inc
8. Bruckner B and Wyllie SG, 2008. Fruit and Vegetable Flavour: Recent Advances and Future Prospectus. CRC Press.
9. Ferreira V and Lopez R, 2013. Flavour Science, Academic Press

FPT 516 Bioprocessing and Separation Technology 3 (2+1)

Theory

UNIT I

Introduction to various separation processes, Gas-Liquid, Gas–Solid, Liquid-Liquid, Liquid-Solid separation; Concept of phase equilibrium, Stage equilibrium, Stage efficiency, Equilibrium concentration; Single stage contact equilibrium, counter-current multiple contact stages, Concept of equilibrium line and operating line, Determination of optimum number of contact stages by analytical and graphical method; Rate of extraction, Rate of gas absorption, Individual and over all mass transfer coefficient; Calculation of

tower height for gas absorption for both dilute and concentrated solution. Construction and working mechanism of different extraction equipment like single stage extraction, Multiple stage static bed system, Bollmann extractor, Hildebrandt extractor, Rotocell extractor

UNIT II

Various separation processes- Solid separation process:- Introduction, concept of size, shape, cut- size, sieving, magnetic separation, eddy-current separation, wet separation, ballistic separation, colour separation, Wet separation process- Liquid-solid and liquid- liquid separation by hydro cyclones, Surface velocity classifier, Elutriators, Impingement separator, Electrostatic precipitation, Distillation: Introduction, boiling point diagram, differential or simple distillation, Flash or equilibrium distillation, Continuous rectification with and without reflux, Reflux ratio, Optimum reflux ratio, Batch distillation, Application of distillation in food processing

UNIT III

Membrane separation technology: Introduction to micro-filtration, ultrafiltration, reverse osmosis, electro dialyses, dialyses, Physical characteristics of membrane separation, Factors affecting reverse osmosis process, Concentration polarization, Design of reverse osmosis and ultra- filtration systems, Operation layout of the modules, Electrodialysis, Per-vaporization, Fabrication of membranes, Application of membrane technology in food industry

UNIT IV

Powder Technology: Classification of powder, Separation of powder, Sieving, Air classification,Factors affecting air classification, Cyclone application, Air separation, Particle size distribution

Supercritical Fluid Extraction: Introduction, Properties of SCF, Food application, Application of SCFE in analytical technique, Pharmaceutical application.

Practical

- Determination of contact equilibrium in counter current and multiple contact model systems
- Determination of rate of extraction in gas-liquid, gas-solid, liquid-liquid and liquid-solidsystems.
- Study of working mechanisms of different extraction equipment
- Evaluation of physical separation techniques based on size, shape and densities, magnetic, eddy current, ballistic and colour separation
- Use of air classification, hydrocyclones, electrostatic and distillation techniques for fractionation and separation application studies on Microfiltration, Ultrafiltration, reverseosmosis and dialysis.

Suggested Readings

1. Saravacos G.D. & Maroulis Z.B. (2011) Food Process Engineering Operations. CRC Press
2. Smith PG (2011) Introduction to Food Process Engineering. Springer

FPT 517 Enzymes in Food Processing 3 (2+1)

Theory

UNIT I

Introduction: General characteristics of enzymes, Classes and nomenclature of enzymes, Enzymatic reactions, Factors affecting enzyme activity, Enzyme kinetic, Enzyme inhibition

Enzyme Production: Selection and sources of commercial enzymes, Advantages of microbial enzymes, rDNA in enzyme engineering, Problems of scale up, Enzyme extraction and purification

UNIT II

Immobilization: Techniques, advantages and disadvantages, use of immobilized biocatalysts in food processing

Enzymes for protein modification (hydrolysates and bioactive peptides), Enzymes for lipid modification

Enzymes in cereal processing: Application of enzymes in process of malting, brewing, milling, baking (fungal–amylase for bread making; maltogenic – amylases for anti-staling xylans and pentosanes as dough conditioners; lipases or dough conditioning; oxidases as replacers of chemical oxidants; synergistic effect of enzymes, production of high fructose corn syrup, glucose syrups

UNIT III

Enzymes in fruit processing: Applications of enzyme in fruit juice clarification, removal of haziness and bitterness, Uses of enzymes in wine production

Enzymes in meat, fish and milk processing: Meat tenderization and flavour development, fish processing (De-skinning, collagen extraction etc.) Egg processing, Cheese processing

UNIT IV

Flavour production: Role of enzymes, enzyme-aided extraction of plant materials for production of flavours, Production of flavour enhancers such as nucleotides, MSG; Flavours from hydrolysed vegetable/animal protein

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 randomization, Enzyme allergy

Practical

- To investigate some of the kinetic properties of invertase
- To study time course of the reaction catalysed by alkaline phosphatase
- To investigate the thermal stability of horseradish peroxidase
- Quantitative estimation of endoglucanase
- Quantitative estimation of exo-glucanase
- Quantitative estimation of â galactosidase
- Quantitative estimation of Pectinase
- Quantitative estimation of Protease
- Quantitative estimation of Lipase
- Immobilization of amylase by sodium alginate and comparative evaluation with nativeenzyme
- To immobilize yeast cells and demonstrate its biological activity by invertase assay
- To carry out amylase fermentation
- To carry out protease fermentation
- To carry out lipase fermentation

Suggested Readings

1. Palmer T, 2008. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry EastWest
2. Laskin AI, 2007. Enzymes and Immobilized Cells in Biotechnology. Benjamin/Cummings Pub. Co.
3. El-Mansi M and Bryce C, 2011. Fermentation Microbiology and Biotechnology. CRC Press
4. Price, N. C. and Stevens, L, 2000. Fundamentals of Enzymology. Oxford University Press

5. Reed G, 2007. Enzymes in Food Processing. Academic Press
6. Whitehurst RJ and Oort MV, 2010. Enzymes in Food Technology. Blackwell Publ.
7. Bayindirli A, 2010. Enzymes in Fruit and Vegetable Processing: Chemistry and Engineering Applications. CRC Press

FPT 518 Food Process Automation and Modelling 2 (2+0)

Theory

UNIT I

Principles of modelling: Linear programming-concepts, graphical and algebraic solution; Simplex method; Duality theory; Post-optimality analysis; Sensitivity analysis; Transportation and assignment models; Computer applications to LP, queuing theory; Project scheduling and management by PERT-CPM; Integer programming; Non-linear programming; Simulation; Goal programming; Decision theory; Markov chains; Sequencing problem.

Food process modelling: The principles of modelling, kinetic modelling, the modelling of heat and mass transfer; introduction to diffusion equation, the Navier-stokes equations, heat and mass transfer in porous media Luikov's equation. Modelling thermal processes: cooling and freezing, modelling product heat load during cooling & freezing. Modelling foods with complex shapes, numerical solution of the heat conduction equation with phase change. Modelling thermal processes: heating, introduction, processing of packed and solid foods, continuous heating and cooling processes, Modelling food quality and microbiological safety. Case Studies in Modelling, Control in Food Processes

UNIT II

Food process equipment design: Design considerations of agricultural and food processing equipment. Design of food processing equipment, Dryers, design of dryers. Determination of heat and air requirement for drying grains. Types of heat exchanger. Design of heat exchangers and evaporators. Design of material handling equipment like belt conveyor, screw conveyor, bucket elevator and pneumatic conveyors.

Digital image processing: digital representation of image, morphological image processing – dialation, erosion, opening and closing, line and edge detection, thresholding, segmentation, techniques for finding length, breadth, perimeter, surface area, eccentricity and surface roughness of solids. Machine vision-based measurement systems for fruit and vegetable quality control in postharvest

Genetic algorithm optimization: traditional optimization techniques and their limitations, non- traditional method, fitness function in biological evolution, computational procedure for optimization of independent parameters using genetic algorithm

Artificial neural network modelling: Developing predictive model between independent and dependent parameters by using Artificial neural network. Neural network architecture, weights and bias values of neurons, least square method for NN parameters optimization, matrix representation and computation of the values of NN parameters

UNIT III

Automation in different unit operations of food processing: Raw food material sorting, grading, size reduction, mixing and agitation, thermal processing, dehydration, packaging, CIP, quality control. Bottle Washing Machine Automation, Bottling Plant Drive System, Demineralization Plant Control System, Labelling Machine Control system, Charger level automation, Reverse Osmosis plant automation, Thermal plant automation, Dehydration and freezing plant automation

Suggested Readings

1. Najim K, 1989. Process Modeling and Control in Chemical Engineering -CRC Press
2. Das H, 2005. Food Processing Operations Analysis. Asian Books Private Limited
3. Ahmed J and Rahman S. 2012. Handbook of Food Process Design.Wiley-Blackwell
4. Tijskens LMM, Hertog MLATM and Nicolai BM, 2001. Food Process Modelling. Woodhead Publishing
5. Bernd H, 2017. Measurement, Modeling and Automation in Advanced Food Processing. Springer International Publishing
6. Moreira RG, 2001. Automatic Control for Food Processing Systems. Aspen publishers

FPT 519 Zero Waste Processing 2 (2+0)

Theory

UNIT I

Introduction: Food processing waste and by-product, ISO 14000 for environmental management system, biochemical and nutritional aspects of food processing by-products

Waste minimization: Supply-chain management issues and good housekeeping procedures, minimise energy use in food processing, minimise water use in food processing

UNIT II

Food waste separation: Microbiological risk management, Effects of postharvest changes in quality on the stability of plant co-products, Separation technologies for food wastewater treatment and product recovery

UNIT III

Co-product recovery techniques: Enzymatic extraction and fermentation for the recovery of food processing products, Supercritical fluid extraction and other technologies for extraction of high- value food processing co-products, Membrane and filtration technologies, Recovery of nutraceuticals, micronutrients, functional ingredients, natural dyes

UNIT IV

Waste management and co-product recovery: Meat, cereal, dairy, fish, fruit and vegetable, vegetable oil, plantation crops processing, waste management of food packaging

Food processing waste water treatment and gas production from solid food processing

Suggested Readings

1. Waldron K, 2009. Handbook of waste management and co-product recovery in food processing Woodhead Publishing
2. Arvanitoyannis IS, 2007. Waste Management for the Food Industries. Academic Press
3. Nout MJR and Sarkar PK, 2013 Valorisation of Food Processing By-Products CRC Press

Course Title with Credit load Ph.D. in Food Processing Technology

Minimum Credit Hours

i Course Work	
Major Courses	12
Minor Courses	06
Supporting Courses	05
Seminar	02
ii **Thesis Research**	75
Total	100

S. No.	Title	Course No	Credits
Major Courses			
1	Novel Technologies for Food Processing and Shelf Life Extension	FPT 601	3(3+0)
2	Food Packaging	FPT 602	3(3+0)
3	Food Manufacturing Technology	FPT 603	3(3+0)
4	Plant Food Products	FPT 604	3(3+0)
5	Food Process Modeling and Scale up	FPT 605	3(3+0)
6	Animal Food Products	FPT 606	3(3+0)
7	Special Problem	FPT 607	2(0+2)
Minor Courses			
1	Concentration and Drying Engineering	FPE 602	3(3+0)
2	Food Handling and Storage Engineering	FPE 606	3(3+0)
3	Quality Assurance in Food Supply Chain	FSQ 603	3(3+0)
4	Formulation of Standards of Food Products, Packaging and Labeling	FSQ 604	2(2+0)
Supporting			
1	Food Analytical Techniques	FPE 605	3(1+2)
2	Sensory Evaluation of Foods	FSQ 607	2(1+1)
Seminars			
1	Seminar I	FPT 698	1(1+0)
2	Seminar II	FPT 699	1(1+0)

ii Thesis Research

1	Doctoral Research/ Thesis	FPT 666	75(0+75)

Course Contents

FPT 601 Novel Technologies for Food Processing and Shelf Life Extension 3 (3+0)

Theory

Recent advances in novel food processing technology; Membrane processing, Supercritical fluid extraction, Microwave and radio frequency processing, High Pressure processing, Ultrasonic processing, Ozonation, Plasma Technique, Novel drying techniques. Various techniques to increase shelf life and shelf life prediction.

Suggested Readings

1. Gould G W, 2000. New Methods of Food Preservation, CRC Press
2. Barbosa-Canovas, 2002. Novel Food Processing Technologies, CRC Press
3. Dutta AK and Anantheswaran RC, 1999. Hand Book of Microwave Technology for Food Applications, CRC Press
4. Sun DW, 2015. Emerging Technologies for Food Processing, Elsevier Ltd
5. Kudra T and Mujumdar AS, 2009. Advanced Drying Technologies, CRC Press
6. Kilkast D and Subramanium P, 2000.The stability and shelf life of food. CRC Press
7. Doona C J and Feeherry F E, 2007.High pressure processing of foods. Blackwell Publishing Ltd

FPT 602 Food Packaging 3 (3+0)

Theory

Recent advances in active and intelligent packaging like antimicrobial food packaging, Non- migratory bioactive polymers, Freshness indicator, Recycling, Biodegradable packaging, Edible films and coatings, Aseptic packaging, Self-heating and hydrate packages.

Suggested Readings

1. Ahvenainen R, 2001. Novel Food Packaging Techniques, CRC Press.
2. Rooney ML, 1988. Active Food Packaging, Chapman & Hall.
3. Coles R and Kirwan M, 2011. Food and Beverage Packaging Technology, Wiley -Blackwell.
4. Han J and Han J, 2005. Innovations in Food Packaging, Academic Press.
5. Yam K and Lee D, 2012. Emerging Food Packaging Technologies, Woodhead Publishing.
6. Mihindukulasuriya SDF and Lim LT, 2014. Nanotechnology development in food packaging-a review. Trends in Food Science and Technology, 149-167.
7. Souza VGL and Fernando L, 2016. Nano-particles in food packaging-biodegradibility andpotential migration to food – a review. Food Packaging and Shelf Life, 63-70.

FPT 603 Food Manufacturing Technology 3 (3+0)

Theory

Manufacturing resource planning, Inventory control, Production planning, Production scheduling,Material requirement planning, Resource planning, Capacity requirement planning. Jobscheduling.

Suggested Readings

1. Badiru AB, 2015. Global Manufacturing Technology Transfer: Africa-USA Strategies, Adaptations, and Management, CRC Press.
2. Hitomi K, 1996. Manufacturing Systems Engineering: A Unified Approach to Manufacturing Technology, Production Management and Industrial Economics, CRC Press.
3. Yamane Y and Childs T, 2013. Manufacturing Technology Transfer: A Japanese MonozukuriView of Needs and Strategies, CRC Press.

FPT 604 Plant Food Products 3 (3+0)

Theory

Post-harvest handling of fresh fruits and vegetables, Minimally processed fruits and vegetables, Advances in chilling, freezing, and drying; Alcoholic and non-alcoholic beverages; Dough quality measurements; Bakery, RTE, RTC products; Hydrogenation, fractionation, winter ization, inter- esterification etc. Process for obtaining tailor-made fats and oils; Speciality fats and designer lipidsfor nutrition and dietetics, Textured plant proteins.

Suggested Readings

1. Rodrigues S and Fernandes FAN, 2016.Advances in Fruit Processing Technologies, CRC Press.
2. Smith DS, Cash JN, Nip WK and Hui YH, 1997. Processing Vegetables: Science andTechnology, *CRC Press.*
3. Chakraverty A and Singh RP, 2016. Postharvest Technology and Food Process Engineering, CRC Press.
4. Frame ND, 1994. Technology of Extrusion Cooking, Springer US
5. O'Brien RD, 2008. Fats and Oils: Formulating and Processing for Application, CRC Press.
6. Davis B, Lockwood A, Alcott P and Pantelidis L, 2012. Food and Beverage Management, CRCPress.
7. Dhillon PS and Verma S, 2012. Food and Beverage: Production Management for HospitalityIndustry, Abhijeet Publications.

FPT 605 **Food Process Modeling and Scale- up** **3 (3+0)**

Theory

Recent advances in modeling of high and low temperature processing; Kinetic modeling of microbial growth and its destruction, enzyme inactivation, nutrient retention, Scale up of food processing.

Suggested Readings

1. Tijskens LMM, Hertog MLATM and Nicolai BM. 2001. Food Process Modelling, Woodhead Publishing.
2. Ozilgen M, 2011.Handbook of Food Process Modeling and Statistical Quality Control. CRCPress.
3. Bernd H, 2017. Measurement, Modeling and Automation in Advanced Food Processing,Springer.
4. Valentas KJ, Clark JP and Levin L, 1990. Food Processing Operations and Scale-up. CRCPress.

FPT 606 **Animal Food Products** **3 (3+0)**

Theory

Research and development activities on meat, fish and poultry products. gross and microstructure of muscle, Pre-slaughter care, ante and post mortem, slaughter, handling of offal (edible and inedible). Methods to improve tenderness, Special poultry products, Breaded poultry, packaged precooked chicken, Freeze dried poultry meat. Egg preservation, egg powder production. Meat analogues and restructured meat products, Production of fish paste, fish oils, sauce, fish protein concentrates. Irradiation of fish and fisheries products, packaging of fish products, Quality controland quality assurance. Allergens, toxins and infectious diseases from meat, Poultry and fish products.

Suggested Readings

1. Nollet ML, 2012. Handbook of Meat, Poultry and Seafood Quality, Wiley-Blackwell.
2. Mountney GJ, 1988. Poultry Meat and Egg Production, Springer.
3. Robert RJ, 2012. Fish Technology, Wiley-Blackwell.
4. Mead G, 2004. Poultry Meat Processing and Quality, Woodhead Publishing.
5. Sahoo J, Sharma DK and Chatli MK, 2016. Practical Handbook on Meat Science and Technology, Daya Pub. House.
6. Pearson, AM and Gillet TA, 1996. Processed Meat, Springer.
7. Kerry JP, Kerry JF and Ledwood D, 2002. Meat Processing, Elsevier.
8. Wheaton FW and Lawson TB, 1985. Processing of Aquatic Food Products, John Wiley & Sons.

Food Process Engineering

Course Title with Credit load M. Tech. in Food Process Engineering

i Course Work	
Major Courses	20
Minor Courses	08
Supporting Courses	06
Common Course	05
Seminar	01
ii Thesis Research	30
Total	70

i. Course Work

Major Courses

S. No.	Course Title	Course No	Credits
1	Emerging Food Engineering Operations*	FPE 501	3(2+1)
2	Engineering Properties of Food Materials*	FPE 502	3(2+1)
3	Transport Phenomenon*	FPE 503	3(2+1)
4	Bio Processing and Down Stream Engineering	FPE 504	3(2+1)
5	Energy Management and Auditing in Food Industry	FPE 505	3(2+1)
6	Numerical Techniques and Simulation	FPE 506	2(1+1)
7	Computer Aided Design of Food Plant Machinery and Equipment	FPE 507	3(1+2)
8	Food Safety and Storage Engineering	FPE 508	3(2+1)
9	Equipment, Machine and System Design for Indigenous Food Product	FPE 509	2(0+2)
10	Operation Research	FPE 510	3(2+1)
11	Process Control in Food Industries	FPE 511	3(2+1)
12	Project Engineering and Management	FPE 512	3(2+1)
13	Food Process Automation and Robotics	FPE 513	3(2+1)
14	Water and Waste Management	FPE 514	3(2+1)
15	Special problem / Summer internship	FPE 515	2(0+2)

*Compulsory

Rest of the courses will be decided by the students advisory committee keeping the minimum limits set award of degree.

Minor Courses

S. No.	Course Title	Course No	Credits
1	Emerging Technologies in Food Packaging	FPT 502	2(2+1)
2	Industrial Manufacturing of Food and Beverages	FPT 503	3(2+1)
3	Food Material and Product Properties	FPT 504	3(2+1)
4	Aseptic Processing and Packaging	FPT 510	3(2+1)
5	Advanced Food Chemistry	FSQ 503	3(2+1)
6	Global Food Laws and Regulations	FSQ 504	2(2+0)
7	Process and Products Monitoring for Quality Assurance	FSQ 506	2(2+0)
8	Management of Food By-products and Waste	FSQ 508	3(2+1)

Supporting Courses

S. No.	Course Title	Course No	Credits
1	Research Methodology	BSH 501	2(2+0)
2	Food Informatics	BSH 502	2(2+0)
3	Post-Harvest Management	FBM 501	3(2+1)
4	Food Business Management	FBM 502	2(2+0)
5	Food Processing Entrepreneurship and Start up	FBM 503	2(1+1)
6	Food Safety Management Systems and Certification	FSQ 505	2(2+0)
7	Quality Concepts and Chain Traceability	FSQ 507	2(2+0)

Common Courses

S. No.	Course Title	Credits
1	Library and Information Services	1
2	Technical Writing and Communications Skills	1
3	Intellectual Property and its Management in Agriculture	1
4	Basic Concepts in Laboratory Techniques	1
5	Agricultural Research, Research Ethics and Rural Development Programmes	1

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

Seminar

S. No.	Course Title	Course No.	Credits
1	Seminar	FPE 599	1(1+0)

ii Thesis Research

S. No.	Course Title	Course No.	Credits
1	Masters Research	FPE 555	30(0+30)

Course Contents

FPE 501 Emerging Food Engineering Operations 3(2+1)

Theory

UNIT I

Ionizing and non-ionizing radiation processing system & operations: types of radiations, generation, microwave assisted processing systems, IR assisted processing systems, radio frequency systems, O_3, UV and X-ray assisted processing systems, gamma irradiations systems, e-beam radiation systems and applications.

UNIT II

Pulse electric field (PEF) generation system and applications, cold plasma generation systems and applications, high pressure processing systems and applications, ultrasonic processing systems and applications.

UNIT III

Extrusion systems, batch and continuous ohmic heating systems and applications, inductive heating systems and applications, applications of nanotechnology

UNIT IV

Drying systems: superheated steam drying, refractance window drying, heat pump drying, freeze drying, spray drying, foam bed drying, microwave drying, instant pressure drop (DIC) drying and hybrid drying systems.

UNIT V

Membrane processing systems: UF, MF, NF, reverse osmosis and vapour permeation, pervaporation, membrane distillation. Supercritical fluid extraction: concept, property of near critical fluids (NCF), extraction methods. Cryoprocessing-cryogens properties, systems and their different applications.

Practical

- To evaluate the characteristics of treated water and selected liquid foods using membrane systems (NF, UF, RO etc)
- To study super critical fluid extraction system and application
- To study microwave system and microwave assisted food processing
- To study efficacy of hot water, steam, microwave, ultrasound blanching of selected fruits and vegetables

- To study the ultrasonicator and applications
- To study cryogenic processing system and applications
- To prepare Nano emulsion and study of their characteristics
- To study ohmic/inductive heating systems and applications
- To study cold plasma system and applications
- To study gamma irradiation system and applications
- To study drying kinetics using different drying systems
- To study operations in 3 D printing
- Solving problems in food processing and case studies
- Visits of food industries utilizing advance food processing systems.

Suggested Readings

1. Datta, A. K. (2001). Handbook of microwave technology for food application. CRC Press.
2. Purkait, M. K., Singh, R. (2018). Membrane technology in separation science. CRC Press Taylor & Francis Group.
3. Frame, N. D. (1994). The technology of extrusion cooking. Blackie.
4. Gould, G. W. (2012). New methods of food preservation. Springer Science & Business Media.
5. Berk, Z. (2018). Food process engineering and technology. Academic press.
6. Nema, P. K., Kaur, B. P. & Mujumdar, A. S. (2019). Drying technologies for foods: Fundamentals and applications. CRC Press
7. Meredith, R. J. (1998). Engineers' handbook of industrial microwave heating (No. 25). Iet.
8. Arvanitoyannis, I. S. (2010). Irradiation of food commodities: techniques, applications, detection, legislation, safety and consumer opinion. Academic Press.
9. Yanniotis, S. (2008). Solving problems in food processing and case studies. Springer
10. Hui, Y.H., Clary, C., Farid, M.M., Fasina, O.O., Noomhorm, A. & J. Welti-Chanes (2008). Food drying science and technology. DEStech Publications
11. Fellows P.J. (2017). Food processing technology, 4ed. Elsevier

FPE 502 Engineering Properties of Food Materials 3(2+1)

Theory

UNIT I

Physical characteristics of different food grains, fruits and vegetables; shape and size, volume and density, porosity, surface area, water activity. Thermal properties: Specific heat, thermal

conductivity, thermal diffusivity, phase transition, methods of determination, steady state, transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, temperature dependent electrical conductivity and dielectric constant, method of determination, energy absorption from high-frequency electric field.

UNIT II

Magnetic properties: paramagnetism, ferromagnetism, diamagnetism, magnetization, applications for magnetic field forces, magnetic resonance; Electromagnetic properties: electric polarization, temperature dependency, frequency dependency, microwave, conversion of microwaves into heat, penetration depth of microwaves, applications; Optical properties: refraction, colorimetry, near infrared, ultraviolet, applications; Acoustical properties: sound, ultrasonic sound and applications; Radioactivity: types of radiation, radioactive decay, measurement of ionizing radiation, natural radioactivity, applications.

UNIT III

Contact stresses between bodies, hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity 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.

UNIT IV

Rheological properties and classification of fluid foods: measurement methods and techniques; Mechanisms and relevant models; Effect of temperature; Compositional factors affecting flow behavior; Viscosity of food dispersions – dilute and semi-dilute systems, concentration effects.

UNIT V

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.

UNIT VI

Large deformations and failure in foods: fracture, rupture and other related phenomena; Relationship between instrumental and sensory data; Texture Profile Analysis; Instrumental measurements – Empirical and Fundamental methods; Rheometers and Texture Analyzers; Measurement of Extensional viscosity; Acoustic measurements on crunchy foods.

UNIT VII

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 relationships.

UNIT VIII

Examining food microstructures: light microscopy transmission electron microscopy, scanning electron microscopy, other instrumentation and techniques, image analysis: image acquisition, image processing and analysis.

Practical

- Viscosity measurements of fruit juices and semisolid food products
- Comparative analysis of Newtonian and non-Newtonian fluids
- Development of stress and strain curve and to study viscosity of Newtonian and non-Newtonian fluids
- Temperature dependent and shear dependent rheology
- Pasting analysis of food; Determination of thermal conductivity, specific heat and glass transition temperature using differential scanning colorimetry (DSC)
- Texture analysis of fruits and vegetable-based products
- Texture analysis of baked foods products (bread/ biscuit)
- Starch characterization using starch master
- Dough rheology using doughlab or farinograph
- Determination of microstructures in selected foods using light microscopy
- TEM and SEM, image analysis and image processing techniques
- Evaluation of phase transition in colloidal systems, evaluation of structure texture function relations
- Case studies on food properties and applications.

Suggested Readings

1. Rao, M. A., Rizvi, S.S., Datta, A. K. & Ahmed, J. (2014). Engineering properties of foods. CRC press.
2. Figura O.L. & Teixeira A.A. (2007). Food physics: physical properties - measurement and applications. Springer Science & Business Media.
3. Sahin, S. & Sumnu, S.G. (2006). Physical properties of foods. Springer Science & Business Media.
4. Mohsenin, N.N. (1980). Thermal properties of foods and agricultural materials. New York. USA.
5. Mohsenin, N.N. (1986). Physical properties of plant and animal materials. Gordon and Breach Science Publishers.
6. Peleg, M., & Bagley, E. B. (1983). Physical properties of foods. In IFT basic symposium series (USA). AVI Pub. Co..
7. Ronal, J., Felix E., Bengt, H., Hans, F., Meffert, Th., Walter, E. C., & Gilbert V. (1983). Physical Properties of Foods. Applied Science Publishers.
8. Bourne, M. (2002). Food texture and viscosity: concept and measurement. Elsevier.
9. Norton, I. T., Spyropoulos, F. & Cox, P. (2010). Practical food rheology: an interpretive approach. John Wiley & Sons.

FPE 503 Transport Phenomenon 3(2+1)

Theory

UNIT I

Introduction to transport phenomena – Molecular transport mechanism, transport properties and their proportionality constants in momentum, energy and mass transfer.

UNIT II

Principles of Steady and unsteady state heat transfer and governing equations; transient heat transfer; Lumped system analysis; Estimation of Conductivity and other thermal properties of foods; overall heat transfer coefficient.

UNIT III

Steady-state equations - Momentum transport equations for Newtonian and non-Newtonian fluids, continuity equation in different co-ordinates.

UNIT IV

Equations of motion - Navier–Stokes equations and their application in viscous fluid flow between parallel plates and through pipes.

UNIT V

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.

UNIT VI

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.

UNIT VII

Dimensional analysis – Buckingham Pi-theorem and matrix method, application to transport phenomena, analysis among mass, heat and momentum transfer, Reynolds' and relevant analogies.

UNIT VIII

Boundary layer concept - Theoretical and exact solutions for heat, mass and momentum transfer.

Practical

- Effects of water concentration and water vapor pressure on the water vapor permeability and diffusion of chitosan films
- Mass transfer description of the osmo dehydration
- Pretreatment efficiency in osmotic dehydration
- Structural effects of blanching and osmotic dehydration pretreatments on air drying kinetics of fruit tissues
- Thermal processing of particulate foods by steam injection (1. Heating rate index for diced vegetables 2. Convective surface heat transfer coefficient for steam)
- 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)
- Heat and mass transfer during the frying process; Influence of liquid water transport on heat and mass transfer during deep-fat frying

- Numerical simulation of transient two-dimensional profiles of temperature, concentration, and flow of liquid food in a can during sterilization
- Case studies on transport phenomenon and its applications.

Suggested Readings

1. Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2007). Transport phenomena. John Wiley & Sons.
2. Treybal, R. E. (1980). Mass transfer operations. New York.
3. Yuan, S. W. (1969). Foundations of Fluid Mechanics. Prentice Hall of India.
4. Welti-Chanes, J., & Velez-Ruiz, J. F. (Eds.). (2016). Transport phenomena in food processing. CRC press.
5. Geankoplis, C. J., Hersel, A.A., & Lepek, D.H. (2018). Transport processes and separation process principles:(includes unit operations). Prentice Hall Professional Technical Reference.

FPE 504 Bioprocessing and Down Stream Engineering 3 (2+1)

Theory

UNIT I

Introduction: Interaction of biochemical engineering, biochemistry and microbiology, 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.

UNIT II

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.

UNIT III

Alcoholic beverages: 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).

UNIT IV

Single Cell Proteins: Single cell proteins production, substrates, factors effecting SCP production, composition, uses, economic parameters and constrains including safety aspects.

UNIT V

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.

UNIT VI

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.

UNIT VII

Down-stream processing: 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 in-plant sanitation.

UNIT VIII

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.

Practical

- Studying biochemical changes during handling of important food items
- Study of fermenter and fermentation process
- Study of bioprocess instrumentation and control system
- Study of bacterial growth in batch culture
- Production and maintenance of starter culture
- Production of enzyme, extraction and purification
- Production of SCP; Production of microbial pigments
- Production of amino acids
- Production of alcohol and alcoholic beverages
- Visit to brewery
- Visit to effluent treatment plant
- Bioprocess modeling and simulation
- Case Studies & Reports.

Suggested Readings

1. Schügerl, K. & Zeng A.P. (2010). *Advances in biochemical engineering biotechnology: tools and applications of biochemical engineering science*. Springer
2. Scheper Th.(Ed). *Advances in Biochemical Engineering and Biotechnology Series*. Springer
3. Ghose, T. K., & Fiechter, A. (1971). Advances in Biochemical Engineering-I. Indian Journal of Physics, 47, 189-192.
4. James, E. B. & David, F. O. (1986). *Biochemical engineering fundamentals*. McGraw-Hill Book Co. Inc., New York
5. Thomas Scheper, P. Bajpai, P.K. Bajpai, D. Dochain, N.N. Dutta, A.C. Ghosh, R.K. Mathur, A. Mukhopadhyay, M. Perrier, P.L. Rogers, H.S. Shin, B. Wang (2013). *Biotreatment, downstream processing and modelling*. Springer
6. Doran, P. M. (2012). *Bioprocess engineering principles, 2ed*. Elsevier

7. Perry, J. H. (2007). *Chemical engineers' handbook*, 8e. McGraw-Hill Professional
8. Stumbo, C. R. (2013). *Thermobacteriology in food processing*. Elsevier
9. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology, 3ed*. Elsevier
10. Hitzmann, Bernd (2017). *Measurement, modeling and automation in advanced food processing*. Springer

FPE 505 Energy Management and Auditing in Food Industry 3(2+1)

Theory

UNIT I

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.

UNIT II

Energy Auditing Basics: ASHRAE definitions of energy audits, the audit process, pre-site and post-site work, audit report.

UNIT III

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.

UNIT IV

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.

UNIT V

Measurements, Survey instrumentation, and data Collection: General audit instrumentation; co2, 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.

UNIT VI

Energy and Water Conservation Technologies Applied to Food Processing Facilities: Conservation in steam generation and consumption system, energy conservation in heat exchangers, conservation in compressed air system, 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.

Practical

- Study and practice with energy assessment and auditing instruments
- Performance assessment of motors and variable speed drives
- Performance assessment of pump, fans and blowers
- Performance assessment of refrigeration system
- Performance assessment of heat exchangers
- Performance assessment of furnace
- Performance assessment of boilers
- Conservation possibilities in dairy processing facilities
- Conservation possibilities in grains and oilseeds milling plants
- Conservation possibilities in sugar and confectionary processing facilities
- Conservation possibilities in fruit and vegetable processing facilities
- Conservation possibilities in bakery processing facilities
- Conservation possibilities in meat processing facilities
- Case studies & field reports.

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 9e*. Fairmont Press
3. Klemes, J., Smith, R., & Kim, J. K. (2008). Handbo*ok of water and energy management in food processing*. Elsevier.
4. Christopher, C. S. (2007). *Electric water: The emerging revolution in water and energy*. New Society Publishers
5. Books, Cases studies and reports from BEE-NPC

FPE 506 Numerical Techniques and Simulation 2(1+1)

Theory

UNIT I

Modelling and Simulation: Fundamentals of modeling and simulation; Different steps for modeling and simulation, Types of models; Advantages of modeling and simulation, Application areas of simulation.

UNIT II

Solution of partial differential equations models: Differential Laplace, Poisson, parabolic and hyperbolic equations, Bender – Schmidt method, finite difference method, finite volume method.

UNIT III

Optimization: Optimization theory and methods, Graphical and numerical methods of optimization; experimental optimization; linear and nonlinear un-constrain and constrain optimization, multivariate optimization, genetic algorithm, goal driven optimization.

UNIT VI

Modelling and simulation applications of some food engineering operations: Thermal processing, convection & osmotic dehydration, spray & freeze drying, deep fat frying; extrusion process; filtration processes; distillation and Extraction processes.

UNIT V

Computational fluid dynamics (CFD) applications in food processing.

Practical

- Introduction to various features in different spreadsheet softwares
- Solving problems using functions and/or add-Ins and/or Analysis Tool pack in spreadsheets
- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data
- Practice on data visualization and analytics softwares i.e. Power Bi, Tableu, etc.
- 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 etc.
- Practice on modelling and simulation softwares i.e. MATLAB, FLUENT, GAMBIT, EDEM, Solid works, ANSYS, Python, etc.
- Practice on process optimization softwares i.e. SAS, SPSS, Origin Pro, Design Expert (DX), Minitab, Matlab etc.
- Practice on design analysis and optimization softwares i.e. Solid works, ANSYS etc.

Suggested Readings

1. Das, H. (2005). *Food processing operations analysis*. Asian Books Private Limited
2. Denn, M. M. (1986). *Process modeling*. Longman
3. Holland, C. D. (1975). *Fundamentals and modeling of separation processes*. Prentice Hall.
4. Luyben, W. L. (1990). *Process modeling simulation and control for chemical engineers* 2ed. McGraw Hill.
5. Najim, K. (1990). *Process modeling and control in chemical engineering*. CRC
6. Aris, R. (1999). *Mathematical modeling, Vol. 1: A chemical engineering perspective (Process System Engineering)*. Academic Press.
7. Kreyszig, E. (2005). *Advanced engineering mathematics*. John Wiley & Sons publication
8. Granato, D. & Ares, G. (2014). *Mathematical and statistical methods in food science and technology*. IFT Press, Wiley Blackwell
9. Standard software for modelling, analysis and simulations

FPE 507 Computer Aided Design of Food Plant Machinery and Equipment 3(1+2)

Theory

UNIT I

Introduction - Definition of CAD/CAM, product cycle.

UNIT II

Automation, CPU, types of memory, input/output devices, data presentation, data and file structures, data base design, design work station.

UNIT III

Graphics terminal, operating devices, plotters and other output devices, CPU secondary storage, Turnkey CAD system, selection criteria, evaluation of alternative systems.

UNIT IV

Geometric Modeling Techniques - wireframe, surface and solid modeling, Geometric transformations, Graphics standards.

UNIT V

CAM - Introduction to Numerical Control (NC) technology, current status of NC, Influence of NC in design & manufacturing.

UNIT VI

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.

Practical

- Preparation of manual drawings with dimensions from Models and Isometric drawings of objects and machine components
- Preparation of sectional drawings of selected machine parts
- Drawing of riveted joints and thread fasteners
- Demonstration and practice on computer graphics and computer aided drafting using standard softwares such as AutoCAD and/or Inventor and/or Solidworks and/or Creo and/or Catia
- Computer graphics for food engineering applications
- Practice and use of basic and drawing commands on AutoCAD and Solid works
- Generating simple 2-D drawings with dimensioning using AutoCAD and Solidworks
- Small projects using CAD/CAM
- Practice on assembly using Solidwork assembly tool
- Analysis of machine/equipment component for structural parameters using FEM
- Design optimisation of food machine/equipment using goal driven optimization technique
- Kinematic and dynamic analysis of mechanism and machines using Solidworks motion study tool

- Small projects using CAD/CAM
- To study design standards of general food processing equipment and systems
- Case studies or reports on hygienic design of food plant machinery, equipment and plants

Suggested Readings

1. Farin, G., Hoschek, J. & Kim, M. S. (2002). *Handbook of computer added geometric design*. Elsevier Science
2. Goetsch, D.L. (1988). *MicroCADD: Computer aided design and drafting on microcomputers*. Prentice Hall
3. Holah, J.T. & Lelieveld, H. L. M. (2011). *Hygienic design of food factories*. Woodhead publishing house
4. Higgins, L.&Morrow, L. C. (1977). *Maintenance engineering hand-book*. McGraw Hill. Keating, F. H. (1959). *Chromium-Nickel Austentic Steel*. Butterworths Scientific Publ.
5. Newcomer, J. L.(1981). *Preventive maintenance manual for dairy industry*. Venus Trading Co., Anand.
6. Stanier, W. (1959). *Plant engineering hand-book*. McGraw Hill.

FPE 508 Food Safety and Storage Engineering 3(2+1)

Theory

UNIT I

Overview of food microbiology: Foodborne illness, food spoilage, food fermentation, microbiological physiology and food preservation, microbiological analysis, safety management systems. Overview of foodborne pathogens: Bacterial pathogens, food borne viruses and parasites.

UNIT II

Chemical safety of foods: nature of chemical hazards in foods, food safety engineering and control of chemical hazards, food allergen control. Intrinsic and extrinsic parameters for microbial growth and heat inactivation: Intrinsic and extrinsic factors affecting microbial growth, factors affecting heat resistance, combining traditional peroration techniques.

UNIT III

Kinetics of microbial inactivation: Microbial inactivation kinetics based on food processing methods: thermal, pressure, pulsed electric field, microwave and radio frequency, ohmic and inductive heating etc. Kinetic parameter for the inactivation of pathogens: Salmonella, Listeria monocytogenes, Staphylococcus aureus, Escherichia coli, Bacillus cereus, Clostridium, Vibrio, other pathogens.

UNIT IV

Predictive microbial modelling: classification of models: Kinetic & probability, Empirical & mechanistic models, Primary, secondary & tertiary models, Deterministic & stochastic models; Description of main models, Modelling growth curves, Modelling inactivation/survival curves,

Secondary models, Probability models; Applications of predictive microbial modelling: Hazard analysis critical control point (HACCP) & quantitative risk assessment (QRA), Microbial shelf- life studies, Temperature function integration and temperature monitors, Product research and development, Design of experiments; Predictive microbial modelling and quantitative risk assessment.

UNIT V

Process-dependent microbial modeling: Predictive microbial kinetic models, Temperature- dependent microbial growth kinetic models, Irradiation-dependent microbial growth model, Pulsed electric field-dependent microbial growth model, High-pressure-dependent microbial growth model; Process modeling; Integration of process and microbial growth kinetic models.

UNIT VI

Storage and handling systems for grains, horticultural and animal based produces; post-harvest physiology of fruits and vegetables; biochemical changes during storage, production, distribution; storage capacity estimate models, ecology, storage factors affecting losses, storage requirements.

Practical

- Rapid methods and automation in microbiology: trends and predictions
- Study on phage-based detection of foodborne pathogens
- Study on real-time PCR
- Study on DNA Array
- Study on immunoassay
- Offline and online assessments for food safety for industry
- Storage pest, insects and rodent control
- Study on storage systems and structures
- Shelf life evaluation of packaged food products
- Recent advancements in storage and handling systems
- Hygienic design standards and codes for food processing equipment / system
- Case studies on food safety engineering, guidelines, regulations.

Suggested Readings

1. Sun, D. W. (2015). *Handbook of food safety engineering*. Wiley Black Well Academic Press, Elsevier Ltd
2. International Organization for Standardization. (2018). *Food safety management systems: requirements for any organization in the food chain*. ISO.
3. Shejbal J (1980). *Controlled atmosphere storage of grains*. Elsevier.
   Vijayaraghavan S. (1993). *Grain storage engineering and technology* Batra Book Service
4. Chakraverty A. & Singh R.P. (2014). *Postharvest technology and food process engineering*. CRC Press
5. Chakraverty A., Mujumdar A.S. & Ramaswamy H.S. (2002). *Handbook of postharvest technology: cereals, fruits, vegetables, tea, and spices*. CRC Press

6. ISO 22000 *Food safety management systems - Requirements for any organization in the food chain*. Technical Committee ISO/TC 34, Food products and updates
7. Case studies and field reports - Food Safety Engineering

FPE 509 Equipment, Machine and System Design for Indigenous Food Products 2 (0+2)

Objective/preamble:

To develop understanding for mechanization of selected indigenous food products, associated materials of construction, codes and standards, mass balance, specific energy consumption, design, instrumentation, scale of automation, ergonomics, schematics and designing systems/line as a whole.

Students (in group or individual) should be able to evaluate existing production process and categorize whole process in different unit operations such as raw material handling, storage, thermal processing, packaging etc. Computer added design, drafting and simulation of existing system for production and packaging of indigenous food products.

Practical

- Visits to indigenous food manufacturing sites and study of existing indigenous food production system
- Study of relevant codes, guidelines and standards for the existing indigenous food production system (product, process, area and personal hygiene)
- Evaluation of available concepts of indigenous food product manufacturing and amelioration
- Computer aided design, drafting and simulation of the selected systems
- Case studies on equipment, machine and system available for the indigenous food products

Suggested Readings

1. Holah, J., & Lelieveld, H. (Eds.). (2011). *Hygienic design of food factories*. Elsevier.
2. Steinkraus, K. (2004). *Industrialization of indigenous fermented foods*, revised and expanded. CRC Press.
3. Steinkraus, K. H. (1995). *Handbook of indigenous fermented foods*. CRC press
4. Couper, J. R., Penney, W. R., Fair, J. R. & Walas, S. M. (2012). *Chemical process equipment - selection and design*, 3e. Elsevier
5. Saravacos, G. & Kostaropoulos A.E. (2016). *Handbook of food processing equipment*, 2e. Springer
6. Cramer, M.M. (2013). *Food plant sanitation: design, maintenance, and good manufacturing practices, 2e*. CRC Press.
7. Willey, R.R. (2006). *Practical design, construction and operation of food facilities*. Academic Press
8. Baker, C.G. & Christopher G.J.B (Ed.). (2013). *Handbook of food factory design*. New York, NY: Springer.
9. Joshi, M. V., & Mahajani, V. V. (2000). *Process equipment design, 3e*. Macmillan India.
10. Brownell LE, Young EH (1968). *Process equipment design, 2e*. Wiley Eastern Edn. New York
11. Ahmad T (2009). *Dairy plant engineering and management, 8e*. Kitab Mahal
12. Hygienic design & sanitary guidelines and related documents / publications

FPE 510 Operation Research 3(2+1)

Theory

UNIT I

Introduction to operations research: Elementary concepts and objectives of Operations Research, Applications of operations research in decision making.

UNIT II

Linear programming problem: Mathematical formulation of the linear programming problem and its graphical solution, Simplex method, dual simplex, revised simple algorithms. Primal dual redactions, decomposition algorithm.

UNIT III

Transportation problem: Definition and mathematical formulation, Initial basic feasible solution, Optimal solution. Assignment problem: Introduction and mathematical formulation, Solution of assignment problem.

UNIT IV

Inventory control: Introduction and general notations, Economic lot size models with known demand. Replacement theory: Introduction and elementary concepts, Replacement of items deteriorating with time.

UNIT V

Sequencing problem: Introduction and general notations, Solution of a sequencing problem.

UNIT VI

Queuing theory: Introduction and classification of queues, Solution of queuing models. Nonlinear programming, classical optimization algorithms.

UNIT VII

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).

Practical

- Studies on application of Linear Programming on food product standardization
- Studies on use of Transportation and Assignment Problems in food plant operations
- Studies on Economic Order Quantity and Replacement Model
- Studies on Sequencing of food plant operations; Studies on Queuing Model
- Network Analysis using CPM and PERT.
- Practice on relevant softwares (LINDO, LINGO etc) for linear programming
- Practice on relevant softwares (LINDO, LINGO etc) for linear inventory control
- Case studies and reports

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
5. Panneerselvam, R. (2012). *Operations Research*. PHI Learning Pvt.
6. Prasanna, C. (2009). Projects. Tata McGraw-Hill Publication, New Delhi.
7. Nicolas, J. M. (2003). *Project management for business and technology – principles and practices*. Pearson Prentice Hall
8. Kerzner, H., & Kerzner, H. R. (2017). *Project management: a systems approach to planning, scheduling, and controlling*. John Wiley & Sons.
9. Gopalakrishnan, P., & Ramamoorthy, V. E. (2005). *Textbook of project management*. Macmillan.

FPE 511 Process Control in Food Industries 3(2+1)

Theory

UNIT I

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.

UNIT II

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).

UNIT III

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 systems. Multiplexing systems. Modern digital data acquisition system. Control systems for processing plants.

UNIT IV

Industrial Automation. 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.

UNIT V

Image Processing Applications: Methodology, Shape analysis, Object identification and feature/s detection, Three-dimensional processing. Application to food industry: Inspection and inspection Procedures, X-Ray, Computer vision systems, Electronic nose and Electronic tongue.

UNIT VI

Virtual Instrumentation: Introduction to LABVIEW: Virtual instruments, Parts of VI, Project explorer, Front panel and block diagram window, Creating simple VI.

Practical

- Study of various online / offline industrial instrumentations for measurement of pressure, temperature, flow, level etc.
- Study of PLC and to program a PLC using Ladder programming & PLC based control of Multi process system
- To make ladder logic diagrams and flow sheet diagrams for control logic
- Study of data loggers- computerized data acquisition and data processing
- Programming and making GUI in LABVIEW and other relevant softwares
- Study of image acquisition system and analysis using suitable softwares
- Study of SCADA application software/ computerized control of PC-PLC based multi- process control system.
- Study on applications of electronic nose and electronic tongue.
- Case studies and reports on instrumentation and process control for food manufacturing.

Suggested Readings

1. McFarlane I. (1995). *Automatic control of food manufacturing processes, 2e*. Springer Science and Business Media

2. Bhanot, S. (2008). *Process control: principles and application*. Oxford University Press.
3. Singh, S. K. (2005). *Industrial instrumentation & control, 2e*. Tata McGraw-Hill Education.
4. Krishnaswamy, K. (2003). *Industrial Instrumentation (Vol. 1)* . New Age International.
5. Liptak, B. G. (2018). *Instrument engineers' handbook, volume two: process control and optimization*. CRC press.
6. Jain, R. K. (1988). *Mechanical and industrial measurements*. Khanna Publishers.
7. Rangan, C. S., Sarma, G. R., & Mani, V. S. V. (1983). *Instrumentation: devices and systems*. Tata McGraw-Hill.
8. Patranabis, D. (1976). *Principles of industrial instrumentation*. Tata McGraw-Hill Publishing.
9. Mittal G.S. (1997). *Computerized control systems in the food industry*. CRC Press

FPE 512 Project Engineering and Management 3(2+1)

Theory

UNIT I

Overview of project management: Functions and viewpoints of management, evolution of project management, forms and environment of project management.

UNIT II

Project life cycle; Project selection: Project identification and screening, project appraisal, project charter, project proposal, project scope, statement of work; Feasibility studies

UNIT III

Project planning and scheduling: Work breakdown structure, planning and scheduling of activity networks, network scheduling, precedence diagrams, critical path method, program evaluation and review technique, assumptions in PERT modelling, decision CPM, GERT

UNIT IV

Project cost estimating: Technical Analysis and introduction to various component of project installation and commissioning cost and their estimation; Types of estimates and estimating methods, dynamic project planning and scheduling, time-cost trade-offs, resource considerations in projects, resource profiles and levelling, limited resource allocation

UNIT V

Project implementation, monitoring and control:, project management process and role of project manager, team building and leadership in projects, organizational and behavioral issues in project management, project monitoring and control, PERT/cost method, earned value analysis

UNIT VI

Elements of Cost of Production; Financing of projects: Debt-Equity ratio etc. Introduction to concepts of inflation, location index and their use in estimating plant and machinery cost. Depreciation concept, Indian norms and their utility in estimation, Capital cost estimation, Working capital estimation, Project Evaluation, break-even analysis, ROI, IRR., Discounted cash flow analysis

UNIT VII

Project completion and future directions: Project completion and review; Project management: Recent trends and future directions; Computers in project management

Practical

- Studies on Market Survey based on enterprise
- Preparation of Project Report
- Project selection, identification, appraisal and scope
- Methods of monitoring and feasibility of projects
- Studies on investment and repayment plants
- Project monitoring and Control – PERT Modeling
- Case studies and reports-Projects

Suggested Readings

1. Patel J.B. & Allampalli, D. G. 1991. A manual on how to prepare a project report.
2. Patel J.B. & Modi, S. S. 1995. *A Manual on Business Opportunity Identification and Selection*.
3. EDI Ahmedabad (2005). *Manual for Entrepreneurs*. Tata McGraw Hill Education.
4. Projects: Planning, Analysis, Selection, Financing, Implementation, and Review by P. Chandra
5. Plant Design and Economics for Chemical Engineers by M. S. Peters and K. D. Timmerhaus
6. Project Engineering of Process Plants by H.F. Rase
7. Panneerselvam, R. (2012). Operations Research. PHI Learning Pvt. Ltd.
8. Prasanna, C. (2009). Projects. Tata McGraw-Hill Publication, New Delhi.
9. Nicolas J. M.. Project Management for Business and Technology – Principles and Practices. Pearson Prentice Hall
10. Kerzner, H., & Kerzner, H. R. (2017). Project management: a systems approach to planning, scheduling, and controlling. John Wiley & Sons.
11. Gopalakrishnan, P., & Ramamoorthy, V. E. (2005). Textbook of Project Management. Macmillan.

FPE 513 Food Process Automation and Robotics 3(2+1)

Theory

UNIT I

Automated evaluation of food quality, food quality quantization and process control, typical problems in food quality evaluation.

UNIT II

Data acquisition: Sampling elaboration with examples, concepts and systems for data acquisition such as: ultrasonic signal acquisition, electronic nose data acquisition, frying data acquisition for quality process control, Image acquisition.

UNIT III

Data analysis: Data preprocessing, Static data analysis, Dynamic data analysis, Image processing: Image segmentation, Image feature extraction.

UNIT IV

Modeling & prediction: Modeling strategies: Theoretical and empirical modeling, Static and dynamic modeling, Linear statistical modeling, ANN modeling, fuzzy logic, artificial intelligence and machine learning. Prediction and classification, Sample classification based on linear statistical and ANN models, Electronic nose data; One-step- ahead prediction.

UNIT V

Control: Process control, Internal model control, Predictive control, Neuro-fuzzy PDC for snack food frying and other processes, Systems integration: Food quality quantization and process control systems integration.

UNIT VI

Automation in sorting, thermal processing, fresh produce; Automation in food chilling and freezing; In storage, transport, retail systems; fruit vegetable processing; cleaning, grading, canning etc.

UNIT VII

Automation in meat processing, carcass production, separation; before and after chilling; Automation in poultry industry; hanging, conveying, processing, packing; Automation in sea food processing, in unit operations associated.

UNIT VIII

Automatic process control in food industry. Process control methods in food industry, current, future trends. Robotics in food industry, specification of food sector robot, control law algorithms.

Practical

- To study different types of sensors for measurement of temperature, pressure, flow and level
- To study interfacing systems for analogue to digital signals
- To study sensors for automated food process control
- To study different logic controlling systems
- To study computer vision systems used in industries
- To study machine vision systems used in industries
- To study optical sensors and online spectroscopy for automated quality and safety inspection of food products
- To study supervisory Control and Data Acquisition (SCADA) and related systems for automated process control in the food industry

- To study different configurations of industrial robots
- To study gripper technologies for food industry robots
- To study wireless sensor networks (WSNs) components in the agricultural and food industries
- To study intelligent quality control systems in food processing based on fuzzy logic
- Application of automation and robotics for bulk sorting, chilling and freezing, meat processing, poultry industry, seafood processing, packaging in confectionery etc in food processing industries
- Case studies and field reports on Food Process Automation and Robotics.

Suggested Readings

1. Caldwell, D. G. (Ed.). (2012). *Robotics and automation in the food industry: Current and future technologies*. Elsevier.
2. Dwivedi, S. N., Verma, A. K. & Sneckenberger, J. E. (1991). *CAD/CAM robotics and factories of the future*. Springer
3. Doeblin E.O. & Manik D.N. (2003). *Measurement systems: applications and design, 5e*. Tata McGraw Hill.
4. Kuo, B. C., & Golnaraghi, F. (1995). *Automatic control systems, 9e*. Prentice-Hall.
5. Rajput, R. K. (2008). *Robotics and Industrial Automation, 2e*. S. Chand Publishing
6. Eugene, E.I. (1988). *Mechanical Design of Robots*. McGraw Hill
7. Mitchell T. (1997). *Machine Learning*. McGraw Hill
8. Groover, M. P., Weiss, M., Nagel, R. N., & Odrey, N. G. (1986). *Industrial robotics: technology, programming, and applications*. McGraw-Hill.
9. Groover, M P. (2019). *Automation, Production Systems, and Computer Integrated Manufacturing, 5e*, Pearson Prentice Hall.
10. Groover, M. and Zimmers, E. (2014). *CAD/CAM: Computer-aided Design and Manufacturing*, Prentice-Hall of India Private Ltd.
11. Huang, Y., Whittaker, A. D., & Lacey, R. E. (2001). *Automation for food engineering: food quality quantization and process control*. CRC Press.
12. Bhuyan, M. (2006). *Measurement and control in food processing*. CRC Press.
13. Zude, M. (2008). *Optical monitoring of fresh and processed agricultural crops*. CRC press.
14. Dochain, D. (2001). *Automatic control of bioprocesses. Control systems, robotics and manufacturing series*. Wiley-ISTE
15. Sun, D. W. (Ed.). (2012). *Computer vision technology in the food and beverage industries*. Elsevier.
16. Kress-Rogers, E., & Brimelow, C. J. (Eds.). (2001). *Instrumentation and sensors for the food industry*. Woodhead Publishing.

FPE 514 Water and Waste Management 3(2+1)

Theory

UNIT I

Basic considerations: Characterization of different industry effluents and utilization of by- products; Standards for emission or discharge of environmental pollutants from industries. Elements of importance in the efficient management of wastes.

UNIT II

Physical and chemical parameters for waste; oxygen demands; BOD, COD and their interrelationships; residues (solids), fats, oils and grease, forms of nitrogen, sulphur and phosphorus, anions and cations, surfactants, colour, odour, taste, toxicity. Unit concept of treatment of food industry effluent, screening, sedimentation floatation as pre - and primary reactants.

UNIT III

Primary treatment, secondary and tertiary waste treatments by physical, chemical and biological methods. Effluent and solid waste utilization by Biological oxidations: Objects, organisms, reactions, oxygen requirements, aeration devices systems: lagoons, activated sludge process, oxidation ditches, rotating biological contractors and their variations and advanced modifications.

UNIT IV

Wastewater treatment systems. Physical separations, coagulation and flocculation; micro-strainers, filters, ultra-filtration and reverse osmosis; water softening. Physico-chemical separations:

activated carbon adsorption, ion-exchange electro-dialysis and magnetic separation. Chemical oxidations and treatment coagulation and flocculation. Disinfection. Handling disposal of sludge.

UNIT V

Waste management strategies and value added products from of agri-food processing industry; Recovery of biologicals from fruit, vegetables, dairy, meat, fish and poultry processing industry.

Practical

- Determination of Alkalinity, Acidity and pH of a given waste water sample
- Determination of electric conductivity of a given sample
- Determination of hardness (Chlorides and Sulphates) of a given waste water sample
- Determination of Solids in wastewater, Total Solids, Suspended Solids, Dissolved Solids, Volatile Solids, Fixed Solids, Settleable Solids
- Estimation of dissolved oxygen and BOD exerted by the given waste water sample
- Estimation of COD exerted by the given waste water sample
- Determination of nitrates in waste water
- Determination of fats, oils and greases in waste water
- Determination of fecal contamination of water- qualitative and quantitative estimation
- Determination of SPC of different wastes
- Visit of an effluent treatment plant in a food processing industry.

Suggested Readings

1. Arvanitoyannis, I. S. (2010). Waste management for the food industries. Academic Press.
2. Zall, R. R. (2008). Managing food industry waste: Common sense methods for food processors. John Wiley & Sons.
3. Shuler M.L., Kargi F., DeLisa M. (2017). Bioprocess engineering: basic concepts. Prentice- Hall.
4. Waldron, K. W. (Ed.). (2009). Handbook of waste management and co-product recovery in food processing. Elsevier.
5. Mattsson, B., & Sonesson, U. (Eds.). (2003). Environmentally-friendly food processing. Woodhead publishing.
6. Garg, S. K. Environmental engineering-Vol.1 & 2. Khanna publishers.
7. Manuals published by Central Public Health & Environmental Engineering Organisation (CPHEEO). Ministry of Housing and Urban Affairs, Government of India.
8. Environment (Protection) Act 1986, Govt of India and other relevant publications.

Course Title with Credit load Ph.D. in Food Process Engineering

Minimum Credit Hours

i Course Work	
Major Courses	12
Minor Courses	06
Supporting Courses	05
Seminar	02
ii **Thesis Research**	75
Total	100

i Course Work

S.No.	Title	Course No	Credits
Major Courses			
1	Food Machinery and Utility Design	FPE 601	3(3+0)
2	Concentration and Drying Engineering	FPE 602	3(3+0)
3	Automation and Robotics	FPE 603	2(2+0)
4	System Analysis and Optimization	FPE 604	3(3+0)
5	Food Analytical Techniques	FPE 605	3(1+2)
6	Food Handling and Storage Engineering	FPE 606	3(3+0)
7	Separation Engineering	FPE 607	3(3+0)
8	Novel Food Process Engineering	FPE 608	2(2+0)
9	Design of Packaging System	FPE 609	2(2+0)
10	Special problem	FPE 610	2(0+2)
Minor Courses			
1	Novel Technologies for Food Processing and Shelf-Life Extension	FPT 601	3(3+0)
2	Food Process Modeling and Scale up	FPT 605	3(3+0)
3	Quality Assurance in Food Supply Chain	FSQ 603	3(3+0)
4	Formulation of Standards of Food Products, Packaging and Labeling	FSQ 604	2(2+0)

Supporting Courses

1	Food Analytical Techniques	FPE 605	3(1+2)
2	Sensory Evaluation of Foods	FSQ 607	2(1+1)
3	Food Business Management	FBM 502	2(2+0)

Seminar			
1	Seminar I	FPE 698	1(0+1)
2	Seminar II	FPE 699	1(0+1)
Thesis Research			
1	Doctoral Research	FPE 666	75(0+75)

Course Contents

FPE 601 Food Machinery and Utility Design 3 (3+0)

Theory

Current trends in use of machinery and utilities, utilities for production of indigenous food products, systems used in mass food production, codes and standards applicable, performance assessment, safety and hygiene requirement with respect to machine, products and operator, suitability and scale of automation, innovativeness, environmentally friendly, ergonomics, resource utilization and assessment.

Suggested Readings

1. Kutz Myer (2013). Handbook of Farm, Dairy, and Food Machinery, 2e. Academic Press
2. Hitzmann, Bernd (2017). Measurement, Modeling and Automation in Advanced Food Processing. Springer
3. Robert L. Norton (2003). Design of Machinery. McGraw-Hill
4. Helmut Traitler, Birgit Coleman, Karen Hofmann (2014). Food Industry Design, Technology and Innovation. Wiley-Blackwell
5. Selwyn Piramuthu and Weibiao Zhou (2015). RFID and Sensor Network Automation in the Food Industry. Wiley-Blackwell
6. John Holah and Huub Lelieveld (2011). Hygienic Design of Food Factories. Woodhead Publishing

FPE 602 Concentration and Drying Engineering 3(3+0)

Theory

Recent development in concentration and drying processes, technologies and engineering, problem solving and case studies.

Suggested Readings

1. Anandharamakrishnan C., Ishwarya S. Padma (2015). Spray Drying Techniques for Food Ingredient Encapsulation. Wiley-Blackwell
2. Georg-Wilhelm Oetjen, Peter Haseley (2018). Freeze-Drying, 3e. Wiley-VCH
3. MagdaliniKrokida (2018). Thermal and Nonthermal Encapsulation Methods. CRC Press
4. Anandharamakrishnan C (2017). Handbook of Drying for Dairy Products. Wiley-Blackwell
5. Min Zhang, Bhesh Bhandari, Zhongxiang Fang (2017). Handbook of Drying of Vegetables and Vegetable Products. CRC Press

6. Om Prakash,Anil Kumar (2017). Solar Drying Technology: Concept, Design, Testing, Modeling, Economics and Environment. Springer Singapore
7. Azharul Karim, Chung-Lim Law (2017). Intermittent and Nonstationary Drying Technologies: Principles and Applications. CRC Press
8. Minea, Vasile (2016). Advances in Heat Pump-Assisted Drying Technology. CRC Press
9. Woo, MengWai (2016). Computational Fluid Dynamics Simulation of Spray Dryers: An Engineer's Guide. CRC Press
10. Felipe Richter Reis (2014). Vacuum Drying for Extending Food Shelf-Life. Springer International Publishing
11. Sueli Rodrigues (2008). Advances in Fruit Processing Technologies. CRC Press
12. M. Angela A. Meireles (2008). Extracting Bioactive Compounds for Food Products Theory and Applications. CRC Press
13. Enrique Ortega-Rivas (2009). Processing Effects on Safety and Quality of Foods. CRC Press
14. N I Lebovka; EugèneVorobiev; FaridChémat (2012). Enhancing Extraction Processes in the Food Industry. CRC Press
15. Y.H. Hui, C. Clary, M.M. Farid, O.O. Fasina, A. Noomhorm, and J. Welti-Chanes (2008). Food Drying Science and Technology. DEStech Publications

FPE 603 Automation and Robotics 2(2+0)

Theory

Rigid-body kinematics, inverse kinematics, newton-euler dynamics of robots, lagrangian dynamics, kane's method in robotics, systems of interacting rigid bodies, trajectory planning for flexible robots, robotic end effectors, sensors, precision positioning of rotary and linear systems, modeling and identification for robot motion control, step motion control by linear feedback methods, force/impedance control for robotic manipulators, robust and adaptive motion control of manipulators, sliding mode control of robotic manipulators, impedance, coordinated motion control of multiple manipulators, robot simulation, geometric vision, interface to virtual environments, flexible robot arms, manufacturing automation, problem solving and case studies.

Suggested Readings

1. Darwin G. Caldwell (2013). Robotics and Automation in the Food Industry: Current and Future Technologies. Woodhead Publishing
2. Yanbo Huang, A. Dale Whittaker, Ronald E. Lacey (2001). Automation for Food Engineering: Food Quality Quantization and Process Control. CRC Press
3. Tom Greeves, C.A. Moore (1995). Automation in the Food Industry. Springer
4. K.P. Sandeep (2011). Thermal Processing of Foods: Control and Automation. Wiley-Blackwell
5. Stephen J. Derby (2005). Design of Automatic Machinery. Marcel Dekker
6. Selwyn Piramuthu and Weibiao Zhou (2015). RFID and Sensor Network Automation in the Food Industry. Wiley-Blackwell

FPE 604 System Analysis and Optimization 3(3+0)

Theory

Analyzing and creating data flow diagram, system development, requirement elicitation techniques, analysis strategies, creating and validating entity relation diagram, system acquisition, analysis of architectural design, hardware and software specification, moving logical models, and optimizing techniques for food plant systems, implementation, local and total optimization, optimization with and without restrictions; Total optimization techniques, Global search algorithms, Genetic Algorithms, Firefly Algorithm, Particle Swarm Optimization, advanced applications of Matlab and other softwares, problem solving and case studies.

Suggested Readings

1. Anatoly Lisnianski, Ilia Frenkel, Yi Ding (2010). Multi-state system reliability analysis and optimization for engineers and industrial managers.
2. Yanbo Huang, A. Dale Whittaker, Ronald E. Lacey (2001) Automation for Food Engineering: Food Quality Quantization and Process Control. CRC Press
3. Edward J. Haug (1984). Computer aided Analysis and Optimization of Mechanical System Dynamics. Springer
4. ThiThi Zin, Jerry Chun-Wei Lin (2019). Big Data Analysis and Deep Learning Applications. Springer
5. Bruce Ratner (2011). Statistical and Machine-Learning Data Mining: Techniques for Better Predictive Modeling and Analysis of Big Data, 2e. CRC Press
6. Ferruh Erdogdu (2008). Optimization in Food Engineering. CRC Press

FPE 605 Food Analytical Techniques 3(1+2)

Theory

Hands on experience on advance methods, equipment and instruments used for analysis of raw material, food products and confirmation of standards. Offline and online assessment of food properties.

Practical

- Practice on UV-Visible, IR, Raman, & Mass spectroscopy. Practice on Fluorescence, Turbidimetric and related techniques. Practice on NMR/ESR spectroscopy.
- Practice on general and advanced chromatographic (HPLC, GC, Paper, TLC/HPTLC, Ion, Flash etc.) techniques.
- Practice on biological techniques such as Electrophoresis, PCR/RTPCR, Immunoassays etc Practice on Immuno based analytical techniques such as ELISA & Lateral flow assay.
- Determination of common adherents, colour, flavours and composition using specified methods.
- Separation of selected biomolecules (protein, colour, amino acids, fat, colour, flavours, peptides, anti / nutritional factors, casein etc) using different techniques.

- Gel-filtration of biomolecules.
- SDS gel electrophoresis and molecular weight determination.
- Measurement of size and zeta potential of colloidal solution or emulsion using dynamic light scattering / particle size analyser.
- Practice on purification of selected biomolecules. Estimation of minerals using AAS.
- Determination of specific and non-specific antimicrobial factors of selected biomolecules. Determination of health benefits of selected biomolecules / products.
- Correlation of offline with online assessment of selected parameters.
- Correlation among industrial, national and international methods of selected concerned parameters.

Suggested Readings

1. Ioannis S. Boziaris (2014). Novel Food Preservation and Microbial Assessment Techniques. CRC Press
2. Lu, Renfu (2016). Light scattering technology for food property, quality and safety assessment. CRC Press

FPE 606 Food Handling and Storage Engineering 3(3+0)

Theory

Recent development in handling and storage. Bulk storage structure, silos, cold storages, CA storages, Modified atmosphere storage, transportation and cold chain systems, handling and storage low and ambient temperatures, during supply chain, codes and standards, problem solving and case studies.

Suggested Readings

1. Raquel Pinho Ferreira Guiné; Paula Maria dos Reis Correia (2013). Engineering Aspects of Cereal and Cereal-based Products. Taylor & Francis
2. Rodolfo H Mascheroni (2012). Operations in Food Refrigeration. CRC Press
3. Mohammed M Farid (2010). Mathematical Modeling of Food Processing. CRC Press
4. José A Teixeira; António A Vicente (2014). Engineering Aspects of Food Biotechnology. CRC Press
5. Theodoros Varzakas, Constantina Tzia (2014). Food Engineering Handbook. CRC Press
6. Saravacos, George D.; Maroulis, Zacharias B. (2011). Food Process Engineering Operations. CRC Press
7. Ron B.H. Wills, John Brett Golding (2015). Advances in Postharvest Fruit and Vegetable Technology. CRC Press
8. Dejmek, Petr; Rayner, Marilyn (2015). Engineering Aspects of Food Emulsification and Homogenization. CRC Press
9. Tzia, Constantina; Varzakas, Theodoros (2016). Handbook of Food Processing: Food Safety, Quality, and Manufacturing Processes. CRC Press

FPE 607 Separation Engineering 3(3+0)

Theory

Recent development in separation processes (absorption, adsorption, extraction, distillation, chromatography, crystallization, flocculation, coagulation and membranes etc), associated material and mass balance, material for construction and interaction with products, resource requirements, design configurations, codes and standards applicable, problem solving and case studies.

Suggested Readings

1. Robert W. Field, Erika Bekassy-Molnar, Frank Lipnizki, Gyula Vatai (2017). Engineering Aspects of Membrane Separation and Application in Food Processing. CRC Press
2. C. D. Holland (1983). Computer Methods for Solving Dynamic Separation Problems. Mcgraw Hill
3. Phillip C Wankat (2012). Separation Process Engineering, 3ed. Prentice Hall
4. Sundergopal Sridhar (2019). Membrane Technology. CRC Press
5. Albert Rushton, Anthony S. Ward, Richard G. Holdich (1996). Solid-Liquid Filtration and Separation Technology. Wiley-VCH.
6. PK Tewari (2016). Nanocomposite Membrane Technology. CRC Press
7. Angelo Basile, Alberto Figoli, Mohamed Khayet (2015). Pervaporation, vapour permeation and membrane distillation: principles and applications. Woodhead Publishing
8. James Dickson, Kang Hu (2015). Membrane Processes for Dairy Ingredient Separation. John Wiley & Sons
9. Eric M. V. Hoek, V. V. Tarabara (2013). Encyclopaedia of Membrane Science and Technology. Wiley
10. Richard V. Levy, Maik W. Jornitz, Maik W. Jornitz (2006). Sterile Filtration. Springer- Verlag Berlin Heidelberg
11. SmainChemat (2017). Edible oils: Extraction, Processing, and Applications. CRC Press

FPE 608 Novel Food Process Engineering 2 (2+0)

Theory

Developments in thermal and non-thermal processes such as HPP, SCFE, cryoprocessing, PSE, cold plasma, ultrasonication, radiofrequency, pulse light, microencapsulation, micro fluidization, spray freeze drying, minimal processing, radiation processing, fermentation, novel sensors etc problem solving and case studies.

Suggested Readings

1. Milan Houška, FilipaVinagre Marques da Silva (2017). High Pressure Processing of Fruit and Vegetable Products. CRC Press
2. N I Lebovka; EugèneVorobiev; FaridChémat (2012). Enhancing Extraction Processes in the Food Industry. CRC Press
3. Passos, Maria Laura; Ribeiro, Claudio P (2016). Innovation in Food Engineering: New Techniques and Products. CRC Press
4. ÖzlemTokusoglu; Barry G Swanson (2014). Improving Food Quality with Novel Food Processing Technologies. CRC, Taylor and Francis

5. Tatiana Koutchma (2014). Adapting High Hydrostatic Pressure (HPP) for Food Processing Operations. Academic Press
6. K. ShikhaOjha, Brijesh K. Tiwari (2016). Novel Food Fermentation Technologies. Springer International Publishing
7. MohdSyaifudin Abdul Rahman, Subhas Chandra Mukhopadhyay, Pak-Lam Yu (2014). Novel Sensors for Food Inspection: Modelling, Fabrication and Experimentation. Springer International Publishing
8. Ioannis S. Boziaris (2014). Novel Food Preservation and Microbial Assessment Techniques. CRC Press
9. M. Angela A. Meireles (2008). Extracting Bioactive Compounds for Food Products Theory and Applications. CRC Press.
10. Enrique Ortega-Rivas (2009). Processing Effects on Safety and Quality of Foods. CRC Press.

FPE 609 Design of Packaging System 2(2+0)

Theory

Compatibility of packaging material with products, designing of unit and bulk package, developments in smart, intelligent and active packaging, continuous packaging systems for liquidand food, recent development in testing of packaging material and interaction, migrations study, edible packaging, process friendly packaging, shelf life assessment, codes and standards, problem solving and case studies.

Suggested Readings

1. Raija Ahvenainen (2003). Novel Food Packaging Techniques. CRC Press
2. Otto G. Piringer, A. L. Baner (2008). Plastic Packaging: Interactions with Food and Pharmaceuticals, 2e. Wiley-VCH
3. Otto G. Piringer, A. L. Baner (2000). Plastic Food Packaging Materials: Barrier Function, Mass Transport, Quality Assurance, Legislation. Wiley-VCH
4. Aaron L. Brody (2001). Active Packaging for Food Applications. CRC Press
5. Da-Wen Sun (2000). Handbook of Frozen Food Processing and Packaging. CRC Press
6. Cerqueira, Miquel Angelo (2015). Edible Food Packaging: Materials and Processing Technologies. CRC Press
7. Gordon L. Robertson (2009). Food Packaging and Shelf Life A Practical Guide. CRC Press
8. Howard R. Moskowitz, M. Reisner, John B. Lawlor, R. Deliza (2009). Packaging Research in Food Product Design and Development. Wiley-Blackwell
9. RinusRijk, Rob Veraart (2010). Global Legislation for Food Packaging Materials. Wiley-VCH Contemporary Food Engineering Series of CRC Press

Food Safety and Quality

Course Title with Credit load M. Tech. in Food Safety and Quality

Minimum Credit Hours

i. Course Work	
Major Courses	20
Minor Courses	08
Supporting Courses	06
Common Course	05
Seminar	01
ii. Thesis Research	30
Total	70

i. Course Work

Major Courses

S. No.	Course Title	Course No.	Credits
1	Techniques in Food Quality Analysis*	FSQ 501	4(2+2)
2	Microbiology of Food Spoilage and Pathogens*	FSQ 502	3(2+1)
3	Advanced Food Chemistry	FSQ 503	3(2+1)
4	Global Food Laws and Regulations	FSQ 504	2(2+0)
5	Food Safety Management Systems and Certification	FSQ 505	2(2+0)
6	Process and Products Monitoring for Quality Assurance	FSQ 506	2(2+0)
7	Quality Concepts and Chain Traceability*	FSQ 507	2(2+0)
8	Management of Food By-products and Waste	FSQ 508	3(2+1)
9	Special Problem / Summer Internship	FSQ 509	2(0+2)
10	Toxicology of Food Ingredients and Products	FSQ 510	3(2+1)
11	Food Plant Utilities and Sanitation	FSQ 511	2(2+0)
12	Advances in Food Biotechnology	FSQ 512	4(2+2)
13	Fundamentals of Microbial Controls in Foods	FSQ 513	4(2+2)

* Compulsory

Rest of the courses will be decided by the students advisory committee keeping the minimum limits set for award of degree.

Minor Courses

S. No.	Title	Course No	Credits
1	Emerging Technologies in Food Packaging	FPT 502	2(2+0)
2	Industrial Manufacturing of Food and Beverages	FPT 503	3(2+1)
3	Food Material and Product Properties	FPT 504	3(2+1)
4	Food Ingredients and Additives	FPT 514	3(2+1)
5	Aseptic Processing and Packaging	FPT 510	3(2+1)
6	Engineering Properties of Food Materials	FPE 502	3(2+1)
7	Bioprocessing and Down Stream Engineering	FPE 504	3(2+1)
8	Numerical Technique and Stimulation	FPE 506	2(1+1)
9	Food Safety and Storage Engineering	FPE 508	3(2+1)

Supporting Courses

S.No.	Title	Course No	Credits
1	Research Methodology	BSH 501	2(2+0)
2	Food Informatics	BSH 502	2(2+0)
3	Post-Harvest Management	FBM 501	3(2+1)
4	Food Business Management	FBM 502	2(2+0)
5	Food Processing Entrepreneurship and Start up	FBM 503	2(1+1)
6	Energy Management and Auditing in Food Industry	FPE 505	3(2+1)
7	Operation Research	FPE 510	3(2+1)

Common Courses

S. No.	Course Title	Credits
1	Library and Information Services	1
2	Technical Writing and Communications Skills	1
3	Intellectual Property and its Management in Agriculture	1
4	Basic Concepts in Laboratory Techniques	1
5	Agricultural Research, Research Ethics and Rural Development Programmes	1
These courses are available in the form of e-courses/MOOCs. The students may be allowed to register these courses/similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/she may be permitted to register for other related courses with the prior approval of the HoD/BoS.		

Seminar

S. No.	Course Title	Course No.	Credits
1	Seminar	FSQ 599	1(1+0)

ii **Thesis Research**

S. No.	Course Title	Course No.	Credits
1	Masters Research	FSQ 555	30(0+30)

Course Contents

FSQ 501 Techniques in Food Quality Analysis 4 (2+2)

Theory

UNIT I

Sampling Procedures, Calibration and Standardization: Sub- sampling and its procedures, LOD, LOQ, Internal standards, Reference standards and certified reference materials. Spectroscopy techniques: Operation, calibration and standardization procedures as applicable to particular technique. Principles and applications of pH Meter, Digital analyzer, Auto-analyzer, Ultraviolet- visible spectroscopy (UV-VIS), Infra-Red, Fourier-Transform Infrared Spectroscopy (FTIR), Near Infra-Red (NIR), Atomic Absorption spectroscopy (AAS).

UNIT II

Chromatography Techniques: Principles, Components and applications of (i) Paper Chromatography-Ascending and Descending-One dimensional & Two-dimensional (ii) Thin layer chromatography (iii) Ion Exchange (iv) GC (v) GLC (vi) HPLC (vii) HPTLC (viii) GCMS (ix) LCMS (x) Amino acid Analyzer

UNIT III

Separation Techniques: Dialysis, Gel filtration, Electrophoresis: Principles, components and applications of (i) Paper (ii) Starch (iii) Gel (iv) Agar-gel (v) Polyacrylamide gel (vi) Moving boundary (vii) Immuno electrophoresis. Centrifugation: Types of centrifuge – Ordinary and Ultracentrifuge-Principle and applications.

UNIT IV

Principle, Components and Applications of (i) Differential scanning calorimetry (DSC) (ii) Thermogravimetric analysis (TGA) (iii) Isothermal microcalorimetry (IMC) (iv) Thermomechanical analysis (TMA) (v) Isothermal titration caloritmetry (ITC) (vi) Dynamic elemental thermal analysis (DETA) (vii) Nuclear magnetic resonance (NMR) (viii) Scanning electron microscopy (SEM) (ix) Transmission electron microscopy (TEM) (x) X-ray diffraction technique (XRD) (xi) Rapid visco-analyzer (xii) Texture analyzer and (xiii) Micro-dough lab.

UNIT V

Sampling for microbial analysis, Quantitative methods for enumeration of microorganisms in foods, Methods for isolation of microorganisms in foods, Rapid detection of microorganisms using molecular biological tools, immunoassays and biosensors.

Practical

- Analysis and characterization of pigment in fruits by UV-VIS.
- Characterization of starches by FTIR spectroscopy.

- Assessment of microstructure of food components by SEM/Reviewing a micrograph obtained through SEM
- Study of thermal denaturation of proteins and food enzymes by DSC.
- Quantization of allergenic proteins by LCMS.
- Separate and identification of pesticides in food samples by HPLC.
- Identification and molecular characterization of proteins by SDS-PAGE.
- Quantization of lipids and fatty acids using TLC.
- Assessment of pasting properties of starches and flours/flour-blends using RVA.
- Analysis of textural properties of food products with texture analyzer.
- Comparative rheological study of wheat flour samples of different varieties.
- Differential thermal analysis (DTA) and Thermogravimatric Analysis of a food samples
- A rapid, visual demonstration of protein separation by gel filtration chromatography.
- Amino acid profiling of food samples
- Detection of food borne pathogens using RT-PCR
- Rapid detection of microorganisms using ELISA

Suggested Readings

1. Ongkowijoyo P, Luna-Vital DA, de Mejia EG (2018) Extraction techniques and analysis of anthocyanins from food sources by mass spectrometry: An update Food chemistry.
2. Trimigno A, Marincola FC, Dellarosa N, Picone G, Laghi L (2015) Definition of food quality by NMR-based foodomics, Current Opinion in Food Science 4:99-104.
3. Pare, J. R. J. and Bélanger, J. M. R. (2015). Instrumental Methods of Food Analysis: Elsevier.
4. Alejandro Cifuentes (2012) Food Analysis: Present, Future, and Foodomics, ISRN Analytical Chemistry.
5. Skoog, D. A., Holler, F. J. and Nieman, T. A. (1998). Principles of Instrumental Analysis (5 Ed.): Harcourt, Singapore.

FSQ 502 Microbiology of Food Spoilage and Pathogens 3 (2+1)

Theory

UNIT I

Food Borne Pathogens, Host Invasion, Pathogenesis, Significance to public health Food hazards and risk factors, Pathogenic foodborne microorganisms – Salmonella, Pathogenic *Escherichia coli* and other *Enterobacteriaceae*, *Staphylococcus aureus, Listeria monocytogenes, Clostridium botulinum, Clostridium perfringens* and *Bacillus cereus* Other Gram-positive pathogens, *Campylobacter, Brucella, Aeromonas, Vibrio cholerae, Mycobacterium, Shigella*.

UNIT II

Fungal and viral food-borne disorders, Food-borne important animal parasites, Mycotoxins, Incidence and behavior of microorganisms in meat, poultry, milk and milk products, fresh agro produce, sea foods

UNIT III

Controlling pathogens and microbial toxin via food processing, Microbial growth and shelf life, Modeling of microbial growth, Safety concerns of food processed through non thermal processing, management of microbial risk and toxin in foods through HACCP, Risk in antimicrobial nano materials, Risk assessment and predictive modeling

UNIT IV

Molecular approaches for detection and identification of food borne pathogens, Enzyme Immunoassay (EIA), Enzyme-linked immunosorbent assay (ELISA), Radioimmunoassay (RIA) - instrumentation and applications of each immunoassay technique. DNA: DNA purification, DNA Fingerprinting. PCR/RTPCR (Real time) based analysis and sequencing, Biosensors, Recombinant DNA technology; Microchip based techniques, cDNA and genomic libraries, immunochemical techniques.

UNIT V

Important factors in microbial food spoilage, Spoilage of specific food groups, New food spoilage bacteria in refrigerated foods, Indicators of microbial food spoilage.

Practical

- Preparation of common laboratory media and special media for cultivation of bacteria, yeast & molds.
- Isolation and identification of pathogens.
- Coliforms analysis of milk and water samples.
- Identification tests for bacteria in foods: IMVIC urease, catalase, coagulase, gelatin and fermentation (acid/gas).
- Determination of thermal death characteristics of bacteria.
- Determination of DNA and RNA of spoilage microorganism using PCR.
- Detection of DNA of trace components allergens, like nuts using ELISA.
- DNA/RNA based microarray experiment.
- Demonstration of DNA fingerprinting.
- Determination of growth and activity of microorganisms in incubator.
- Determination of preservatives and food colours using Biosensor.
- Process time calculation for an indicator organism
- Microbes responsible recall – case studies.

Suggested Readings

1. Ray, B., and A. Bhunia. 2007. Fundamental Food Microbiology, 4th Ed. CRC Press, Boca Ratan, FL.
2. Food and Drug Administration. Food-Borne Pathogenic Microorganisms and Natural Toxins Handbook: The Bad Bug Book.
3. Fratamico PM, Bhunia AK & Smith JL. 2005. Food-Borne Pathogens: Microbiology and Molecular Biology. Caister Academic Press.
4. Vijay K. Juneja, Hari P. Dwivedi, John N. Sofos Editors, 2017, Microbial Control and Food Preservation - Theory and Practice, Springer
5. Ronald H. Schmidt and Gary E. Rodrick 2013 Food Safety Handbook Wiley

FSQ 503 Advanced Food Chemistry 3 (2+1)

Theory

UNIT I

Composition, nutritional and functional value of food: Water activity and sorption phenomenon, Engineered foods and influencing water activity and shelf-life; Chemical reactions of carbohydrates– oxidation, reduction, with acid & alkali; Maillard reaction, Caramelization, Ascorbic acid oxidation, Resistant Starch, Soluble and Insoluble fibre, Pigments and approaches to minimize the impact of food processing, Molecular Mobility.

UNIT II

Structure and Properties of proteins; electrophoresis, sedimentation, amphoterism, denaturation, viscosity, gelation, texturization, emulsification, foaming, protein-protein and other interactions in food matrix; Lipids: melting point, softening point, smoke, flash and fire point, turbidity point, polymorphism and polytypism; polymerization and polymorphism, flavor reversion, auto- oxidation and its prevention, fat in food matrix like fat globule in milk, PUFA, MUFA, CLA, ù - fatty acids, trans fatty acids, phytosterol, etc.

UNIT III

Description of food flavours; Flavour enhancers, Food acids their tastes and flavours, Principles and techniques of flavour encapsulation, types of encapsulation; Factors affecting stabilization of encapsulated flavour and their applications in food industry.

UNIT IV

Processing and packaging induced chemicals and their control – acrylamide, nitrosamines, carcinogenic and genotoxic chlorpropanols such as 3-monochloropropane-1,2 diol (3-MCPD), PAHs (in grilled and smoked products), dioxine, histamine, ethyl carbamate, furan, bisphenol A or phthalates from plastic materials, microplastics, 4-methylbenzophenone and 2- isopropylthioxanthone from inks, mineral oil from recycled fibers or semicarbazide from a foaming agent in the plastic gasket.

Practical

- Estimation of protein content in food samples using spectroscopic methods
- Study of effect of heat on protein denaturation using enzymes
- Study of effect of various salt solutions on solubility of proteins
- Separation of milk proteins by salting out method
- Separation of proteins using chromatographic methods
- Fractionation of proteins
- Extraction and purification of essential oil/ flavoring compound of a natural source
- Study the process of starch retrogradation, gelatinization and modification
- Estimation of crude and dietary fibres in given food sample
- Analysis of resistant starches

- Estimation of various antioxidants, polar compounds and free fatty acids in frying oils
- Extraction and purification of natural plant pigment
- Functional properties and isoelectric point of proteins
- Qualitative and quantitative evaluation of processing and packaging induced chemicals
- Qualitative identification of different flavoring compounds

Suggested Readings

1. O.R. Fennema, Ed., (2008). Food Chemistry, Marcel and Dekker, Inc., New York, NY.
2. Belitz, H. D., Grosch, W., & Schieberle, P. (2009). Food chemistry. Springer.
3. Peter Varelis, Laurence Melton and Fereidoon Shahidi (2019). Encyclopedia of Food Chemistry. Elsevier.
4. Cheung, Peter C. K., Mehta, Bhavbhuti M. (2015) Handbook of Food Chemistry. Springer

FSQ 504 Global Food Laws and Regulations 2 (2+0)

Theory

UNIT I

International Plant Protection Convention, world organization for animal health (OIE), sanitary and phytosanitary measures (SPS), Codex Alimentarius, FAOLEX, OECD Agriculture and Fisheries, International Trade Centre's Standards Map, FAO Food safety and quality emergency Prevention, JFSCA, Fundamental Principles of food safety governance, Risk Analysis as a Method to Determine the Regulatory Outcome, Increasing Responsibility of Businesses (Private) Risk Assessors, Concept of harmonization of global food laws,

UNIT II

EU Food Safety Standards - Regulation 178 of 2002, The European food safety authority (EFSA), A critical overview of the EU food safety policy and standards, COMESA Food Safety Standards - An overview, Case Studies in Food Safety Standards in EU-COMESA Trade, Private voluntary standards (PVS) and EU food safety standards, FDA Food safety modernization Act (FSMA), FSPCA Preventive Controls for Human Food, Foreign Supplier Verification Programs (FSVP), Food Facility Registration, FDA - Current Good Manufacturing Practices (CGMPs)

UNIT III

Hazard Analysis & Critical Control Points (HACCP) guidelines, Foreign Food Facility Inspection Program, International and Interagency Coordination, Registration of Food Facilities, Seafood Imports and Exports, Regulation on GM Foods Regulations on Irradiated foods, Global Regulations on Health Foods, International Law on Adequacy of thermal processing, Grain Fumigation for Export, Law of trading horticultural Products, Safety Frame Applied to Food Applications of Nanotechnology.

UNIT IV

Review of Indian Regulatory Scenario in Food and Food Products - Food Safety and Standards (FSS) Act, 2006, FSS Rules and Regulations, Agricultural Produce Act, 1937 (Grading and Marketing), Export (Quality Control & Inspection), Act, 1963 and Rules, Bureau of Indian Standards relevant to food safety, Legal Metrology Act, International Food Control Systems/ Laws

Suggested Readings

1. Onsando Osiemo, 2018, Food Safety Standards in International Trade: The Case of the EU and the COMESA, CRC
2. Andrea Barrios Villarreal, 2018, International Standardization and the Agreement on Technical Barriers to Trade, Cambridge University Press
3. Bernd Meulen, Harry Bremmers, Kai Purnhagen, Nidhi Gupta, Hans Bouwmeester L. and Leon Geyer, 2014, Governing Nano Foods: Principles-Based Responsive Regulation
4. Understanding the Codex Alimentarius, 3rd ed., 2006.
5. JessicaVapnek and Melvin Spreij, 2005, Perspectives and guidelines on food legislation, with a new model food law for the Development Law Service FAO Legal Office
6. US FDA Website
7. European Food Safety Authority (EFSA) website

FSQ 505 Food Safety Management Systems and Certification 2 (2+0)

Theory

UNIT I

Food safety management systems and its requirements for any organization in the food chain, Block chain concept, Global food safety initiative (GFSI), PAS 220, Prerequisite programs on food safety for food manufacturing, Audits: Introduction, objectives, documentation, responsibilities.

UNIT II

Food safety plan overview, Good manufacturing practices and other prerequisite programs, GAP and GMP, Preliminary Steps in Developing a food safety plan, Resources for food safety plans, HACCP, TACCP and VACCP.

UNIT III

Biological/ Chemical/ Physical and Economically motivated food safety hazards, Process preventive controls, Food allergen preventive controls, Sanitation preventive controls, supply chain preventive controls, verification and validation Procedures, Record Keeping Procedures, Recall Plan

UNIT IV

FSMS and FSSC 22000. ISO 22003, ISO 20005 and traceability in food chain, ISO 14000 series – certification and its importance, ISO 17025 - General requirements for the competence of testing and calibration laboratories, BRC Standard, BRC Storage and Distribution, SQF, Southern Rocklobster Seafood, Retailer programs like Woolworths, Coles, Costco and ALDI, Concept of Auditing.

Suggested Readings

1. Erasmo Salazar, 2013, Understanding Food Safety Management Systems: A Practical Approach to the Application of ISO-22000:2005, Create Space Independent Publishing Platform.

2. ISO 22000 Standard Procedures for Food Safety Management Systems, 2008, Bizmanualz, Inc.
3. Mike Dillon and Chris Griffith (ed), 2001 Auditing in the food industry - From safety and quality to environmental and other audits, CRC Press
4. Alli, Inteaz, 2003, Food Quality Assurance: Principles and Practices, CRC Press
5. Respective certification documents

FSQ 506 Process and Products Monitoring for Quality Assurance 2 (2+0)

Theory

UNIT I

Variability of the Production Process - Control chart of the middle values and ranges, Medians and ranges, Middle values and standard deviations, Largest and smallest selected value and other individual values.

UNIT II

Automation of the Control of Production Processes, Fluorescence cytometry for the rapid analysis of food microorganisms, Infrared spectroscopic methods,

UNIT III

Machine vision for the food industry, Ultrasonic methods, Sampling procedures for on line quality

UNIT IV

Evaluation the Capability of Production Process and Machine, Chemical sensors RFID, Analysis of the Current State of the Regulation of Manufacturing Processes

Suggested Readings

1. Process Monitoring and Improvement Handbook, Second Edition 2018 by Manuel E. Peña-Rodríguez, ISBN: 978-0-87389-974-1
2. Food Process Monitoring Systems 1993 by Pinder, A.C., Godfrey, G., Springer

FSQ 507 Quality Concepts and Chain Traceability 2 (2+0)

Theory

UNIT I

Quality – Concepts, Quality as winning strategy, Total quality management TQM: Introduction, definitions and principles of operation, Tools and Techniques, such as, quality circles, 5 S Practice, Total quality control (TQC), Total employee involvement (TEI), Problem solving process, Quality function deployment (QFD), Failure mode and effect analysis (FMEA), Fault Tree Analysis (FTA), Kizen, Poka-Yoke, QC Tools, PDCA Cycle, Quality Improvement Tools, TQM implementation and limitations, JH – Autonomous maintenance

UNIT II

Introduction, Content, Methods, Advantages and Limitation of: Just –in –Time and Quality Management KANBAN system, Total productive maintenance (TPM), QS 9000. Basic concept, Principle, methodology of contemporary trends: Lean manufacturing, Agile manufacturing, World class manufacturing, Concurrent engineering, Bench marking, Cost of quality (COQ) system.

UNIT III

Reliability engineering fundamentals; Failure data analysis; Failure rate; mortality curve; Concept of burn in period; Useful life and wear out phase of a system; Mean time to failure (MTTF); Mean time between failure, (MTBF) and mean time to repair (MTTR); Reliability in terms of Hazard rate and failure density, Measurement systems analysis for accuracy, Probability for quality.

UNIT IV

SQC -Statistical quality control– X / R / p and c chart, Shewhart and types of control charts, Process capability analysis, process capability index. Acceptance sampling by variables and attributes, design of sampling plans, single, double, sequential and continuous sampling plans, design of various sampling plans for food industry (Note: SQC tables can be used in the examination), Capability analysis. Statistical process control.

UNIT V

Traceability in food safety management, Applications of traceability, Traceability challenges, Traceability requirements and standards: ISO 22005, Traceability implementation & application: Traceability data & process flow, Traceability process participants, Traceable item, Batch/Lot and Traceability links management, Food authenticity tools.

Suggested Readings

1. Montgomery, Jennings and Pfund, 2010, Managing, Controlling and Improving Quality, Wiley
2. K C Arora, 2016 (4th Edition), Total Quality Management, S K Kataria & Sons Pub
3. Eugene L. Grant and Richard S. Leavenworth,7th Ed 1996, Statistical Quality Control, McGraw- Hill

FSQ 508 Management of Food By-products and Waste 3 (2+1)

Theory

UNIT I

Management of Food Waste, Principles of sustainable systems and Green chemistry, Waste management purpose and strategies, Waste & its consequences in pollution and global warming, Food waste classification, Mitigation measures for food processing wastes, Food waste Handling and Management laws – National and international.

UNIT II

Approaches to Solid Waste Management - Bio gas and electricity generation, Bioactive compounds extraction, Sourcing natural colour, Valorization, Biofueling, Biofertilizers, Bio- ethanol, Activated carbon, Biochar, other biological approaches, Use for biodegradable plastic, biofertilizers and environmental bioremediation.

UNIT III

Approaches to Effluent Waste Management Basic unit operations in wastewater treatment, Anaerobic digestion of organic residues and wastes, Fundamentals and applications of anaerobic digestion for sustainable treatment of food industry wastewater, Effluent treatment strategies for dairy / brewery / winery, Common biological treatment processes and on-site treatment systems.

UNIT IV

Case studies, commercially viable practices and success stories of value-added products of waste and by-products from processing of different plant and animal food products, Food waste for pulp & paper, flavorings and aromas production

Practical

- Study of waste utilisation processes by site visit / site plan studies
- Characterization of effluent for Dissolved solids (TDS), Suspended solids, BOD, COD, Nitrogen (as N), Phosphorus (as P), Alkalinity (as CaCO3), Sulphate (as SO4), Total organic carbon (TOC)
- Characterization of food waste as feedstock for anaerobic digestion
- Various treatments in use for waste disposal: study on operational precautions;
- Extraction of banana fibre,
- Utilisation of ghee residue in caramel toffee;
- Extraction of volatile oils from organic waste;
- Use of fruit/vegetable residue for the production of cellulose;
- Use of mango kernels for manufacturing of starch;
- Production of pectin/citric acid from organic waste

Suggested Readings

1. Wastewater treatment and use in agriculture - FAO irrigation and drainage paper 47, http://www.fao.org/docrep/t0551e/t0551e00.htm#Contents
2. Waste Biomass Valor (2017) 8:2209–2227 DOI: 10.1007/s12649-016-9720-0
3. Guillermo et. al. A Methodology for Sustainable Management of Food Waste 2017, Waste and Biomass Valorization, Volume 8, Issue 6, pp 2209–2227
4. Agricultural Waste Management Systems, Chapter 9, USDA Agricultural Waste Management Field Handbook https://directives.sc.egov.usda.gov/OpenNonWeb Content.aspx? content=31493. wba
5. Oreopoulou, Vasso, Russ, Winfried (Eds.) Utilization of By-Products and Treatment of Waste in the Food Industry, 2007, Springer
6. Anil Kumar Anal (Editor), 2017, Food Processing By-Products and their Utilization, Wiley-Blackbell

FSQ 510 Toxicology of Food Ingredients and Products 3 (2+1)

Theory

UNIT I

General Concepts in Food Toxicology: Definitions, General principles of food toxicology, Toxicology terminologies – Acute, Subacute, Subchronic and Chronic toxicity and other important terminologies; Classification of toxicants, Food Allergy, Food Toxicity, Food Idiosyncrasy, Common food adulterants, Risk assessment, Common techniques for identification/quantification of food toxins, LD50 and LC50 oral-dermal-inhaled, feeding trials and in vitro tests for toxicology.

UNIT II

Toxicology of Food additives: Food additives toxicity, Safety Determination of direct and Indirect Food Additives, Acceptable daily intake (ADI), estimated daily intake (EDI), Interaction in food matrix, Evaluation of new and emerging ingredients, Toxicological Study Requirements as per FSSAI for the approval of non-specified foods/food ingredients,

UNIT III

Toxicants and contaminants in food: algal toxins, plant toxins and anti-nutrients, dietary estrogens and antiestrogens, Inherent toxins & allergens, process induced toxicants, toxins from packaging, fumigants, safety challenges in of genetically engineered foods, pesticides, heavy metals, carcinogens, polycyclic aromatic hydrocarbons etc.,

UNIT IV

Nutraceuticals and functional foods: toxicity and toxicological clearance from regulator, Interactions of prescription drugs, food, alcohol and nutraceuticals. National and international regulatory aspects of health foods and nutraceuticals.

Practicals

- Determination of trypsin inhibitors in legumes
- Estimation of phytates/oxalates in cereals/legumes
- Determination of Acrylamide and 5-hydroxymethylfurfural formation in reconstituted potato chips during frying
- Determination of Hydroxy methyl furfural in Baby Foods
- Metals and toxic Metals e.g. Cd, Hg etc.
- Pesticide residues e.g. Dioxin, Aldrin, Malathion etc.
- Mycotoxins, Argemone, Khesari dal, Ergot, Karnal bunt, Dhatura, etc.
- Allergens, Antibiotic & hormone residues, Veterinary drug res idue,
- Other new contaminants and toxins (For example: Cyclopiazonic acid in Buckwheat flour)
- Determination of Naturally Occurring Toxic Substances (NOTS) and Deoxynivalenol (DON)
- Elisa for toxins and allergens

Suggested Readings

1. Introduction to Food Toxicology: By Takayuki Shibamoto and Leonard F. Bjeldanes. 2nd edition; Academic Press

2. Safety evaluation of certain contaminants in food, WHO Food Additives Series: 63, FAO JECFA Monographs 8, http://www.fao.org/3/a-at881e.pdf
3. Chapter 30: Food Toxicology. In Casarett and Doull's Toxicology: The Basic Science of Poisons by Curtis D. Klaassen. 8th edition; McGraw-Hill Medical Publishing Division
4. Food Toxicology: Current Advances and Future Challenges by Ashish Sachan, Suzanne Hendrich, 2017, Apple Academic Press
5. Food Toxicology by Debasis Bagchi, Anand Swaroop, 2016, CRC Press
6. General Standard For Contaminants and Toxins in Food and Feed (CODEX STAN 193-1995) Amended up to 2015,www.fao.org/input/download/standards/17/CXS_193e_ 2015.pdf

FSQ 511 Food Plant Utilities and Sanitation 2 (2+0)

Theory

UNIT I

General principles of food plant Design and layout, CIP system, sanitizers used in food industry. Personnel hygiene and assessment of surface sanitation by swab and rinse method

UNIT II

Sanitation of coolers/chillers/freezers, Design of warehouses, conventional & modern storage structures for fruits, vegetables, meat and marine products, pest and rodent control

UNIT III

Waste disposal for Food Plant Hygiene and Sanitation, ETP design and layout, Food hygiene and safety in transportation, with a focus on warehouse storage and refrigerated ships, Process water quality and treatments at plant level, Process plant sanitation - chemistry and water in CIP

UNIT IV

Preparation of a sanitation schedule for food preparation area, testing of sanitizers and disinfectants, Steam generation and performance, Boiler operation, forced and induced draught. Flue gas composition and performance analysis, Process air generation, air requirement & supply system. Air Moving and vacuum equipment, Power supply system for food process plants and plant earthing.

Suggested Readings

1. Norman G. Marriott and Robert B. Gravani. (2006). Principles of Food Sanitation, 5th edition
2. Rao, D. G. (2010). Fundamentals of Food Engineering, PHI learning Private Ltd.
3. James A (2013) The supply chain handbook, distribution group.
4. FAO, US (1984) Design and operations of cold store in developing.

FSQ 512 Advances in Food Biotechnology 4 (2+2)

Theory

UNIT I

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, Strain improvement, techniques.

UNIT II

Introduction to enzyme, Characteristics of enzyme, Food applications of enzymes; amylases, proteases, lipase, pectinase, celluloses, glucose oxidase. Microencapsulation of enzyme/probiotics.

UNIT III

Fermentation processes, fermentation processes of: alcohol and organic acids, Amylases, protease, lipase, bacteriocins,

UNIT IV

Functional and nutraceuticals, supplementation/fortification of bioactive peptides and other functional ingredients, nutrigenomics.

UNIT V

Application of molecular tools, PCR, RT-PCR, biosensors etc. for the detection of pathogens.

Practicals

- Demonstration of fermenter
- To carry out fermentation of amylase enzyme
- Introduction to enzyme purification techniques
- To carry out quantitative estimation of amylase
- To carry out enzyme assay of invertase
- Demonstration of enzyme immobilization
- Determination of stability of enzyme at different temperature, pH
- Extraction and clarification of juices using enzymes
- Introduction to microbial isolation techniques
- Detection of food borne pathogen by conventional microbiological method
- Microencapsulation of probiotics and study of their viability
- Isolation of genomic DNA
- Agarose gel electrophoresis
- DNA amplification by using PCR
- RT PCR for pathogen detection
- 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.

FSQ 513 Fundamentals of Microbial Controls in Foods 4 (2+2)

Theory

UNIT I

Introduction

Introduction: scope of food microbiology Microorganisms important in food industry Types of microorganisms, their importance in foods, classification of food borne bacteria, their morphology and distinguishing features with examples.

UNIT II

Growth of microorganisms in foods

Intrinsic (pH, moisture content, redox potential, nutrient content, antimicrobial constituents and biological structures) and extrinsic factors (temp., RH, presence and concentration of gases) governing growth of microorganisms in food.

UNIT III

Food Preservation:

Principles of preservation, methods of food preservation – high temperature, low temperature, drying, radiation, chemical preservatives, bio-preservatives, hurdle technology, active packaging, novel processing technologies.

UNIT IV

Special topics in safety:

Microbial attachment and biofilm formation, microbial metabolism of food components, food preservatives of microbial origin, bacteriocins and nanotechnology, food spoilage by microbial enzymes, opportunistic bacterial pathogens, molds and mycotoxins, viruses, parasites, fish and shell fish toxins.

Practicals

- Methods of sampling.
- Concept of shelf life of different foods
- To study the concept of asepsis and sterilization
- Determination of pH of different foods using pH meter.
- Study quality characteristics of foods preserved by drying.

- Study quality characteristics of foods preserved by dehydration.
- Study quality characteristics of foods preserved by freezing.
- To perform pasteurization of fluids using different methods.
- To perform blanching of different plant foods.
- To study the thermal destruction curve.
- Industrial Visits

Suggested Readings:

1. Fundamental Food Microbiology, Arun Bhunia Bibek Ray, CRC Press
2. Modern Food Microbiology, JM JAY, APAC
3. Microbiology of Safe Food, S J Forsythe, Blackwell Science
4. Microbiology of foods, J C Ayres, J O Mundt, W E Sandine, W H Freeman Elsevier

Course Title with Credit load Ph.D. in Food Safety and Quality

Minimum Credit Hourse

i. Course Work	
Major Courses	12
Minor Courses	06
Supporting Courses	05
Seminar	02
ii Thesis Research	75
Total	100

Major Courses

S. No.	Title of Subjects	Course No	Credits
1.	Food Quality and Safety Assessment	FSQ 601	3(1+2)
2.	Food Toxicology and Risk Assessment	FSQ 602	3(3+0)
3.	Quality Assurance in Food Supply Chain	FSQ 603	3(3+0)
4.	Formulation of standards of Food Products, Packaging and Labeling	FSQ 604	2(2+0)
5.	Food and Nutraceutical Chemistry	FSQ 605	3(3+0)
6.	Food Microbiology and Safety	FSQ 606	3(3+0)
7	Sensory Evaluation of Foods	FSQ 607	2(1+1)
8	Special problem	FSQ 608	2(0+2)
Minor Courses			
1	Novel Technologies for Food Processing and Shelf Life Extension	FPT 601	3(3+0)
2	Food Process Modeling and Scale up	FPT 605	3(3+0)
3	Concentration and Drying Engineering	FPE 602	3(3+0)
4	Food Handling and Storage Engineering	FPE 606	3(3+0)

Supporting Courses			
1	Post-Harvest Management	FBM 501	3(2+1)
2	Food Business Management	FBM 502	2(2+0)
3	Operation Research	FPE 510	3(2+1)
Seminars			
1	Seminar I	FSQ 698	1(1+0)
2	Seminar II	FSQ 699	1(1+0)
Thesis Research			
1	Doctoral Research	FSQ 666	75(0+75)

FSQ 601 Food Quality and Safety Assessment 3 (1+2)

Theory

Physical quality - Advances in Quantitative Evaluation of Physical Characteristics of Food as an indicator of quality, modern approaches for colour, texture and microstructure of food

Chemical Quality - Advances in instrumentation used for chemical analysis of foods and methods developed for rapid analytical methods, modern non-destructive testing methods, newer biomarkers for food authenticity, and approaches for using an analyte protectant in gas chromatographic analysis. Review of recent updates on the chemical safety threats such as contaminants from agrochemicals, process, packaging materials and environment.

Biological Quality - Updates in molecular biological approaches for rapid detection, Relevance of metabolomics, transcriptomics and proteomics in food analysis and quality evaluations and current food industry applications, Emerging microbial and other macro-biological threats for foods: mitigation and detection.

Practicals

- Lab exercises on food microstructures
- Food authentication, newer approaches in food analysis
- Complex culture isolation and identification
- Molecular methods to detect pathogens
- Individual exercise on design of experiments in food analysis and inter learner parity.
- Protein based detection of genetic modification ingredient
- Detection of 3-monochloropropane-1,2-diol (MCPD) esters, mineral oil saturated hydrocarbons (MOSH) or mineral oil aromatic hydrocarbons (MOAH), or polyfluorinated alkyl substances (PFAS)
- Species differentiation in meat - tryptic digestion of myosine by LC-MS/MS

Suggested Readings

1. J Sofos.2013. Advances in Microbial Food Safety, 1st Edition, Woodhead Publishing.
2. Jian Zhong.2019. Evaluation Technologies for Food Quality.
3. Steven C. Ricke, Janet R Donaldson, Carol A Phillips,2015. Food Safety: Emerging Issues, Technologies and Systems.

FSQ 602 Food Toxicology and Risk Assessment 3 (3+0)

Theory

Review of natural origin or processing induced toxicants and indirect additives: pesticides, pesticide residues, metallic contamination, radionuclides, other adulterants; Contemporary approaches for safety of genetically engineered foods, Advances in In-vitro toxicological analysis of foods, Novel approaches to derive points of departure for food chemical risk assessment.

Biomarkers in Epidemiology: Risk assessment and regulatory toxicology, Role of biomarkers for the evaluation of dietary ingredients; Nutriphenomics in rodent models: impact of dietary choices on toxicological biomarkers. Challenges in safety assessment of food packaging materials: Use of new/improved tools and exposure assessment models, Computational toxicology and risk assessment.

Suggested Readings

1. Ramesh C. Gupta. Biomarkers in Toxicology
2. Food Toxicology. W. Helferich and C. K. Winter (Ed.), CRC Press, London. ISBN 0-8493-2760-1
3. Toxicology and Risk Assessment,1st Edition, Anna M. Fan, George Alexeeff, Elaine Khan

FSQ 603 Quality Assurance in Food Supply Chain 3 (3+0)

Theory

Modern food safety risk analysis and management, Food defense plan and food fraud Mitigation plan, Beyond HACCP: TACCP and VACCP, Advanced block chain and IoT technology behind the lifecycle traceability – Indian requirements and simple solutions, Enzymes as analytical tools for the assessment of food quality and safety, Nanoparticles as biosensors for food quality and safety assessment, Advances in Food identification and authentication with modern analytical tools, Emerging real time quality depicting packaging solutions. Supply chain research gaps pertaining to temperature abuse, transportation pallet tracking, refrigerated container management, automated systems in final distribution, clean labels etc.

Suggested Readings:

1. Naomi Rees. David Watson. 2000. International standards for food safety, Aspen Publications.
2. Assuring food safety and quality. 2012. FAO Food and Nutrition Manual., FAO publications, Rome.

FSQ 604 Formulation of Standards of Food Products, Packaging and Labeling 2(2+0)

Theory

Product and process certification – Systems, regulations and international market, Toward a safe and open global food supply, Harmonization and assessment of the state of food regulation, Role of WTO in the food regulatory frameworks, Recommendations for improving regulation, Emerging food regulation issues, scope for trade conflicts, Attributes of labelling process and clean label concept, Regulatory developments: genetically modified foods, organics, and animal welfare, the challenges ahead.

Suggested Readings

1. Roberts, Donna and Laurian Unnevehr, International Trade and Food Safety ed. Sy J. Buzby. Agricultural Economics Report 828. Washington: Economic Research Service. USDA. 2002.
2. Tim Josling, Donna Roberts and David Orden, Food Regulation and Trade: Towards a Safe and Open Global System. Institute for International Economics. 2004

FSQ 605 Food and Nutraceutical Chemistry 3 (3+0)

Theory

Recent advances in mechanism of action and chemical properties of potential and established nutraceutical compounds and their applications in functional foods - Updates in chemistry of Nutraceuticals with diseases modifying indications modifying potential for Allergy, Alzheimer's disease and nutraceuticals, Cardiovascular diseases, Cancer, Diabetes, Eye disorders, Immune system, Inflammation, Obesity, Parkinson's, Alzhaimar etc. Complications and toxicity potential of nutraceuticals, Modern approaches regulatory clearance and ban of nutraceutical.

Regulatory developments in health claims. Disease risk reduction claims and proprietary claims – recent protocols for phytosterols, digestible starch, slowly digestible starch, flavanols, grain/millet fibre, glucomannan, guar gum and hydroxypropyl methylcellulose and fructose etc.

Suggested Readings

1. Robert E.C. 2006. Handbook of Nutraceuticals and Functional Foods. 2nd Ed. Wildman.
2. Chintale Ashwini et al. 2013. Role of Nutraceuticals in Various Diseases: A Comprehensive Review. ISSN: 2231-2781.
3. Barbara Schneeman.2015. Science-Based Regulatory and Policy Considerations in Nutrition, American Society for Nutrition. Adv. Nutr. 6: 361S–367S, 2015; doi:10.3945/an.114.007013.

FSQ 606 Food Microbiology and Safety 3 (3+0)

Theory

Technological advances in starter cultures, Prospective application of food-grade microorganisms and fermenters for food preservation and food safety, Newer approaches on molecular techniques for detection of food borne pathogens, Safety evaluation of novel technologies of processing and food-surface disinfection, Latest software tools for predictive microbiology and microbial risk assessment in foods, Use of next generation sequencing for improving food safety, Role of nanotechnology in microbial food safety, New rapid detection methods including immune chromatographic or "dipstick" assays, commercial kits for indicator and pathogenic bacteria, Microbial bio-sensors and detector system in monitoring of food pathogens and antibiotic/pesticide residues.

Suggested Readings

1. Fratamico, PM and Bayles DO in food borne.
2. Ve rma, DK. Microbiology for food and health, technological developments and advances.
3. Advances in Microbial Food Safety,1st Edition, J Sofos, Woodhead Publishing

FSQ 607 Sensory Evaluation of Foods 2 (1+1)

Theory

Advances in rheological and texture measurement, Current sensory evaluation approaches, Applications and limitations of e-nose, e-tongue, Data Analysis for Electronic sensory judgment and validation approaches. Computer-aided sensory evaluation of foods, statistical analysis of sensory data.

Practical

- To understand the importance of the selection and training of sensory panel.
- To determine of threshold value for basic tastes, odour etc.
- To perform sensory evaluation by difference tests – a. Paired Comparison Test b. Triangle Test c. Duo-Trio Test , d. Ranking test etc.
- Development of structured and unstructured scale and statistical analysis.
- Statistical analysis of the hedonic testing of given food product
- Quantitative descriptive analysis of given product
- Principal component analysis of sensory data using sensomine or other software
- Recognition tests for various food flavours, flavor defects in milk.
- Sensory evaluation of milk and milk products.
- Texture evaluation of various food samples- crispies/ cookies/ biscuits/ snack foods
- Measurement of colour by using Tintometer/ Hunter Colour Lab etc.
- Qualitative tests for hydrogenated fats, butter, ghee
- Platform tests for milk
- Quality evaluation of various food stuffs- cereals, pulses, honey, jaggery, sugar, tea, Coffee etc.

Suggested Readings

1. Rao E. S. (2013). Food Quality Evaluation, Variety Books.
2. Meilgard (1999). Sensory Evaluation Techniques, CRC Press
3. Maslowitz H. (2000). Applied Sensory Analysis of Foods. Vols. I, II. CRC Press.

Syllabus of Supporting Courses

FBM 501 **Postharvest Management** **3 (2+1)**

Theory

UNIT I

Post-harvest handling of F&V. Maturity indices, harvesting and post-harvest handling of fruits and vegetables. Respiration and ripening process. Factors affecting respiration and ripening. Pre and post-harvest factors affecting quality on post-harvest shelf life. Chemicals used for hastening and delaying ripening of fruits and vegetables. Methods of storage – precooling, pre-storage treatments, low temperature storage, controlled atmospheric storage, hypobaric storage, irradiation and low cost storage structures, Cleaning & Washing machinery and methods for grading.

UNIT II

Packing technology for export. Fabrication of types of containers, cushioning material, vacuum packing, poly shrink packing, specific packing for export of mango, banana, grapes kinnow, sweet orange, and mandarin etc. Principles of preservation by heat, low temperature, chemicals and fermentation. Cut fruits and vegetables.

UNIT III

Post-harvest practices for safe storage of food grains. Preparation of threshing, threshers for different crops, parts, terminology, care and maintenance. Winnowing, manual and power operated winnowers. Groundnut decorticators- hand and power operated, principles of working. Maize shellers & castor shellers. Drying-grain drying method and equipment. Grain storage and practices.

UNIT IV

Post-harvest technology for major spices (black pepper, cardamom, coriander, cinnamon, ginger, onion and garlic, paprika, saffron, turmeric), their post-harvest diseases and storage pests and their management; Packaging and storage of spices and spice powders.

Practical

- Macro quality analysis, grading, packaging.
- Harvesting indices of different vegetable crops;
- Grading and packing of vegetables;
- Practice in judging the maturity of various fruits and vegetables.
- Conservation of zero energy cool chambers for on farm storage.
- Determination of physiological loss in weight (PLW), total soluble solids (TSS), total sugars, acidity and ascorbic and content in fruits and vegetables. Packing methods and types of packing and importance of ventilation.
- Pre cooling packing methods for export or international trade. Methods of prolonging storage life.
- Effect of ethylene on ripening of banana, sapota, mango.
- Identification of equipment and machinery used is preservation of fruits and vegetables.
- Preservation by drying and dehydration.
- Visit to local processing units.
- Visit to local market yards and cold storage units.
- Visit to local market and packing industries.

Suggested Readings

1. Pantastico B. Post-Harvest Physiology, Handling and Utilization of Tropical and Subtroopical Fruits and Vegetables. The AVI Publishing Co. Inc, Westport
2. Ryall, AL and Lipton WJ. Handling, storage and transportation of Fruits & Vegetables. Vol I. The AVI Pub. Company
3. Ryall, AL and Peltzer, WT. Handling, Storage and Transportation of Fruits and Vegetables -Vol II. The AV I Pub. Co.
4. Rydstm Heele, S, Post-Harvest Physiology and Pathology of Ve getables. Marcel Dekker

FBM 502 Food Business Management 2 (2+0)

Theory

UNIT I

Business management; introduction, theories and functions, food industry management; marketing management and human resource development, personal management. Sectors in food industry and scale of operations in India.

Human resource management, study the basics about HR and related policies and capacity mapping approaches for better management. Consumer Behavior towards food consumption, consumer surveys by various institutes and agencies, Various journals on consumer behaviour and market research, Internet based data search.

UNIT II

Materials management – types of inventories, inventory costs, managing the inventories, economic order quantity (EOQ). Personnel management – recruitment, selection and training, job specialization. Marketing management – definitions, planning the marketing programmes, marketing mix and four P' s. Financial management – financial statements and rations, capital budgeting. Project management – project preparation evaluation measures.

UNIT III

International trade; basics, classical theory, theory of absolute advantage. theory of comparative, modern theory, free trade- protection, methods of protection, quotas, bounties, exchange control, devaluation, commercial treaties, terms of trade, balance of payments, EXIM policy, foreign exchange, mechanics of foreign exchange, GATT, WTO, role of WTO,

International Trade in agriculture. World trade agreements related with food business, export trends and prospects of food products in India.

UNIT IV

World consumption of food; patterns and types of food consumption across the globe. Ethnic food habits of different regions. Govt. institutions related to international ad trade; APEDA, Tea board, spice board, wine board, MOFPI etc. management of export import organization, registration, documentation, export import logistics, case studies. Export and import policies relevant to horticultural sector. Project: Consumer Survey on one identified product - both qualitative and quantitative analysis (say, Consumer behavior towards Pickles and Chutneys).

Suggested Reading

1. David D and Erickson S. 1987. Principles of Agri Business Management. Mc Graw Hill Book Co., New Delhi.
2. Acharya S S and Agarwal N L. 1987. Agricultural Marketing in India. Oxford & ISH Publishing Co., New Delhi.
3. Cundiff Higler. 1993.Marketing in the International Environment, Prentice Hall of India, New Delhi.
4. Batra G S & Kumar N. 1994. GAD implications of Denkel proposals - Azmol Publications Pvt., New Delhi.
5. Phill Kottler .1994. Marketing Management - Prentice Hall of India, New Delhi.

FBM 503 Food Processing Entrepreneurship and Start-up 2(1+1)

Theory

UNIT I

Assessing overall business environment in the Indian economy. Overview of Indian social, political and economic systems and their implications for decision making by individual entrepreneurs. Globalisation and the emerging business / entrepreneurial environment.

UNIT II

Concept of entrepreneurship; entrepreneurial and managerial characteristics; managing an enterprise; motivation and entrepreneurship development; importance of planning, monitoring, evaluation and follow up; managing competition; entrepreneurship development programs; Social Responsibility of Business.

UNIT III

SWOT analysis, Generation, incubation and commercialization of ideas and innovations. Government schemes and incentives for promotion of entrepreneurship. Government policy on Small and Medium Enterprises (SMEs) / SSIs. Export and Import Policies relevant to food sector. Venture capital. Contract farming and joint ventures, public-private partnerships. Overview of horti inputs industry. Characteristics of Indian food processing and export industry.

Communication Skills: Structural and functional grammar; meaning and process of communication, verbal and non-verbal communication; listening and note taking, writing skills, oral presentation skills; field diary and lab record; indexing, footnote and bibliographic procedures. Reading and comprehension of general and technical articles, précis writing, summarizing, abstracting; individual and group presentations, impromptu presentation, public speaking; Group discussion. Organizing seminars and conferences.

Practical/Assignments/Case studies:

- Study of a regulated market,
- Study of a fruit and vegetable market,
- Study of State and Central Warehousing Corporation
- Study of functioning of a regional rural bank and commercial bank for loan.

- Study of food processing enterprise,
- Formulation of project reports for financing food Industry,
- Working out repayment plans,
- Legal Issues in Product Development, Marketing and Market Segments
- Case studies: Innovations in Dairy industry, Bakery industry, fats and oils industry, fruit and vege table industry, primary and secondary processing of cereals, brewing industry.

Note : In practical of plant design and project engineering a plant design problem should be assigned to a group of (3-4) students. The students should carry out the conceptual design, flow sheeting, material and energy balance calculations, and cost and profitability analysis of any Food Plant.

Suggested Reading

1. Hu, R. 2005. Food Product Design a Computer-Aided Statistical Approach, Technomic Publishers.
2. Moskowitz H R, Saguy S. and Straus T. 2006. An Integrated Approach to New Food Product Development, CRC Press
3. Moskowitz H R, Porretta S. and Silcher M. 2006. Concept Research in Food Product Design and Development, Blackwell Publishing Ltd.
4. M.S. Peters and K.D Timmerhaus 2005. Plant Designs and Economics for Chemical Engineers, McGraw Hill, 5th Edition,
5. Ahmad T. 2009. Dairy Plant Engineering and Management., Kitab Mahal, 8th Edition.

BSH 501 Research Methodology 2 (2+0)

Theory

UNIT I

Introduction to Research, Objective and importance of research, Types of research, steps involved in research, Ethical considerations in research, Defining research problem, Research design, Methods of research design, Laboratory safety considerations.

UNIT II

Sampling techniques, Classification of Data, Methods of Data Food informatics
Collection, designing of experiments, characteristics of a good design: selection of variables, design matrix, factorial design, fractional factorial design, Principal Component Analysis, Taguchi methods.

UNIT III

Data Analysis and interpretation Data analysis, Statistical techniques and choosing an appropriate statistical technique, Optimization techniques, Bioassays- direct and indirect.

UNIT IV

Hypothesis, Hypothesis testing, sampling and Non- sampling errors, Data processing software, statistical inference, Interpretation of results.

UNIT V

Technical Writing and reporting of research, referencing and referencing styles, Research journals, Indexing and citation of journals, acknowledgement, conflict of interest, Intellectual property, plagiarism.

Suggested Readings

1. Creswell, John W. Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications, 2013.
2. Ranjit Kumar, Research Methodology: A Step by Step Guide for Beginners, 2nd Edition, SAGE, 2005
3. C. R. Kothari, Gaurav Garg, Research Methodology Methods and Techniques, New Age International publishers, Fourth Edition.
4. John A. Bower, Statistical Methods for Food Science, 2009, Blackwell Publishing
5. Anthony Wilson, Handbook of Science Communication, 1998, CRC Press
6. Douglas C. Montgomery, Design and Analysis of Experiments, 2017, Willey
7. George W. Snecdecor and William G. Cochran, Statistical Methods, 8th Edition 1991, Wiley-Blackwell
8. Pages Israel Saguy, Computer aided techniques in Food Technology, 1983, Taylor and Francis

BSH 502 Food Informatics 2 (2+0)

Theory

Unit I

Informatics: Meaning and purpose, Making food-related information available for food researchers, Smart Data searching, Data Retrieval, File search or text search in file on a system, Meta Search Engines. Major centers of food research in India and abroad,

Unit II

Data bases and Management in Food Processing, Data storage and distribution by using various information technology tools and methods, Computer vision for food detection, segmentation and recognition, 3D reconstruction for food portion estimation Augmented reality for food monitoring.

Unit III

Evaluation protocols of dietary monitoring/management systems, Mobile computing for dietary assessment Smartphone technologies for dietary behavioral patterns, Dietary behavioral pattern modelling using sensors and/or smartphones

Unit IV

Laboratory Information Management System (LIMS) introduction and applications, LIMS in the food safety workflow, Wearable Food Intake Monitoring Technologies, Computerized food composition (nutrients, allergens) analysis

Unit V

Chemometric techniques - to gain fundamental understanding of complex food systems through the combination of data from independent measurement techniques, Product lifecycle tracing and tracking – ICT tools and technique

Suggested Readings

1. Food informatics: Applications of Chemical Information to Food Chemistry Martinez-Mayorga, Karina-Medina-Franco,
2. Food Informatics: Sharing Food Knowledge for Research & Development Nicole J.J.P. Koenderink1, J. Lars Hulzebos1, Hajo Rijgersberg1 and Jan L. Top.

Non-Gradial Common Courses

Course Title with Credit load Non- Gradial Common Courses

Sr. No	Course Code	Course Title	Credit
1	PGS -501	Library and Information Services	(0+1)
2	PGS -502	Technical Writing and Communications Skills	(0+1)
3	PGS -503	Intellectual Property and Its Management In Agriculture	(1+0)
4	PGS -504	Basic Concepts in Laboratory Techniques	(0+1)
5	PGS -505	Agricultural Research, Research Ethics and Rural Development Programmes	(1+0)
6	PGS -506	Advertising and Brand Management	(1+0)

Course Contents

PGS – 501 LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

PGS - 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing – Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article. Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

1. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
2. Collins' Cobuild English Dictionary. 1995.
3. Harper Collins. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed.
4. Holt, Rinehart & Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
5. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
6. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East- West Press.
7. Mohan K. 2005. Speaking English Effectively. MacMillan India.
8. Richard WS. 1969. Technical Writing.

9. Barnes & Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
10. Abhishek. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
11. Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

PGS -503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

1. Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS - 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab;

- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralization of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath, water bath, oil bath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

1. Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.
2. Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

PGS - 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co- operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
4. Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

PGS – 506 ADVERTISING AND BRAND MANAGEMENT (1+0)

LEARNING OUTCOMES

This course investigates various promotional tools used in the communication mix, such as advertising, sales promotion, and publicity, to sell products and services. Concepts include: advertising planning processes, determining advertising and promotional goals and objectives, control and evaluation of advertising and promotional programs, and regulatory issues. Students will develop a comprehensive advertising campaign for a real or imaginary product.

Theory

BLOCK 1: INTRODUCTION

UNIT 1

Introduction to Advertising Management: Integrated Marketing Communications, Setting Goals and Objectives, how advertising works: Segmentation and Positioning Assess the strengths, weaknesses, opportunities and threats (SWOT) of different kinds of promotional campaigns

UNIT 2

Message Strategy: Attention and comprehension, Advertising appeals, Associating Feelings with the Brand, Brand Equity, Image and Personality and Group Influence and word of mouth advertising, Media Planning and Media Strategy, Media Strategy and Tactics, Legal, Ethical and Social concerns of Advertising.

UNIT 3

Consumer Promotions and Trade Promotions: Their purpose and types How to plan and evaluate a successful promotion, The relationship between advertising and promotions, Introduction to Global Marketing, Advertising and sales promotion.

BLOCK 2: BRANDING DECISION

UNIT 1

Major Brand Concepts and branding Decision: Identifying and selecting brand name Building brand personality, image and identity; Brand positioning and re-launch; Brand extension; Brand portfolio; communication for branding Enhancing brand image through sponsorship and even management.

UNIT 2

Managing Brand Equity and Loyalty: Brand Building in Different Sectors - Customers, industrial, retail and service brands. Building brands through Internet, social Media. Building Indian brands for global markets.

TEACHING METHODS/ACTIVITIES:

- Lecture and Discussion
- Case Study
- PPT presentation

SUGGESTED READINGS

- Keller, Kevin Lane; *Strategic Brand Management;* Pearson education, New Delhi Verma, Harsha*: Brand Management;* Excel Books; New Delhi
- Kapferer, Jean Noel; *Strategic Brand Management;* Kogan Page; New Delhi
- Kumar, S. Ramesh; *Marketing and Branding–The Indian Scenario;* Pearson Education; New Delhi Kapoor, Jagdeep ; *24 Brand Mantras*, Sage Publications; New Delhi
- *Sengupta Subroto; Brand Positioning: Strategies for competitive advantage; Tata Mc Graw Hill; New Delhi Clifton, Rita & Simmons., John; Brands and Branding; The Economist; Delhi*