

**COURSE STRUCTURE AND SYLLABUS FOR M.TECH (FOOD AND PROCESS ENGINEERING) PROGRAMME**

**DEPARTMENT OF AGRICULTURAL ENGINEERING AND TECHNOLOGY,  
SCHOOL OF ENGINEERING AND TECHNOLOGY  
NAGALAND UNIVERSITY, KOHIMA CAMPUS**

<b>SEMESTER 1</b>						
<b>S.N.</b>	<b>Course Code</b>	<b>Course title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>Credits</b>
1	AEFT501	Transport Phenomena in Food Processing	3	1	0	4
2	AEFT502	Unit Operations in Food Process Engineering	3	1	0	4
3	AEFT503	Storage Engineering and Handling of Agricultural Produce	3	1	0	4
4	AEFT504	Food Package Engineering	3	1	0	4
5	AEFE5**	Elective I	3	1	0	4
6	AEFE5**	Elective II	3	1	0	4
		Total				24
<b>SEMESTER 2</b>						
<b>S.N.</b>	<b>Course Code</b>	<b>Course title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>Credits</b>
1	AEFT505	Field Crops Process Engineering	3	1	0	4
2	AEFT506	Horticultural Crops Process Engineering	3	1	0	4
3	AEFT507	Food Processing Equipment and Plant Design	3	1	0	4
4	AEFT508	Food Quality and Safety	3	1	0	4
5	AEFT509	Horticultural Crops Process Engineering Lab	0	0	4	2
6	AEFE5**	Elective III	3	1	0	4
		Total				22
<b>SEMESTER 3</b>						
<b>S.N.</b>	<b>Course Code</b>	<b>Course title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>Credits</b>
1	AEFT601	Research Methodology & Proposal Writing	3	1	0	4
2	AEFE6**	Elective IV	3	1	0	4
3	AEFE6**	Skill Enhancement Elective V	3	1	0	4
4	AEFT602	Seminar	0	3	0	3
5	AEFT603	M.Tech. Thesis (Part – I)	0	0	20	10
		Total				25
<b>SEMESTER 4</b>						
<b>S.N.</b>	<b>Course Code</b>	<b>Course title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>Credits</b>
1	AEFT604	M.Tech. Thesis (Part – II)	0	0	20	10
2	AEFT605	Comprehensive Viva-Voce	0	0	16	8
		Total				18
		<b>Grand total credit</b>				<b>89</b>

Elective courses I & II						
S.N.	Course Code	Course title	L	T	P	Credits
1	AEFE501	Processing of Cereals, Pulses and Oilseeds	3	1	0	4
2	AEFE502	Fruits and Vegetables Process Engineering	3	1	0	4
3	AEFE503	Processing of Meat, Poultry and Fish	3	1	0	4
4	AEFE504	Agri-Project Planning and Management	3	1	0	4
Elective courses III						
S.N.	Course Code	Course title	L	T	P	Credits
1	AEFE505	Storage Engineering and Handling of Agricultural Products	3	1	0	4
2	AEFE506	Food Extrusion Technology	3	1	0	4
3	AEFE507	Non-Thermal Food Processing Technologies	3	1	0	4
Elective courses IV						
S.N.	Course Code	Course title	L	T	P	Credits
1	AEFE601	Dairy Product Processing	3	1	0	4
2	AEFE602	Advanced refrigeration and air conditioning system	3	1	0	4
3	AEFE603	Food Processing Technologies	3	1	0	4
Skill Enhancement Elective V						
S.N.	Course Code	Course title	L	T	P	Credits
1	AEFE604	Food Plant and Equipment Design	3	1	0	4
2	AEFE605	Project Management	3	1	0	4
3	AEFE606	Industrial Safety	3	1	0	4

### Major courses:

#### AEFT501 Transport Phenomena in Food Processing

- Introduction to heat and mass transfer and their analogy. Steady and unsteady state heat transfer. Analytical and numerical solutions of unsteady state heat conduction equations. Use of Gurnie-Lurie and Heisler Charts in solving heat conduction problems: Applications in food processing including freezing and thawing of foods.
- Convective heat transfer in food processing systems involving laminar and turbulent flow. Heat transfer in boiling liquids. Heat transfer between fluids and solid foods. Functional design of heat exchangers: shell and tube, plate and scraped surface heat exchangers. Radiation heat transfer: governing laws, shape factors, applications in food processing.
- Momentum transfer. Mass flow and balance. Steady and unsteady flow. Theory and equation of continuity. Bernoulli's theorem and application. Flow through immersed bodies, Measurement of flow, pressure and other parameters. Flow driving mechanism.
- Molecular diffusion in gases, liquids and solids. Molecular diffusion in biological solutions and suspensions. Molecular diffusion in solids. Unsteady state mass transfer and mass transfer coefficients. Molecular diffusion with convection and chemical reaction. Diffusion of gases in porous solids and capillaries. Mass transfer applications in food processing.

**Recommended Books:**

1. Transport Phenomena, John Wiley & Sons. Bird, Stewart, Lightfoot 2002.
2. Introduction to Transport Phenomena, PHI. Bodh Raj 2012.
3. Transport Process and Unit Operations. Prentice-Hall of India Private Limited, New Delhi ISBN 0-13-045253-X. Christie J. 1993.
4. Chemical Engineering. Vol. II, IV. The Pergamon Press. Coulson JM and Richardson JF. 1999.
5. Unit Operations in Food Processing. Pergamon Press. Earle RL. 1985.
6. Heat Transfer. McGraw Hill. Holman JP 1992.
7. Transport Phenomena in Food Processing. CRC Press ISBN: 9781566769938 Geankoplis. Jorge Welty-Chanes, Jorge F and Velez-Ruiz 2002.
8. Unit Operations of Chemical Engineering. McGraw Hill. McCabe WL and Smith JC 1999.
9. Transport Phenomena Fundamentals, CRC Press, ISBN: 978-1-4665- 5535-8, 1466555351. Plawsky, Joel L 2014.

**AEFT502 Unit Operations in Food Process Engineering**

- Review of basic engineering mathematics. Units and dimensions. Mass and energy balance. Principles of fluid flow. Heat transfer: Conduction, convection and radiation. Heat exchangers and their designs.
- Drying and dehydration: Psychrometry, theories of drying, EMC, equipment for drying of solid, pastes and liquid foods. Evaporation: Components, heat and mass balance in single and multiple effect evaporators, equipment and applications, steam economy. Thermal processing: Blanching, pasteurization and sterilization, death rate kinetics, process time calculations, sterilization equipment.
- Refrigeration and freezing: Principles, freezing curve, freezing time calculation, freezing equipment, cold chain.
- Mechanical separation: Principle and equipment involved in sieving, filtration, sedimentation and centrifugation, cyclone separation. Material handling: Conveyors and elevators, components and design considerations for belt, chain, bucket and screw conveyors.
- Size reduction: Principles of size reduction, size reduction laws. Size reduction equipment: Jaw crusher, gyratory crusher, roller mill, hammer mill.

**Recommended Books:**

1. Food Process Engineering and Technology, Academic Press, ISBN: 978-0-12-812018-7. Berk. 2018.
2. Food Engineering Operations. Elsevier. Brennan JG, Butters JR, Cowell ND and Lilly AEI. 1990.
3. Food Processing Technology: Principle and Practice. VCH Publ. Fellows P 1988.
4. Unit Operations of Chemical Engineering. McGraw Hill. McCabe WL and Smith JC. 1999.
5. Unit Operation of Agricultural Processing. Vikas Publ. House. Sahay KM and Singh KK. 1994.
6. Introduction to Food Engineering. Academic Press. Singh RP and Heldman DR. 1993.
7. Introduction to Food Process Engineering, Springer. Smith. 2011.
8. Fundamentals of Food Process Engineering, Springer. Toledo. 2007.

9. Food Engineering Handbook, CRC press. Varzakas. 2015.

### **AEFT503 Storage Engineering and Handling of Agricultural Produce**

- Storage of grains, biochemical changes during storage, production, distribution and storage capacity estimate models, storage capacity models, ecology, storage factors affecting losses, storage requirements.
- Bag and bulk storage, godowns, bins and silos, rat proof godowns and rodent control, method of stacking, preventive method, bio-engineering properties of stored products, function, structural and thermal design of structures, aeration system.
- Grain markets, cold storage, controlled and modified atmosphere storage, effects of nitrogen, oxygen, and carbon dioxide on storage of durable and perishable commodities, irradiation, storage of dehydrated products, food spoilage and preservation, BIS standards.
- Physical factors influencing flow characteristics, mechanics of bulk solids, flow through hoppers, openings and ducts; design of belt, chain, screw, roller, pneumatic conveyors and bucket elevators, principles of fluidization, recent advances in handling of food materials.

#### **Recommended Books:**

1. Grain Handling and Storage. Elsevier. Boumans. 1985.
2. Design and Operation of Cold Stores in Developing Countries. FAO. FAO. 1984.
3. Crop Post-Harvest: Science and Technology. Vol 1 Wiley-blackwell. Golob. 2002.
4. Handling and Storage of Food Grains in Tropical and Sub-Tropical Areas. FAO Publisher Oxford & IBH. Hall CW. 1970.
5. Agricultural Process Engineering. 5th Ed. AVI Publisher. Henderson S and Perry SM. 1976.
6. Crop Post-Harvest: Science and Technology. Vol 2, Wiley-blackwell. Hodges 2004.
7. Controlled Atmosphere and Fumigation in Grain Storage. Elsevier. Ripp BE. 1984.
8. Post-Harvest Handling – A System Approach. Academic Press. Shefelt RL and Prussi SE. 1992.
9. Grain Storage Engineering and Technology. Batra Book Service. Vijayaraghavan S 1993.

### **AEFT504 Food Package Engineering**

- Introduction of packaging: Package, functions and design. Principle in the development of protective packaging. Deteriorative changes in foodstuff and packaging methods of prevention.
- Food containers: Rigid containers, glass, wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and paper sacks, corrosion of containers (tin plate). Flexible packaging materials and their properties. Aluminum as packaging material. Evaluation of packaging material and package performance.
- Packaging equipment: Food packages, bags, types of pouches, wrappers, carton and other traditional package. Retortable pouches: Shelf life of packaged foodstuff.
- Methods to extend shelf life. Packaging of perishables and processed foods. Special problems in packaging of food stuff.
- Package standards and regulation: Shrink packaging, aseptic packaging, CA and MAP.

Biodegradable packaging: Recent advances in packaging, active packaging, smart packaging, antioxidant and antimicrobial packaging, edible films and biodegradable packaging, microencapsulation and nano encapsulation.

### **Practical:**

Thickness, substance weight, water absorption capability of flexible packaging materials, strength properties of packaging materials, water vapour and gas transmission rate of flexible packaging materials, identification and chemical resistance of plastic films. Packaging of fruits/vegetables: Estimation of shelf-life of packaged food stuff, familiarization of types of packaging material

### **Recommended Books:**

1. Food Packaging Materials. Applied Science Publisher. Crosby NT. 1981.
2. A Handbook of Food Packaging. Springer. Frank A. 1992.
3. Food Packaging Materials. Tata McGraw. Mahadeviah M and Gowramma RV. 1996.
4. Developments in Food Packaging. Applied Science Publisher. Hill.Palling SJ. 1980.
5. Food Packaging - Principles and Practice. 3rd Ed Taylor & Francis. Robertson GL. 2013.
6. Principles of Food Packaging. AVI Publisher. Sacharow S and Grittin RC. 1980.

### **AEFT505 Field Crops Process Engineering**

- Production and utilization of cereals and pulses, grain structure of major cereals, pulses and oilseeds and their milling fractions. Grain quality standards and physico- chemical methods for evaluation of quality of flours.
- Pre-milling treatments and their effects on milling quality. Parboiling and drying, conventional, modern and integrated rice milling operations. Wheat roller flour milling. Processes for milling of corn, oats, barley, gram, pulses, paddy and flour milling equipment. Layout of milling plants.
- Dal mills, handling and storage of by-products and their utilization. Storage of milled products. Expeller and solvent extraction processing. Assessment of processed product quality.
- Packaging of processed products. Design characteristics of milling equipment, selection, installation and their performance. Quality standards for various processed products. Value added products of cereals, pulses and oilseeds.

### **Recommended Books:**

1. Processing Tropical Crops. ELBS/MacMillan. Asiedu JJ. 1990.
2. Post-Harvest Technology of Cereals, Pulses and Oilseeds. Oxford and IBH. Chakraverty A. 1995.
3. Crop Post-Harvest: Science and Technology Vol. 1, Wiley-Blackwell. Golob 2002.
4. Crop post-harvest: science and technology Vol. 2, Wiley-Blackwell. Hodges 2004.
5. Post-Harvest Physiology and Crop Preservation. Plenum Press. Morris Lieberman. 1983.
6. Principles of Agricultural Processing. Kalyani. Pandey PH. 1994.
7. Rice - Post Production Manual. Wiley Eastern. Pillaiyar P. 1988.

8. Unit Operations in Agricultural Processing. Vikas Publ. House. Sahay KM and Singh KK. 1994.

### **AEFT506 Horticultural Crops Process Engineering**

- Importance of postharvest technology of fruits and vegetables, structure, cellular components, composition and nutritive value of fruits and vegetables, fruit ripening, spoilage of fruits and vegetables.
- Harvesting and washing, pre-cooling, blanching, preservation of fruits and vegetables, commercial canning of fruits and vegetables, minimal processing of fruits and vegetables.
- Cold storage of fruits and vegetables, controlled atmosphere and modified atmosphere packaging of fruits and vegetables, quality deterioration and storage.
- Dehydration of fruits and vegetables, methods, osmotic dehydration, foam mat drying, freeze drying, microwave heating, applications, radiation preservation of fruits and vegetables, irradiation sources.
- Intermediate moisture foods, ohmic heating principle, high pressure processing of fruits and vegetables, applications, sensory evaluation of fruit and vegetable products, packaging technology for fruits and vegetables, general principles of quality standards and control, FPO, quality attributes.

### **Practical**

Determination of size, shape, density, area-volume-mass relationship of fruits and vegetables, sugar-acid ratio of fruits, evaluation of washer, grader and packaging methods, experiments on drying of fruits and vegetables, controlled atmosphere storage and quality evaluation.

### **Recommended Books:**

1. Fruit and Vegetable Processing. CBS. Bhatti S and Varma U. 1995.
2. Commercial Fruit and Vegetable Products. Agrobios Publisher. Cruesss WV. 2000.
3. Fruit and Vegetable Processing. International Book Publisher. Danthy ME. 1997.
4. Post-Harvest Technology of Horticultural crops. AAP. Simson. 2016.
5. Advances in Post-Harvest Technologies of Vegetable Crops. AAP. Singh. 2018.
6. Fruit and Vegetable Preservation. Principles and Practices. International Book Distr. Srivastava RP and Kumar S. 1994.
7. Post-Harvest Technology of Fruits and Vegetables. Blackwell. Thompson AK. 1996.
8. Post-Harvest Technology of Fruits and Vegetables. Vols. I-II. Indus Publisher. Verma LR and Joshi VK. 2000.

### **AEFT507 Food Processing Equipment and Plant Design**

- Design considerations of processing agricultural and food products.
- Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation, membrane separation.
- Human factors in design, selection of materials of construction and standard component, design standards and testing standards. Plant design concepts and general

design considerations: Plant location, location factors and their interaction with plant location, location theory models, and computer aided selection of the location.

- Feasibility analysis and preparation of feasibility report; Plant size, factors affecting plant size and their interactions, estimation of break-even and economic plant size. Product and process design, process selection, process flow charts, computer aided development of flow charts.
- Hygienic design aspects and worker's safety, functional design of plant building and selection of building materials, estimation of capital investment, analysis of plant costs and profitability's, management techniques in plant design including applications of network analysis, preparation of project report and its appraisal.

#### **Recommended Books:**

1. Food Plant Design. CRC Press. Antonio LG and Gustavo VBC. 2005.
2. Chemical Process Equipment. Selection and Design Elsevier. Couper. 2012.
3. Handbook of Food Processing Equipment. Springer. George S and Athanasios EK. 2015.
4. Process Equipment Design. Wiley-Interscience. Lloyd EB and Edwin HY. 1959.
5. Food Plant Sanitation: Design, Maintenance, and Good Manufacturing Practices. CRC Press. Michael MC. 2013

#### **AEFT508 Food Quality and Safety**

- Food safety: Need for quality control and safety, strategy and criteria, microbiological criteria for safety and quality, scope of food toxicology, toxic potential and food toxicants, biological and chemical contaminants.
- Food additives and derived substances, factors affecting toxicity, designing safety in products and processes, intrinsic factors, establishing a safe raw material supply, safe and achievable shelf life.
- Process equipment and machinery auditing, consideration of risk, environmental consideration, mechanical quality control.
- Personnel hygienic standards, preventative pest control, cleaning and disinfecting system, biological factors underlying food safety.
- Preservation and stability, contaminants of processed foods, adulteration, prevention and control, FSSAI, ISO, Codex, GMP, BIS and HACCP. Practices, principles, standards, specifications, application establishment and implementation, HACCP and quality management system. Food Safety Management Systems (FSMS), Traceability.

#### **Recommended Books:**

1. Quality Control in the Food Industry. Vol. 1 Academic Press. Herschdoerfer, SM. 1984.
2. Quality Control in the Food Industry. Vol. 2 Elsevier Science. Herschdoerfer SM. 2012.
3. Statistical Quality Control for the Food Industry. Springer. Hubbard MR. 2003.
4. Food Packaging Materials. Tata McGraw Hill. Mahadeviah M and Gowramma R V. 1996.

5. Biosensors in Food Processing, Safety, and Quality Control. CRC Press. Mehmet M. 2011.
6. Developments in Food Packaging. Applied Science Publisher. Palling SJ. 1980.
7. Principles of Food Packaging. AVI Publisher. Sacharow S and Grittin RC. 1980.
8. Automation for Food Engineering. Food Quality Quantization and Process Control-CRC Press. Yanbo H, Whittaker AD and Lacey RE. 2001.

### **AEFT509 Horticultural Crops Process Engineering Lab**

### **AEFT601 Research Methodology and Proposal Writing**

- Introduction to Research Methodology: Importance of Research in Decision Making, Defining Research Problem and Formulation of Hypothesis, Experimental Design.
- Data Collection and Measurement; Methods and Techniques of Data Collection, Sampling and sampling Designs, Data Presentation and Analysis; Data Processing.
- Attitude Measurement and Scales; Statistical Analysis and Interpretation of Data, Non-Parametric Tests, Multivariate analysis of Data.
- Measures of Central Tendency, Dispersion, Variation, Correlation, Regression, Model building and Decision Making.
- Report Writing and Presentation: Substance of Reports, formats of Reports, Presentation of Report.

### **Recommended Books:**

1. Research Methodology, C.R. Kothari, New Age Publications, New Delhi,
2. Research Methodology, B. Taylor, G. Sinha and T. Ghoshal, Prentice Hall of India, New Delhi,
3. Research Methodology, R. Panneersalvam, Prentice Hall of India, New Delhi, 2007.
4. Management Research Methodology, K.N. Krishnaswamy, A.I. Sivakumar and M. Mathirajan, Pearson Education, New Delhi, 2008.

### **Elective courses:**

### **AEFE501 Processing of Cereals, Pulses and Oilseeds**

- Production and utilization of cereals and pulses, grain structure of major cereals, pulses and oilseeds and their milling fractions; grain quality standards and physico- chemical methods for evaluation of quality of flours
- Pre-milling treatments and their effects on milling quality; parboiling and drying, conventional, modern and integrated rice milling operations; wheat roller flour milling; processes for milling of corn, oats, barley, gram, pulses, paddy and flour milling equipments.
- Dal mills, handling and storage of by-products and their utilization. Storage of milled products, Expeller and solvent extraction processing, assessment of processed product quality.
- Packaging of processed products, design characteristics of milling equipments; selection, installation and their performance, BIS standards for various processed product.

### **Recommended Books:**

1. Processing Tropical Crops. ELBS/MacMillan. Asiedu JJ.1990.
2. Post-harvest Technology of Cereals, Pulses and Oilseeds. Oxford & IBH. Chakraverty A. 1995.
3. Post-harvest Physiology and Crop Preservation. Plenum Press. Morris Lieberman. 1983.
4. Principles of Agricultural Processing. Kalyani. Pillaiyar P. 1988. Rice - Post Production Manual. Wiley Eastern. Pandey PH. 1994.
5. Unit Operations in Agricultural Processing. Vikas Publ. House, Sahay KM & Singh KK. 1994.

### **AEFE502 Fruits and Vegetables Process Engineering**

- Importance of post harvest technology of fruits and vegetables, structure, cellular components, composition and nutritive value of fruits and vegetables, fruit ripening, spoilage of fruits and vegetables.
- Harvesting and washing, pre-cooling, preservation of fruits and vegetables, blanching, commercial canning of fruits and vegetables, minimal processing of fruits and vegetables.
- Cold storage of fruits and vegetables, controlled atmosphere packaging of fruits and vegetables, gas composition, quality of storage.
- Dehydration of fruits and vegetables, methods, osmotic dehydration, foam mat drying, freeze drying, microwave heating, applications, radiation preservation of fruits and vegetables, irradiation sources.
- Intermediate moisture foods, ohmic heating principle, high pressure processing of fruits and vegetables, applications, sensory evaluation of fruit and vegetable products, packaging technology for fruits and vegetables, general principles of quality standards and control, FPO, quality attributes.

### **Recommended Books:**

1. Commercial Fruit and Vegetable Products. Agrobios. Cruesss WV. 2000.
2. Fruit and Vegetable Processing. International Book Publ. Mircea Enachesca Danthy. 1997.
3. Fruit and Vegetable Preservation. Principles and Practices. International Book Distr. Srivastava RP & Sanjeev Kumar. 1994.
4. Fruit and Vegetable Processing. CBS. Sumanbhatti & Uma Varma. 1995.
5. Post Harvest Technology of Fruits and Vegetables. Blackwell. Thompson AK. 1996.
6. Post Harvest Technology of Fruits and Vegetables. Vols. I-II. Indus Publ. Verma LR & Joshi VK. 2000.

### **AEFE503 Processing of Meat, Poultry and Fish**

- Meat: Genetic engineering of farm animals for better meat quality, automation for the modern slaughterhouse, hot-boning of meat, new spectroscopic techniques for online monitoring of meat quality, real-time PCR for the detection of pathogens in meat, new developments in decontaminating raw meat, automated meat processing,

developments in chilling and freezing of meat, high pressure processing of meat, approaches for the development of functional meat products, new techniques for analyzing raw meat, modified atmosphere packaging, perspectives for the active packaging of meat products.

- Poultry: Breeding and quality of poultry, stunning and slaughter of poultry, processing and packaging of poultry, new techniques of preservation of poultry, production of turkeys, geese, ducks and game birds, microbial hazards in poultry production and processing, latest trends in measuring quality of poultry and poultry products, treatment and disposal of poultry processing waste.
- Fish and seafood: Fresh fish handling and chill storage, modified atmospheric packaging of seafoods, fish odours and flavours, assessment of freshness of fish and seafoods, traditional dried and salted fish products, proteolysed fish products, minced fish technology, retort pouch processing technology, irradiation and microwave in fish handling and processing, advanced freezing technology for fish storage, high pressure processing of seafoods, value addition of freshwater and aqua cultured fish products, application of enzymes in fish processing and quality control, toxins, pollutants and contaminants in fish and seafoods.
- Milk: Physical, chemical and nutritional properties of milk components, improvements in the pasteurization and sterilization of milk. Flavour generation in dairy products, controlling texture of fermented dairy products, functional dairy products, on-line measurement of product quality in dairy processing, high pressure processing of milk products, novel separation technologies to produce dairy ingredients, new technologies to increase shelf-life of dairy products, genetic engineering of milk proteins, production and utilization of functional milk proteins, methods of improving nutritional quality of milk, significance of milk fat in dairy products, chromatographic, spectrometric, ultrasound and other techniques for analysis of milk lipids.

#### **Recommended Books:**

1. Fish Processing and Product Development. CIFE, Kochi. Chooksey MK. 2003.
2. Practical Manual on Fish Processing and Quality Control. CIFE, Kochi. Chooksey MK and Basu S. 2003.
3. Fish Processing Technology. Blabie Academic and Professional. Hall GM. 1997.
4. Developments in Meat Sciences. Vol III Applied Science Publishers. Lawrie RS. 1985.
5. Processing of Poultry. Elsevier. Mead GC. 1989.
6. Processed Meats. AVI Publishers. Pearson AM and Tauber FW. 1984.
7. Egg Science and Technology. AVI Publishers. Stadelman WJ and Cotterill OJ. 1980.

#### **AEFE504 Agri-Project Planning and Management**

- Project development, market survey and time motion analysis.
- Selection of equipment, technology option, techno-economic feasibility and processing in production catchment.

- Product and process design, PERT, CPM, transport model, simplex, linear and dynamic programming, operation log book. Material balance and efficiency analysis, performance testing, performance indices, energy requirement and consumption. Marketing of agricultural products, market positioning.
- BIS/FSSAI/ISO standards/ guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed.

### **Recommended Books:**

1. Dairy Plant Engineering and Management. 4th Ed. Kitab Mahal. Ahmed T. 1997.
2. Project Management, Planning and Control. Albert L. 2017.
3. Agricultural Project Planning and Analysis. Anandajayasekeram P. 2004.

### **AEFE505 Storage Engineering and Handling of Agricultural Products**

- Storage of grains, biochemical changes during storage, production, distribution and storage capacity estimate models, storage capacity models, ecology, storage factors affecting losses, storage requirements.
- Bag and bulk storage, godowns, bins and silos, rat proof godowns and rodent control, method of stacking, preventive method, bio-engineering properties of stored products, function, structural and thermal design of structures, aeration system.
- Grain markets, cold storage, controlled and modified atmosphere storage, effects of nitrogen, oxygen, and carbon dioxide on storage of durable and perishable commodities, irradiation, storage of dehydrated products, food spoilage and preservation, BIS standards.
- Physical factors influencing flow characteristics, mechanics of bulk solids, flow through hoppers, openings and ducts; design of belt, chain, screw, roller, pneumatic conveyors and bucket elevators; principles of fluidization; recent advances in handling of food materials.

### **Recommended Books:**

1. Design and Operation of Cold Stores in Developing Countries. FAO. FAO. 1984.
2. Handling and Storage of Food Grains in Tropical and Sub-tropical Areas. FAO Publ. Oxford & IBH. Hall CW. 1970.
3. Agricultural Process Engineering. 5th Ed. AVI Publ. Henderson S & Perry SM. 1976.
4. Automatic Control of Food Manufacturing Processes. Applied Science Publ. McFarlane Ian. 1983.
5. Preservation and Storage of Grains, Seeds and their Byproducts. CBS. Multon JL. (Ed). 1989.
6. Controlled Atmosphere and Fumigation in Grain Storage. Elsevier. Ripp BE. 1984.
7. Post Harvest Handling – A System Approach. Academic Press. Shefelt RL & Prussi SE. 1992.
8. Controlled Atmosphere Storage of Grains. Elsevier. Shejbal J. (Ed). 1980.
9. Grain Storage Engineering and Technology. Batra Book Service. Vijayaraghavan S. 1993.

## **AEFE506 Food Extrusion Technology**

- Extrusion: definition, introduction to extruders and their principles, types of extruders, Extruders in the food industry: History and uses of extruders in the food industry.
- Single screw extruder: principle of working, net flow, factors affecting extrusion process, Twin screw extruder: counter rotating and co-rotating twin screw extruder, Process characteristics of the twin screw extruder: feeding, screw design, screw speed, screw configurations, die design, Twin screw extruder: Barrel temperature and heat transfer, adiabatic operation, heat transfer operations and energy balances, Problems associated with twin screw extruder.
- Pre-conditioning of raw materials used in extrusion process, Pre conditioning operations and benefits of pre-conditioning and devolatilization, Interpreted-flight expanders - extruders, dry extruders, Chemical and nutritional changes in food during extrusion, pre-extrusion processes, cooker extruder Profiling, Practical considerations in extrusion processing: Addition and subtraction of materials, shaping and forming at the die, post extrusion processes.
- Breakfast cereals: introduction, type of cooking - High shear cooking process, steam cookers, low shear, low pressure cookers and continuous steam pre-cooking, available brands, Breakfast cereal processes: traditional and extrusion methods, classification of breakfast cereals -flaked cereals, oven puffed cereals, gun puffed cereals, shredded products.
- Texturized vegetable protein: Definition, processing techniques, and foods, Snack food extrusion: Direct expanded (DX) and third generation (3G) Snacks: types, available brands, coextruded snacks and indirect-expanded products.

### **Recommended Books:**

1. American Association of Cereal Chemists, St. Paul, Minnesota. Fast R.B. and Caldwell E.F. Breakfast Cereals and How they are made.(2000)
2. Blackie Academic & Professional, New York. Frame N.D. The Technology of Extrusion Cooking. (1994)
3. Extrusion Cooking, Technologies and Applications. Wood head Publishing Limited, Abington, Cambridge. Guy R.
4. Extrusion of Foods. Vol. 1&2 (1991) CRC Press, Inc; Boca Raton, Florida. Harper J.M.
5. Extrusion Technology for the Food Industry. (1987) Elsevier Applied Science, O'Connor C New York.
6. Thermal Technologies in Food Processing. Wood head Publishers, Cambridge. Richardson P.

## **AEFE507 Non-Thermal Food Processing Technologies**

- Introduction to non-thermal processing, comparison of thermal and non-thermal processing, advantages and disadvantages of non-thermal processing.
- Pulse Electric Filed (PEF) processing of foods, general principles, microbial inactivation kinetics by PEF, changes in enzyme activity, protein conformation, vitamin and flavor stability, PEF assisted juice exertion.
- High Pressure Processing (HPP) of foods, general principles, type of HPP systems, applications -inactivation of micro-organisms and enzymes, milk and milk products,

egg, meat and fish products, fruits and vegetable products, high pressure assisted freezing and thawing.

- Food irradiation, ultraviolet light microbial inactivation by ultrasound, magnetic field.
- Non-thermal technology combination with thermal technologies, packaging requirements for non-thermal processed foods, food safety and regulations of non-thermal processed foods.

### **Recommended Books:**

1. Pulsed Electric Fields in Food Processing: Fundamental Aspects and Applications. Technomic: Lancaster, PA. Barbosa-Canovas, G. and Zhang, Q. 2001.
2. Nonthermal Preservation of Food. Marcel Dekker, New York. Barbosa-Canovas, G.V., Pothakamury, U.R., Palou, E. and Swanson, B.G. 1989.
3. Novel-thermal Food Processing Technologies. CRC Press, New York. Barbosa-Canovas, G.V., Tapia, M. S. and Cano, M.P. 2005.
4. New Methods of Food Preservation. Blackie Academic and Professional, Glasgow, UK. Gould, G.W. 1995a.
5. Advances in Food Engineering. Technomic Publishing Co., Lancaster, PA. Lozano, J., Anon, M.C., Parada-Arias, E., and Barbosa-Canovas, G.V. 2000.

### **AEFE601 Dairy Product Processing**

- Procurement, transportation and processing of market milk, cleaning and sanitization of dairy equipment. Special milks such as flavoured, sterilized, recombined and reconstituted toned and double toned.
- Condensed milk: Methods of manufacture and related equipment, evaluation of condensed and evaporated milk. Dried milk: Definition, methods of manufacture of skim and whole milk powder, instantiation, physiochemical properties, evaluation, defects in dried milk powder. Cream: Cream separation, neutralization, sterilization, pasteurization and cooling of cream, defects in cream, Butter: methods of manufacture, defects in butter.
- Ice cream: Methods of manufacture and related equipment, defects in ice cream, technology of softy manufacture. Cheese: Methods of manufacture, cheddar, Gouda, cottage and processed cheese, defects in cheese.
- Indigenous milk products: Method of manufacture of yoghurt, dahi, khoa, burfi, kalakand, gulabjamun, rosogolla, srikhand, chhana, paneer, ghee, lassietc. Probiotic milk product.

### **Recommended Books:**

1. Dairy Powders and Concentrated Products (Society of Dairy Technology). Wiley-Blackwell. Adnan T. 2009.
2. Probiotic Dairy Products (Society of Dairy Technology series). Wiley Blackwell. Adnan T. 2006.
3. Advanced Dairy Science and Technology. Blackwell Publisher: Blackwell Publisher Professional. Britz. 2008.
4. Outlines of Dairy Technology. Oxford. De. 2001.
5. Dairy Science and Technology Handbook. Vol. I, II and III Wiley. Hui YH. 1992.

6. Milk and Dairy Product Technology. Taylor and Francis. Spreer E. 2017.
7. Dairy Science and Technology. CRC, Taylor and Francis. Walstra P, Jan TM, Wouters and Geurts TJ. 2006.

### **AEFE602    Advanced refrigeration and air conditioning system**

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

### **Recommended Books:**

1. Modern Refrigeration and Airconditioning. Good Heart Wilcox Co. Andrew D Althouse & Carl H. Turnquist 1958.
2. Refrigeration and Air-conditioning. Tata McGraw Hill. Arora CP. 2000.
3. Handbook of Air-conditioning System Design. McGraw Hill. Carrier Air-conditioning. 1965.
4. A Course in Refrigeration and Air-conditioning. Dhanpat Rai & Sons. Domkundwar S. 1980.
5. Refrigeration and Air-conditioning and Cold Storage. Chilton Co. Gunther Raymond C. 1957.
6. Refrigeration and Air conditioning. Prentice Hall of India. Jordan RC & Priester GB. 1971.
7. Refrigeration and Air-conditioning. Reston Publ. Langley BC. 1978.
8. Refrigeration and Air-conditioning. Venus Trading Co. New-Comer JL. 1981.
9. Technology and Engineering of Dairy Plant Operation. Luxmi Publ. Ananta Krishnan CP & Simha NN. 1987.

### **AEFE603 Food Processing Technologies**

- Mixing and homogenization; Principles of solid and liquid mixing, types of mixers for solids, liquid and pastes homogenization. Emulsification: Principles and equipments.
- Novel dehydration technologies; Osmotic dehydration, foam mat drying, puff drying, freeze drying, microwave drying, dehumidified air drying. Extrusion: Theory, equipment, applications.
- Non-thermal processing; Principles and equipment involved in ohmic heating, pulsed electric field preservation, hydrostatic pressure technique (vacuum processing, high pressure processing of Foods), ultrasonic technology, irradiation, quality changes and effects on microorganisms, nanotechnology in food processing.
- Distillation, leaching and extraction: Principles and equipment for distillation, crystallization, phase equilibria, multistage calculations, leaching principles and equipment, solvent extraction, super-critical fluid extraction, near critical fluid extraction: Equipment and experimental techniques used in NCF extraction and industrial application, advanced methods for extraction of food components and aroma recovery.
- Food plant hygiene; Cleaning, sterilizing, waste disposal methods, Food processing plant utilities, steam requirements in food processing, HACCP in food processing industries.

#### **Recommended Books:**

1. Food Engineering Operations. Elsevier. Brennan JG, Butters JR, Cowell ND and Lilly AEI 1990.
2. Unit Operations in Food Processing. Pergamon Press. Earle RL. 1985.
3. Food Processing Technology: Principle and Practice. VCH Publisher. Fellows P. 1988.
4. Transport Process and Unit Operations. Allyn & Bacon. Geankoplis JC. 1999.
5. New Methods of Food Preservation. Blackie Academic & Professional. Gould GW. 1996.
6. Hand Book of Food Engineering. Marcel Dekker. Heldman DR and Lund BD. 1992.
7. Unit Operations of Chemical Engineering. McGraw Hill. McCabe WL and Smith JC. 1999.
8. Unit Operation of Agricultural Processing. Vikas Publ. House. Sahay KM and Singh KK. 1994.
9. Fundamentals of Food Process Engineering. AVI Publisher. Singh RP 1991.
10. Introduction to Food Engineering. Academic Press. Singh RP and Heldman DR 1993.

### **AEFE604 Food Plant and Equipment Design**

- Physical properties of food materials, mass and energy balance calculations for preliminary estimation of plant capacity and equipment sizes, preparation of flow sheets for material movement and utility consumption in food plant.
- Selection of materials, design of storage vessels for foods, design of pressure vessels and design of vessel for drum drying, stress and strain calculation, fatigue.

- Performance characteristics and selection of fans, blowers, ejector compressors and vacuum pumps, performance characteristics and selection of centrifugal and positive displacement sanitary pumps, design of fluid conveyance system; pipe, sanitary pipe fitting and valves.
- Design of heat exchange equipment-plate, scraped surface and extended surface for heating and cooling of gas and liquid, design of evaporator calandria, vapor separator and condenser.
- Design considerations for location of food plant, equipment layout and ventilation in food process plants.

#### **Recommended Books:**

1. Unit Operations in Food Engineering. CRC Press, New York. Albert, I., and G.V. Barbosa-Canovas. 2002.
2. Transport Processes and Unit Operations. Prentice Hall of India Pvt. Ltd., New Delhi. Geankoplish, C.J. 2000.
3. Handbook of Food Engineering Practice. CRC Press, New York. Kenneth J. V., Enrique R., and Singh, R.P. 1997.
4. Machinery's Handbook. Industrial Press. Oberg, E., Jones, F.D., Horton, H.L., and Ryffel, H.H. 2008.
5. Introduction to Food Process Engineering. Academic Press. New York. Singh, R.P., and Heldman, D.R. 2004.
6. Food Process Design. CRC Press, New York. Zacharias B.M. and Saravacos, G.D. 2005.

#### **AEFE605 Project Management**

- Definition of Project, Need of Project Management, Project Development Cycle, Project Planning, Project Environment analysis, Project Report Preparation; Preliminary Screening, and Feasibility Report preparation and analysis
- Project Evaluation; Market and Demand analysis, Demand Forecasting, Technical, Financial, Socio-economic, Environmental and Entrepreneurial analyses of project, Project Selection Criteria, Project Implementation.
- Resource Planning and Allocation, Estimation of Project Cost, Cost of Capital, Means of Finance, Working Capital requirement, Profitability projection, Cash Flow Analysis, Breakeven analysis.
- Financial Analysis, Financial Statements, Balance Sheet, Ratio Analysis, Depreciation of Fixed Assets, Social Benefit-Cost Analysis
- Project Review Techniques, Network Technique, Programme Evaluation Review Technique (PERT), Network scheduling, CPM, Activity scheduling, Time-cost trade-offs

#### **Recommended Books:**

1. Project Management, R. Panneerselvam and P. Senthilkumar, PHI, New Delhi, 2009.
2. Project Management for Business and Technology, J.M. Nicholas, Pearson Education, New Delhi, 2009.
3. Project Formulation, Implementation and Appraisal, P. Chandra, Tata McGraw-Hill, New Delhi, 2006.
4. Financial Management, P. Chandra, Tata McGraw-Hills Publishing Co. Ltd., New Delhi,

5. Project Management, H. Kerzner, CBS Publisher and Distributor, New Delhi, 2004.

**AEFE606 Industrial Safety**

- Definition and classification of hazards. Hazardous materials: Classification, characteristics, means of exposure and health effect, disposal. Hazard information label, safety precautions
- Explosive and flammable materials: Types, classification, characteristics, safety signs, material handling. Engineering and administrative safety control
- Fire safety: Causes, safety concept, extinction methods, and fire-fighting equipment. Building safety: means of escape, evacuation strategies and procedure, fire and smoke prevention.
- Electrical hazards: Causes and types of electrical injuries, general electrical safety rules, PPE. Welding: Types, health hazards of welding, reducing hazards of welding
- Hazard communication, medical surveillance, safety legislation, safety management

**Recommended Books:**

1. Introduction to Fire Safety Management, A. Furness and M. Muckett, Butterworth-Heinemann, Oxford, 2010.
2. System Safety Engineering and Management, H. E. Roland and B. Moriarty, John Wiley and Sons Inc., New York, 1990.
3. Safety Engineering, James CoVan, Wiley, New York, 1995