M. Tech Programme in Food Process Engineering

Course Structure

Semester – 1st

A. Theory							
Sl no.	**Paper Code**	**Name of the Paper**	**Contact Period / Week**				**Credits**
			L	T	P	Total	
1.	FPE101	Transport Processes in Food Engineering	3	2	--	5	5
2.	FPE102	Novel Drying Technologies	3	2	--	5	5
3.	FPE103	Food Plant Equipment Design	2	2	--	4	4
4.	FPE104	Elective – I	3	2	--	5	5
					Total Theory	**19**	**19**
B. Practical							
5.	FPE105	Food Analysis Lab	--	--	3	3	2
6.	FPE106	Food Process Engineering Lab	--	--	3	3	2
7.	FPE107	Seminar - I	--	--	3	3	2
					Total Practical	**9**	**6**
					Total Semester	**28**	**25**

Semester – 2nd

A. Theory							
Sl no.	**Paper Code**	**Name of the Paper**	**Contact Period / Week**				**Credits**
			L	T	P	Total	
1.	FPE201	Separation Technology	2	2	--	4	4
2.	FPE202	Food Handling and Packaging	3	2	--	5	5
3.	FPE203	Non-thermal Food Processing Technologies	3	2	--	5	5
4.	MFPE204	Elective – II	3	2	--	5	5
					Total Theory	**19**	**19**
B. Practical							
5.	FPE205	Advanced Food Process Engineering Lab	--	--	3	3	2
6.	FPE206	Food Microbiology Lab	--	--	3	3	2
7	FPE206	Seminar - II	--	--	3	3	2
					Total Practical	**9**	**6**
					Total Semester	**26**	**24**

Semester – 3rd

A. Practical							
Sl no.	**Paper Code**	**Name of the Paper**	**Contact Period / Week**				**Credits**
			L	T	P	Total	
1.	FPE301	Thesis Part - I	--	--	--	--	15
2.	FPE302	Comprehensive Viva Voce	--	--	--	--	10
						Total Theory	**--**	**25**
						Total Semester	**--**	**25**

Semester – 4th

A. Practical							
Sl no.	**Paper Code**	**Name of the Paper**	**Contact Period / Week**				**Credits**
			L	T	P	Total	
1.	FPE401	Thesis Part - II	--	--	--	--	25
						Total Theory	**--**	**25**
						Total Semester	**--**	**25**

List of Electives (I & II)

1. Food Processing OperationsAnalysis
2. Food Safety and Quality Management
3. Non-destructive Food Quality Analysis
4. Tea Processing Technology
5. Food Extrusion Technology
6. Food Process Instrumentation
7. Fruit JuicePowder Technology

Detailed Syllabusfor M. Tech. in Food Process Engineering

Semester – 1st

FPE101: Transport Processes in Food Engineering

Unit 1: Heat Transfer- Fourier's law, conduction, convection and radiation heat transfer, steady state and transient heat transfer, heat transfer in Cartesian and cylindrical coordinates

Unit 2: Mass transfer, molecular diffusion, Fick's law, diffusion in solids, liquids and gases, effective moisture diffusion, heat and mass transfer analogy.

Unit 3: Equation of continuity, type of fluid flow and their classifications, Bernoulli's equation, pipe flow, channel flow, flow through porous media, Ergun's equation, and fluidization of solids, analytical and numerical solutions to transient state heat transfer.

Unit 4: Introduction of transport processes, viscosity and mechanism moment transport, thermal conductivity and mechanism of energy transport, diffusivity and mechanism of mass diffusivity, energy transport by radiation, different applications

Unit 5: Velocity distributions in laminar and turbulent flows, temperature distributions in solids and laminar and turbulent flows, concentration distributions in solids and laminar and turbulent flows, interphase transport

Reference

1. Bird, R.B., Stewart, W.E., and Lightfoot, E.N. 2001. *Transport Phenomena*. John Wiley and Sons. New York.
2. Datta, A. and Rakesh, V. 2009. *An Introduction to Modeling of Transport Processes*. Cambridge University Press, UK.
3. Geankoplish, C.J. 2000. *Transport Processes and Unit Operations*. Prentice Hall of India Pvt. Ltd., New Delhi.
4. Jorge, W., Jorge F.V., G.V. Barbosa-Canovas. 2003. *Transport Phenomena in Food Processing*. CRC Press. New York.
5. Jorge, W., Jorge, Fernando, V., and Barbosa-Canovas, G.V. 2003. *Transport Phenomena in Food Processing*. CRC Press, New York.
6. Saravacos, G.D., Zacharias, B. and Maroulis. 2001. *Transport Properties of Foods*. Marcel Dekker, New York.

7. Treybal, R. 1980. *Mass Transfer Operations*. 3rdEdn. McGraw-Hill. New Delhi.
8. Vassilis, G. 1992. *Transport Phenomena of Foods and Biological Materials.*CRC Press, New York.

FPE102: Novel Drying Technologies

Unit 1: Roult's law and water activity, equilibrium moisture content and latent heat of vaporization, temperature dependency of water activity, moisture sorption isotherms and their calculations

Unit 2: Microwave and radio frequency drying of foods, dielectric properties, MW drying process description, mechanism of MW drying, thermodynamic analysis, vacuum assisted microwave drying, equipment and applications

Unit 3: Intermittent drying, heat pump drying, heat pump assisted drying, general principles, applications

Unit 4: Superheated steam drying, novel spray drying, pulse combustion drying, principles and applications

Unit 5: Atmospheric freeze drying, combined/hybrid drying, drying of heat sensitive food products, principles and applications

References:

1. Chen, X.D. and Mujumdar, A.S. 2008. *Drying Technologies in Food Processing*, Black Willey Publishing Ltd. UK
2. Ian, T. 1997. *Mathematical Modeling and Numerical Techniques in Drying Technology*, Marcel Dekker, New York.
3. Kudra, T. andMujumdar, A. S. 2002.*Advanced Drying Technologies*, Marcel Dekker, New York.
4. Mujumdar, A.S. 2007. *Handbook of Industrial Drying*. CRC Press, Taylor & Francis, New York.
5. Passos, M.L. and Ribeiro, C.P. 2009. *Innovation in Food Engineering*. CRC Press, New York.
6. Tsotsas, E. and Mujumdar, A.S. 2012. *Modern Drying Technology* (Vol. 1 to 5). Willey – VCH, Germany
7.

FPE103: Food Plant Equipment Design

Unit 1: 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

Unit 2: 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

Unit 3: 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

Unit 4: 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

Unit 5: Design considerations for location of food plant, equipment layout and ventilation in food process plants

References:

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

FPE105:Food Analysis Lab

1. Color by reflective spectrophotometer
2. Refractive index of oil by Abbe Refractometer
3. Water activity and construction of MSI by dew point meter
4. Rheological behavior of Newtonian and Non-Newtonian liquids by Rheometer
5. Texture profile analysis by Texturometer
6. Fatty acid profile by Gas-Liquid Chromatograph
7. Flavor components by High Performance Liquid Chromatograph
8. Amylose in starch by Absorption Spectrophotometer
9. Measurement of fat particles after and before homogenization of milk
10. Measurement of whey protein denaturation

References:

1. H. Das, 2005. *Food Processing Operations Analysis*. Asian Book Publications, New Delhi.
2. Jha, S.N. 2012. *Nondestructive Evaluation of Food Quality: Theory and Practice*. Springer.
3. Soojin J. andJ. Irudayaraj. 2008. *Food Processing Operations Modeling: Design and Analysis*. CRC Press, New York.

FPE106: Food Processing Engineering Lab

1. Particle size analysis and energy requirement in comminution
2. High pressure homogenization of milk and the measurement of fat-globule size before and after homogenization
3. Rheological properties of Newtonian and non-Newtonian liquid food
4. Estimation and measurement of flow rate, power requirement and pressure developed in single screw extruder
5. Establishing the relationship between performance index and mixing time in a planetary mixer
6. Estimation and measurement of cut-off size of milk fat-globules in a disk type centrifugal separator
7. Determination of flow pattern, port arrangement and flow rate-pressure drop relationship in a plate heat exchanger
8. Saturation vapor pressure-temperature relationships for pure solvent and dilute solutions
9. Thermal bactericide to achieve commercial sterility of food in sealed containers
10. Dehydration of vegetables in cabinet tray dryer.

11. Drying of fruits and vegetables in vacuum dryer

References:

1. H. Das, 2005. *Food Processing Operations Analysis*. Asian Book Publications, New Delhi.
2. Ranganna, S. 2008. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw Hill, New Delhi

Semester – 2nd

FPE201:Separation Technology

Unit 1: Basic principles of separation techniques, strategies of downstream processing with optical references to plant metabolites, different techniques adopted for separation of bio-molecules

Unit 2: Chromatographic separation process, scale-up methods, large scale purification of bio-molecules, electrophoresis, chromatofocussing, supercritical fluid extraction, Liquid-liquid extraction

Unit 3: Membrane processing, membrane type, membrane modules, rating and performance, separation based on pressure, electro-potential, temperature, concentration

Unit 4: Electro-ultrafiltration, UF in presence of ultrasonic field, dynamic and vibratory membrane filter systems, membrane fouling

Unit: 5 Permeate flux, permeate flux and pore size, concentration polarization, estimation of transport model parameters, ATR-FTIR spectroscopy for membrane analysis, integrated membrane technology

References:

1. Cary, J. K. 19801. *Separation Processes*. McGraw-Hill Publications.
2. Fouad M. Khoury. 2000. *Predicting the Performance of Multistage Separation Processes*. CRC Press, New York.
3. J. D. Seader, Ernest J. Henley. 1998. *Separation Process Principles*. Wiley Publications.

4. Jack, S.W. 1999. *Separation Methods for Waste and Environmental Applications*. Marcel Dekker, UK.
5. Jimmy L. Humphrey, George E. Keller. 1997.*Separation Process Technology*. McGraw-Hill.
6. Philip A. Schweitzer. 1997. *Handbook of Separation Techniques for Chemical Engineers*. McGraw-Hill Publications.
7. Phillip C. Wankat. 2010. *Separation Process Engineering* (2nd Edn.), Prentice Hall, USA.

FPE202: Food Handling and Packaging

Unit 1: Overview of material handling system and devices in food processing plants, design of screw, bucket, belt, oscillating and vibratory conveyors

Unit 2: Packaging materials, their characteristics and properties, manufacture of plastic films, foils, laminates, retortable pouches, rigid plastic container paper and corrugated fibre board, design of shipping cartons and containers, rigid packaging using tin plate and aluminium

Unit 3: Design of aerosol container, metal tubes, glass containers and closures, labels and printing in packages, packaging requirement for different processed and unprocessed foods, e.g., cereal grains, baked foods, milk and dairy products, fish and meat, fresh fruits and vegetables

Unit 4: Principles of working of various type fillers: form- fill-seal machine, gas packaging and modified atmosphere package design, shelf life prediction of foods in packages, quality control in food packaging, product safety and packaging regulations.

Unit 5: Novel packaging technologies – edible packaging, smart packaging, active packaging, anti-microbial packaging, CA and MA packaging, nano-packaging

References:

1. Ahvenainen, R. 2003. *Novel Food Packaging Techniques*. CRC Press, Boca Raton, FL, New York.
2. Brady, A.L. 1989. *Controlled/Modified Atmosphere/Vacuum Packaging of Foods*. 2nd Edn. Food and Nutrition Press, Trumbull, CT.
3. Karel, M. and Lund, D.B. 2003. *Protective Packaging, Physical Principles of Food Preservation*, 2nd Ed. Marcel Dekker, New York.
4. Kilcast, D., and Subramaniam, P. 2000. *The Stability and Shelf life of Food*. CRC Press, Boca Raton, FL, New York.

5. Robertson, G.L. 2006. *Food Packaging: Principle and Practice*. Taylor and Francis, New York.
6. Rockland, L.B. and Beuchat, L.R. 1987. *Water Activity: Theory and Applications to Food*. Marcel Dekker, New York.

FPE203:Non-thermal Food Processing Technologies

Unit 1: Introductionto non-thermal processing, comparison of thermal and non-thermal processing,advantages and disadvantages of non-thermal processing

Unit 2: 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

Unit 3: 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

Unit 4: Food irradiation, ultravioletlight microbial inactivation byultrasound, magnetic field

Unit 5: Non-thermaltechnologycombinationwiththermaltechnologies, packaging requirements for non-thermal processed foods, food safety and regulations of non-thermal processed foods.

Reference:

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

FPE205: Advanced Food Processing Engineering Lab

1. Measurement of thermal conductivity, thermal diffusivity, emissivity and absorptiivty of solid and liquid foods.
2. Flow properties of food powders.
3. Food packaging material evaluation for water vapor transmission range, gas permeability (O_2,N_2 and CO_2), oil permeability, impact resistance, dry and wet strength.
4. Particle size analysis and energy requirement in communition.
5. J –factor analogy
6. Comparison of energyrequirement in vacuum drying and microwave drying
7. Estimation and measurement of flow rate, power requirement and pressure developed in single screw extruder.
8. Homogenization of milk and measurement of size of fat globules before and after homogenization. Estimation and measurement of cutoff size of fat.

References:

1. H. Das, 2005. *Food Processing Operations Analysis*. Asian Book Publications, New Delhi.
2. Ibtisam E. Tothill. 2011. *Rapid and On-Line Instrumentation for Food Quality Assurance*. Woodhead Publication, UK.
3. Jha, S.N. 2012. *Nondestructive Evaluation of Food Quality: Theory and Practice*. Springer.
4. Ranganna, S. 2008. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw Hill, New Delhi
5. Robertson, G.L. 2006. *Food Packaging: Principle and Practice*. Taylor and Francis, New York.
6. Singh, R.P., and Augusto G.M. 1989. *Food Properties and Computer-Aided Engineering of Food Processing Systems*. Kluwer Academic.

FPE 206: Food Microbiology Lab

1. Quantitative analysis of food for proximate composition
2. Determination of acidity and pH of food sample
3. Determination of total and reducing sugar
4. Estimation of mineral content in food sample (Ca, P)
5. Microscopic observation of bacteria, yeasts and moulds
6. Staining of micro-organisms
7. Quantitative estimation of bacteria, yeasts and moulds
8. Isolation and identification of micro organism

Suggested readings

1. S. Ranganna. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. McGraw Hill.