

University of North Bengal



First Draft of Syllabus

M.Sc in Food Technology

University of North Bengal
Department of Food Technology



M.Sc Syllabus in Food Technology

Duration 2 years (Four semesters)

Course curriculum

Semester I

| Core course | | | | |
|---|--------|---|------------|---------|
| Theoretical | | | | |
| Sl. no | Paper | Course Title | Full marks | Credits |
| 1. | FT 1.1 | Food Chemistry and Nutrition | 50 | 2 |
| 2. | FT 1.2 | Principles of Food Engineering | 50 | 2 |
| 3. | FT 1.3 | Food Microbiology | 50 | 2 |
| Practical | | | | |
| 1. | FT 1.4 | Food Chemistry and Nutrition | 25 | 1 |
| 2. | FT 1.5 | Principles of Food Engineering | 25 | 1 |
| 3. | FT 1.6 | Food Microbiology | 25 | 1 |
| Elective theory course to be chosen by students from any one of the listed papers | | | | |
| 1. | FT 1.7 | A. Computer applications in food industry | 75 | 3 |
| | | B. Advanced Microbial Technology | 75 | 3 |
| | | C. Nutraceuticals, Health foods and Specialty Foods | 75 | 3 |
| | | D. Food Toxicology | 75 | 3 |
| Continuing evaluation | | | | |
| 1. | FT 1.8 | Class test and Assignments | 50 | 2 |
| 2. | FT 1.9 | Seminar/ Journal Club | 50 | 2 |
| | | Total | 400 | 16 |

Semester II

| Core course | | | | |
|---|--------|--|------------|---------|
| Theoretical | | | | |
| Sl. no | Paper | Course Title | Full marks | Credits |
| 1. | FT 2.1 | Principles of Food Processing and Preservation | 50 | 2 |
| 2. | FT 2.2 | Post Harvest Technology horticultural crops | 50 | 2 |
| 3. | FT 2.3 | Instrumentation and Analytical Techniques | 50 | 2 |
| Practical | | | | |
| 1. | FT 2.4 | Principles of Food Processing and Preservation | 25 | 1 |
| 2. | FT 2.5 | Post Harvest Technology of horticultural crops | 25 | 1 |
| 3. | FT 2.6 | Instrumentation and Analytical Techniques | 25 | 1 |
| Elective theory course to be chosen by students from any one of the listed papers | | | | |
| 1. | FT 2.7 | A. Advances in statistical methods/ Biostatistics | 75 | 3 |
| | | B. Food ingredients and additives | 75 | 3 |
| | | C. Technology of Cereals, Pulses and Oilseeds | 75 | 3 |
| | | D. Technology of meat, poultry and fish processing | 75 | 3 |
| Continuing evaluation | | | | |
| 1. | FT 2.8 | Class test and Assignments | 50 | 2 |
| 2. | FT 2.9 | Seminar/ Journal Club | 50 | 2 |
| | | Total | 400 | 16 |

Semester III

| Core course | | | | |
|---|--------|---|------------|---------|
| Theoretical | | | | |
| Sl. no | Paper | Course Title | Full marks | Credits |
| 1. | FT 3.1 | Food Fermentation and Bioprocess Technology | 50 | 2 |
| 2. | FT 3.2 | Dairy Engineering/ processing of milk and milk products | 50 | 2 |
| 3. | FT 3.3 | Technology of Food Packaging | 50 | 2 |
| Practical | | | | |
| 1. | FT 3.4 | Food Fermentation and Bioprocess Technology | 25 | 1 |
| 2. | FT 3.5 | Dairy Engineering/ processing of milk and milk products | 25 | 1 |
| 3. | FT 3.6 | Technology of Food Packaging | 25 | 1 |
| Elective theory course to be chosen by students from any one of the listed papers | | | | |
| 1. | FT 3.7 | A. Beverage and Snacks Food Technology | 75 | 3 |
| | | B. Advanced Food Biotechnology | 75 | 3 |
| | | C. Waste management in Food Industry | 75 | 3 |
| | | D. Food Physics | 75 | 3 |
| Continuing evaluation | | | | |
| 1. | FT 3.8 | Class test and Assignments | 50 | 2 |
| 2. | FT 3.9 | Seminar/ Journal Club | 50 | 2 |
| | | Total | 400 | 16 |

Semester IV

| Core course | | | | |
|---|--------|---|------------|---------|
| Theoretical | | | | |
| Sl. no | Paper | Course Title | Full marks | Credits |
| 1. | FT 4.1 | Food Safety, Quality Control and Sensory Evaluation | 50 | 2 |
| 2. | FT 4.2 | Dissertation/ Review work | 175 | 7 |
| Elective theory course to be chosen by students from any one of the listed papers | | | | |
| 1. | FT 4.3 | A. Food Business management and Entrepreneurship | 75 | 3 |
| | | B. Bioethics and Intellectual Property Rights | 75 | 3 |
| | | C. Food Product Development | 75 | 3 |
| | | D. Food Rehology | 75 | 3 |
| Continuing evaluation | | | | |
| 1. | FT 4.4 | Industrial visit/Field Study/Summer Training | 50 | 2 |
| 2. | FT 4.5 | Seminar/ Journal Club/Assignments/Class test | 50 | 2 |
| | | Total | 400 | 16 |

Per Semester 16 credits = 9 credits in Core course + 3 credits in elective + 4 credits in continuing evaluation.

Total credits 16x4 Semester = 64 credits

1 credit = 25 marks

Total marks = 64 credits x 25 = 1600

1 credit = 1 hour Theory class

1 credit = 2 hour Practical class

Semester I

FT.1.1. Food Chemistry and Nutrition

Unit I

Food chemistry- definition, scope and importance; major food constituents and their physicochemical properties; role of water in food.

Unit II

Carbohydrates in food: role and use of carbohydrates, chemical and functional properties of carbohydrates in food, starch and its modification, application in food and allied industries

Lipids in food: role and use of lipids in food, physicochemical properties of lipase, chemistry of rancidity, role of antioxidants, chemistry and technology of processing of fats and oils, and hydrogenation, effect of processing on functional properties and nutritive values of lipids.

Proteins and Amino acids in food: physical and chemical properties of food proteins, functional and nutritional properties of proteins.

Enzymes: Nature, classification and properties of food enzyme, enzyme activity in different food systems, commercial availability. Food enzyme technology, immobilization of enzymes, removal of toxicants through enzymes, flavor production by enzymes.

Browning reaction in foods: Enzymatic and Non-Enzymatic browning in foods of vegetable and animal origin during storage and processing of foods

Unit III

Vitamins and minerals- Vitamins and mineral requirements and allowances, enrichment, restoration and fortification, general causes for loss of vitamins and minerals, Deteriorative reactions, optimization of nutrient retention, vitamin losses in storage, chemical properties of vitamins and minerals- water soluble vitamins.

Unit IV

Pigments and flavours- Chlorophyll, Myoglobin and Haemoglobin, Anthocyanins, Flavanoids, Carotenoids, Tannins, Quinones and Xanthenes

Flavours – Definition, flavor and nutrition, flavours and flavourings in food- source, extraction of flavourings, essential oils and oleoresins, flavor delivery systems, flavor modifiers.

Anti-oxidants, allergens, toxins and anti-nutritional factors in foods

Unit V

Food groups and their typical composition; essential nutrients- sources, functions, deficiency diseases; requirements and recommended dietary allowances; digestion, absorption, transport and metabolism of nutrients in human system; protein quality evaluation

FT.1.4. Practical

1. Determination of moisture in foods.

2. Determination of protein in foods.
3. Determination of fat in foods.
4. Determination of total ash in foods.
5. Determination of crude fiber and minerals in foods.
6. Estimation of reducing, non-reducing, total sugars in foods.
7. Estimation of starch in foods..
8. Determination of ascorbic acid and beta-carotene in foods.
9. Determination of pH and acidity of foods.
10. Estimation of calcium, phosphorus and iron in foods.

FT.1.2. Principles of Food Engineering

Unit I

Introduction to food engineering & processes: principles of thermodynamics and heat transfer applied to food engineering; fundamentals of heat and analogy to mass transfer in food processing.

Unit II

Kinetics of biological reactions - kinetics of reactions occurring in processed foods, reaction velocity constant, order of reaction; quality changes during storage of foods; application of Arrhenius equation to biological reactions.

Unit III

Method for thermal process evaluation - Commercial sterility, pasteurization and sterilization methods based on slowest heating region; determination of the process time based on region of greatest temperature lag; the process equivalence in terms of minutes at 121.1°C; calculation of process time for fluids on stream line flow and turbulent flow heated in heat exchangers; general introduction to aseptic canning process, hydrostatic sterilizer and aseptic packaging practices and design problems.

Unit IV

Food chilling and freezing – Precooling and cold storage; CA and MA; Properties of frozen foods; freezing point depression; general introduction to enthalpy change during freezing; Plank's equation for predicting rates of product freezing; Cryogenic freezing and IQF; design of food freezing equipment such as air blast freezers, plate freezers and immersion freezers.

Unit V

Process Heat Transfer - Modes of heat transfer and overall heat transfer; thermal properties of foods such as specific heat and thermal conductivity; Fourier's law, steady state and unsteady state conduction; heat exchange equipment; energy balances; rate of heat transfer; thermal boundary layer; heat transfer by forced convections; heat transfer to flat plate and in non Newtonian fluids; heat transfer in turbulent flow; heating and cooling of fluids in forced convection outside tubes; natural convection.

FT.1.5. Practical

1. Determination of viscosity of Newtonian fluid, Non Newtonian fluids

2. Design of pumping systems; Determination of thermal properties of foods such as thermal conductivity, thermal diffusivity, calorific value and specific heat.
3. Calculation of freezing time for some typical foods.
4. Study of different types of freezers; Calculation of thermal process time in canning of some foods.
5. Determination of 'U' for PHE; Determination of 'U' for SSHE; Study of blast freezer.
6. Visit to Food Processing Plants.

FT.1.3. Food Microbiology

Unit I

Microbiology: Introduction, historical developments in food microbiology; prokaryotes and eukaryotes; classification of microorganisms- a brief account; sources of microorganisms in foods; microbial growth, growth curve; factors affecting growth-intrinsic and extrinsic factors controlling growth of microorganisms.

Unit II

Growth and survival of microorganisms in foods; spoilage organisms of milk, fruits, vegetables, grains and oilseeds, meat and poultry.

Unit III

Physical and chemical methods to control microorganisms.

Unit IV

Food hygiene and sanitation: Contamination during handling and processing and its control; indicator organisms; Methods of isolation and detection of microorganisms or their products in food; conventional methods; rapid methods (newer techniques) - immunological methods; fluorescent, antibody, radio immunoassay, principles of ELISA, PCR (Polymerized chain reactions).

Unit V

Food Fermentations; Traditional fermented foods of India and other Asian countries; Probiotics and prebiotics; Fermented foods based on milk, meat and vegetables; Fermented beverages.

Unit VI

Indicators microorganisms; microbiological criteria of foods and their significance; the HACCP system and food safety used in controlling microbiological hazards, applications of hurdle technology for controlling microbial growth.

FT.1.6. Practical

1. Microscopic examination of bacteria, and yeast and molds from food.
2. Detection and enumeration of indicator and index organisms for foodborne pathogenesis (MPN of coli forms).
3. Standard plate count of food sample.

4. To study the microflora of Curd.
5. Enumeration of physiological groups- psychrophile, thermotolerants, osmophiles and halophiles.
6. Evaluation of microbiological quality of commonly consumed street foods.
7. Determination of milk quality by Methylene blue reductase test (MBRT).
8. Demonstration of available rapid methods and diagnostic kits used in identification of microorganisms or their products.

FT.1.7. A. Computer applications in food industry

Unit I

Introduction to Computer (Hardware / Software), Microsoft Word and its applications (Documentation and Formatting, MS Excel and its applications (Making Tabular data, charts & formatting, Use of general functions & formulae) MS PowerPoint and its applications (Creating own design, design & formatting of a presentation, Use of Image, audio, video in the presentation)

Unit II

Importance of Computerization and IT in Food Industries Computers, operating environments and information systems for various types of food industries; Principles of Communication.

Unit III

Role of Computer in Optimization: Introduction to operation Research; A Computer Oriented Algorithmic approach; Queuing systems and waiting models; PERT, CPS and CPM.

Unit IV

Food Process Modeling and Simulation; CAD and CAM in Food Industry: instrumentation, process Control, inventory Control, Automation, Robotics, Expert system and artificial intelligence.

FT. 1.7.B. Advanced Microbial Technology

Unit I

Morphology and physiology of industrial microorganisms (Bacteria, yeasts, molds and actinomycetes).

Unit II

Growth and cell division: Measurement of growth (direct and indirect) and factors affecting growth, growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth. Isolation: identification and quantitative estimation of microorganisms. Pure culture technique
Cultivation of microbes: aerobic, anaerobic and facultative.

Unit III

Microbiological assay in Microbial nutrition.

Genetics of some industrial microorganisms, Microbiology of soil, Selection, development and maintenance of cultures.

Unit IV

Chemistry and biosynthesis of microbial products e.g. vitamins, amino acids, enzymes, steroids, antibiotics and polymers.

Unit V

Metabolic regulations in industrial fermentation. Microbial transformation of alkanes, alkaloids, terpenes, aromatic compounds and naturally occurring polymers.

Unit VI

Microbial food production. Spoilage microorganisms in foods and their control. Applied microbiology in animal nutrition. Microbial insecticides.

FT.1.7. C. Nutraceuticals, Health foods and Specialty Foods**Unit I**

Introduction to nutraceuticals: definitions, synonymous terms, basis of claims for a compound as a nutraceutical, regulatory issues for nutraceuticals including CODEX.

Unit II

Concept of angiogenesis and the role of nutraceuticals/functional foods; Nutraceuticals for cardiovascular diseases, cancer, diabetes, cholesterol management, obesity, joint pain, immune enhancement, age-related macular degeneration, endurance performance and mood disorders – compounds and their mechanisms of action, dosage levels, contraindications if any etc.

Unit III

Manufacturing aspects of selected nutraceuticals such as lycopene, isoflavonoids, prebiotics and probiotics, glucosamine, phytosterols etc.; formulation of functional foods containing nutraceuticals – stability and analytical issues, labelling issues.

Unit IV

Clinical testing of nutraceuticals and health foods; interactions of prescription drugs and nutraceuticals; adverse effects and toxicity of nutraceuticals; nutrigenomics – an introduction and its relation to nutraceuticals.

Unit V

Specialty food based on ease in preparation cost health benefits; Functional foods, Convenience food, Health care and medical benefits. Specialty foods based on sources; Cereals and millets, Legumes and pulses, Fruits and vegetables, Animal food sources, By product based, Non conventional foods.

Unit VI

Specialty food based on genetics; Genetically modified foods, Transgenic foods, Biotechnological aspects of detoxification. Proprietary foods. Supplementary foods.

Unit VII

Specific consumer oriented foods; Defence persons, Space / astronaut, High altitude mountain climbers, Disaster situation – crises, care, maintenance. Specialty foods based on growing condition -organic, inorganic farming.

FT.1.7.D. Food Toxicology

Unit I

Definition scope and general principles of food toxicology; manifestation of toxic effects; classification of food toxicants; factors affecting toxicity of compounds; methods used in safety evaluation-risk assessments.

Unit II

Toxicants and allergens in foods derived from plants, animals, marine, algae & mushroom; Microbial toxins; Food Poisoning; Food borne infections and disease.

Unit III

Derived Food toxicants- Processing & Packaging; Toxicants generated during food processing such as nitrosamines, acrylamide, benzene, dioxins and furans; persistent organic pollutants.

Unit IV

Toxicology & food additives; Toxicological aspects of nutrient supplements; Chemicals from processing such as fumigants, chlorinated solvents, autoxidation products, carcinogens in smoked foods and pyrolysis, agrochemicals; heavy metals; intentional and unintentional additives.

Semester II

FT.2.1. Principles of Food Processing and Preservation

Unit I

Basic concept of food processing and preservation: Reason of food Spoilage and Scope of food processing preservation; principles of food processing and preservation.

Unit II

Processing and preservation by heat: (blanching, pasteurization, sterilization, UHT processing, heating, dehydration, canning, Microwave cooking-(principle, changes during microwave cooking, advantages), difference between microwave and conventional heating. Microwave and radio frequency processing: Definition, Advantages, mechanism of heat generation, application in food processing: microwave blanching, sterilization and finish drying.

Unit III

Refrigeration storage: requirements of refrigeration storage, changes of foods during refrigeration storage, refrigeration load, chilling and refrigeration, cold storage. Freezing and frozen storage: freezing curves, slow and quick freezing, factors determining freezing rate, freezing methods, changes in food during freezing, frozen food storage, freeze drying in food processing

Unit IV

Water activity: role of water activity in food preservation, intermediate moisture foods (IMF), principles, characteristics, advantages and problems of IM foods.

Food frying: general principles, frying process; shallow frying and deep frying, frying oils, factors affecting oil uptake during frying.

Chemical Preservation: Preservation of foods by use of sugar, salt, chemicals and antibiotics and by smoking.

Concentration: Application in food industry processes and equipment for manufacture of various concentrated foods and their keeping quality.

Fermentation: Applications in preservation of food; pickling; curing etc.

Unit V

Newer techniques in food processing: Application of technologies of high intensity light, pulse electric field, ohmic heating, IR heating, inductive heating and pulsed X-rays in food processing and preservation.

Nanotechnology: Principles and applications in foods.

Cryogenic grinding- Properties of cryogenics, systems, and their different.

Hurdle technology: concept of hurdle technology and its application, Ultrasonic processing: Properties of ultrasonic, application of ultrasonic as processing techniques,

Unit V

Food processing equipments: material handling, cleaning and grading, conveyors, size reduction, food grain storage, milling, Separation Technique: filtration, agitation and mixing. Baking, Roasting, Frying. Extrusion Technology-(principle, types of extruders).

FT.2.4.Practical

1. To determine the use of different chemicals for food preservation
2. To evaluate the characteristics of treated water using RO system
3. To carry out ultrafiltration study on fruit juices
4. To study microwave system and to evaluate the effect of different power on drying characteristics of selected vegetable product
5. To study microwave blanching of fruits and vegetable and determination of blanching efficacy
6. To study the ultrasonicator and evaluate the effect of ultrasonication on micro-organism present in idli batter
7. To study the ultrasonicator and to evaluate the effect of ultrasonication on extracted juice yield from fruit pomace
8. To study cryogenic grinding of selected spices
9. To compare the yield and quality of bioactive compounds obtained from cryogenically ground spice
10. To prepare nano emulsion and study of their characteristics
11. To study ohmic heating system and to study the processing of fruit pup using ohmic heating system
12. To visit food industries utilizing advance food processing techniques

FT.2.2. Post harvest technology of horticultural crops

Unit I

Importance & scope of post harvest management of fruits and vegetables in Indian economy. Morphology, structure and composition of fruits and vegetables; maturity indices and standards for selected fruits and vegetables; methods of maturity determinations.

Unit II

Harvesting and handling of important fruits and vegetables, Harvesting tools and their design aspects; Field heat of fruits and vegetables and primary processing for sorting and grading at farm and cluster level; factors affecting post harvest losses; Standards and specifications for fresh fruits and vegetable. Role of plants growth regulators in relation to storage; physical and chemical treatment to increase the shelf-life, conditions for transportation and storage, disease and injuries during marketing.

Unit III

Physiological post harvest disorders - chilling injury and disease; prevention of post harvest diseases and infestation; Handling and packaging of fruits and vegetables; Post Harvest handling system for fruits and vegetables of regional importance such as citrus, mango, banana, pomegranate, tomato, papaya and carrot etc., packaging house operations; principles of transport and commercial transport operations.

Unit IV

Post-harvest physiological and biochemical changes in fruits and vegetables; ripening of climacteric and non-climacteric fruits; regulations, methods; Storage practices: CA and MA, hypobaric storage, pre-cooling and cold storage, Zero energy cool chamber; Commodity pretreatments - chemicals, wax coating, prepackaging, VHT and irradiation.

Preservation by freezing, general methods for freezing of fruits and vegetables; problem relating to storage of frozen products; standards for frozen food products.

Dehydration of fruits and vegetables: Methods; packaging, storage, quality control during and after dehydration.

Unit V

Storage of fresh fruits and vegetables. Containers: Tin, glass and other packaging materials used in fruits and vegetables preservations. Canning and bottling: quality of raw materials, preparation of materials, preparation of syrups and brines, canning and bottling, effect of canning and bottling on nutritive value, spoilage of canned foods, detection and control.

Fruit and vegetable juices: Preparation of juice, syrups, squashes, cordials, and nectars; concentrations and drying of juice, packaging and storage and concentrations and powders; fortified and soft drinks.

Preparation of preserve and candied fruits

Unit VI

Pickles and chutneys: Preparation of various types of pickles- theory and practice; preparation of sauces and chutneys; problems relating to the shelf life of pickles and chutneys; quality control.

Tomato products: preparation of various tomato products, food standards and quality control.

Pectin: Raw materials; processes and uses of pectin; products based on pectin manufacture and quality control.

F.T. 2.5.Practical

1. Analysis of canned food products for chemical and microbiological spoilage.
2. Determination of Ascorbic acid content in food products
3. Determination of lycopene content
4. Determination of tannins in food products.

5. Dehydration of fruits and vegetables
6. Preparation of tomato products like ketchup, puree & past
7. Preparation of Jam, Jelly, marmalade, preserve and fruit candy
8. Pectin determination in fruits and vegetable products.
9. Determination of chemical preservatives in fruits and vegetables products.
10. Preparation and analysis of fruits beverages i.e. Squash and cordial.
11. Use of flame photometry in the estimation of trace metals like Sodium and Potassium
12. Visit to commercial packaging house – grape, mango and pomegranate; Visit to commercial storage structures- Onion, garlic and potato.

FT. 2.3. Instrumentation and Analytical Techniques

Unit I

Nature and Concept of Food analysis, Basic instrumentation: Principle for pH meter, Dialysis, ultra filtration, Reverse osmosis. Centrifugation: Principle, Theory (RCF, Sedimentation coefficient) and types of Rotors, Ultracentrifugation, Calorimetry: Bomb calorimeter, Principle of Rheological Analysis- Rheological parameters, rheological methods, instruments and application, Texture profile analysis, Densimetry, Refractometry.

Preparation of Chemical solutions: Concept of molar, molal, and normal solutions, pH and Buffers; importance and measurement of pH.

Unit II

Chromatographic Techniques: General principles. Types of Chromatography, Partitions and adsorption chromatography, Paper, TLC, gas liquid, ion exchange and affinity chromatography. Gel filtration, high pressure liquid chromatography (HPLC).

Unit III

Electrophoretic Techniques: General principles. Gel Electrophoresis. Polyacrylamide Gel Electrophoresis (PAGE), SDS (Sodium dodecyl sulphate), - PAGE Denaturing gradient gel electrophoresis (DGGE).

Unit IV

Spectroscopy: Beers and Lambert's Law. General principles of colorimeters and spectrophotometers (UV-visible, IR, FTIR, NMR, Mass)

Unit V

Flame photometry: atomic absorption spectrophotometry Carbohydrates: Qualitative and quantitative measures for reducing and non-reducing sugars, starch and fiber.

Fats: Physicochemical-extraction and separation procedures, quantitative measures for various lipids.

Unit VI

Proteins: Physico-chemical properties, extraction and separation procedures, and quantitative measures for total proteins, amino acids and enzymes.

Vitamins: Colorimetric Fluorimetric, Microbiological, Chromatographic and other methods for estimation of various vitamins.

Unit VII

Membrane Techniques: Reverse osmosis, Ultra filtration, electrodialysis. Types of system design (a) continuous process (b) Batch process (c) feed and bleed process (d) Internally staged process.

FT.2.6. Practical

1. Sorption isotherms by measuring water activity in any hygroscopic food material (for instance - biscuits/potato chips/coffee powder)
2. Column chromatography: Separation of beta carotene
3. Use of electrophoresis in the determination of proteins.
4. Determination of Rheological properties by using texture analyzer.
5. Separation and identification of sugars in fruit juices;
6. Separation of proteins by ion-exchange chromatography;
7. Separation and identification of carotenoids by column chromatography.
8. Fatty acid analysis using GC.
9. Identification and determination of organic acids by HPLC.
10. Analysis of dietary fibre/glucose by enzymatic method.
11. Heavy metal analysis using atomic absorption spectrometry

FT. 2.7.A. Advances in statistical methods/ Biostatistics

Unit I

Descriptive statistics, Mean, variance, probability, conditional probability, Probability distribution.

Unit II

Density functions, Mean variance.

Unit III

Data and its nature; data representation; diagrams and graphs using MSExcel, Measures of Central tendency; Dispersion, Swekness and Kurtosis; Binomial and Normal Distributions.

Unit IV

Theoretical Probability Distribution: Binomial, Poisson and normal distribution; Testing of Hypothesis: Null and Alternative Hypothesis, level of significance, Student 't' distribution and its application, Chi-square(χ^2) test & its application, 'f' test and its application.

Unit V

Correlation, Regression and ANOVA analysis: Types of correlation; simple, partial and multiple correlation, Method of study & testing the significance of correlation coefficient, Rank Correlation, Regression analysis: regression equations and regression lines, Properties of regression lines, regression coefficient, testing the significance of regression coefficient. Analysis of variance (ANOVA): One way and two way classification and their applications.

Unit VI

Use of different Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

FT.2.7.B. Food ingredients and additives

Unit I

Food additives- definitions, classification and functions, need for food additives, food preservatives, classifications, antimicrobial agents (types, mode of action and their application), safety concerns, regulatory issues in India, international legal issues

Unit II

Antioxidants (synthetic and natural, mechanism of oxidation inhibition), chelating agents: types, uses and mode of action

Coloring agents: color retention agents, applications and levels of use, natural colorants, sources of natural color (plant, microbial, animal and insects), misbranded colors, color extraction techniques, color stabilization

Unit III

Flavour technology: Types of flavours, flavours generated during processing – reaction flavours, flavour composites, stability of flavours during food processing, analysis of flavours, extraction techniques of flavours, flavour emulsions; essential oils and oleoresins; authentication of flavours etc.

Unit IV

Sweeteners: natural and artificial sweeteners, nutritive and non-nutritive sweeteners, properties and uses of saccharin, acesulfame-K, aspartame, corn sweeteners, invert sugar sucrose and sugar alcohols (polyols) as sweeteners in food products

Emulsifiers: Types, selection of emulsifiers, emulsion stability, functions and mechanism of action.

Unit V

Nutrient supplements & thickeners, polysaccharides, bulking agents, antifoaming agents, synergists, antagonists. Additives, food uses and functions in formulations; permitted dosages, indirect food additives; harmful effects/side effects associated with various additives (various diseases), additives and natural alternatives

FT. 2.7.C. Technology of Cereals, Pulses and Oilseeds

Unit I

General introduction and production and utilization trends; Structure and composition of common cereals, pulses and oilseeds.

Unit II

Wheat: Types and physicochemical characteristics; wheat milling - products and byproducts; factors affecting quality parameters; physical, chemical and rheological tests on wheat flour; additives used in bakery products; flour improvers and bleaching agents; manufacture of bakery products (bread, biscuits etc), pasta products and various processed cereal-based foods for infants; manufacture of whole wheat *atta*, blended flour and fortified flour.

Unit III

Rice: Classification, physicochemical characteristics; cooking quality; rice milling technology; by- products of rice milling and their utilization; Parboiling of rice- technology and effect on quality characteristics; aging of rice - quality changes; processed products based on rice.

Unit IV

Corn: Types and nutritive value; dry and wet milling, manufacture of value-added products; manufacture of corn flakes, corn syrup, cornstarch, corn steep liquor, corn oil and canned corn. Composition and processing of barley, oats, sorghum and millets.

Unit V

Legumes and oilseeds: composition, anti-nutritional factors, processing and storage; processing for production of edible oil, meal, flour, protein concentrates and isolates; extrusion cooking technology; snack foods; development of low cost protein foods.

Unit VI

By-products utilisation of cereal process industry. Cereal based animal feed, wheat germ, corn oil. Storage of cereal grain. Insect infestation control measures.

Detection of insect and rodent infestation of cereals.

FT.2.7.D. Technology of meat, poultry and fish processing

Unit I

Meat composition from different sources; muscle structure and compositions; post-mortem muscle chemistry; meat colour and flavours; meat microbiology and safety.

Unit II

Modern abattoirs, typical layout and features, Ante-mortem handling and design of handling facilities; Hoisting rail and traveling pulley system; stunning methods; steps in slaughtering and dressing; offal handling and inspection; inedible by-products; operational factors affecting meat quality; effects of processing on meat tenderization; abattoir equipment and utilities

Unit III

Chilling and freezing of carcass and meat; canning, cooking, drying, pickling, curing and smoking; prepared meat products like salami, kebabs, sausages, sliced, minced, corned; intermediate moisture and dried meat products; meat plant hygiene – GMP and HACCP; Packaging of meat products.

Unit IV

Poultry industry in India, measuring the yields and quality characteristics of poultry products, microbiology of poultry meat, spoilage factors; Lay-out and design of poultry processing plants, Plant sanitation; Poultry meat processing operations, equipment used – Defeathering, bleeding, scalding etc.; Packaging of poultry products, refrigerated storage of poultry meat, by products – eggs, egg products, Whole egg powder, Egg yolk products, their manufacture, packaging and storage.

Unit V

Commercially important marine products from India; product export and its sustenance; basic biochemistry and microbiology; preservation of postharvest fish freshness; transportation in refrigerated vehicles; deodorization of transport systems; design of refrigerated and insulated trucks; grading and preservation of shell fish; pickling and preparation of fish protein concentrate, fish oil and other by products

Semester III

FT.3.1. Food Fermentation and Bioprocess Technology

Unit I

Fermentation: History, definition and types. Isolation screening and genetic improvement of industrially important organisms.

Unit II

Study of a Bio fermentor – its design and operation; Its measurement and control in fermentation, Aeration and agitation in fermentation: Oxygen requirement, sterilization of air and media; scale up in fermentation. Various types of fermentation systems (submerged, surface and solid state fermentation)

Unit III

Down Stream Processing and Product recovery. Recovery of particulate matter, product isolation, distillation, centrifugation, whole broth processing, filtration, aqueous two-phase separation, solvent extraction, chromatography and electrophoresis.

Unit IV

Fermentation substrates, Principles and production of amino acids, enzymes, nucleotides, organic acids, food colours, alcoholic beverages, vinegar, Bioinsecticides, Biofertilizers.

Unit V

Principles and production of microbial proteins, antibiotics and vitamins –properties and applications; mushroom cultivation.

Unit VI

Production of fermented foods: Dairy products (*Acidophilus* milk, Cheese, Yogurt, *Dahi*, *Chhurpii*), Dairy Fermentations-starter cultures and their types, Meat and fishery products (Dry sausages and Fish sauces); other products (Cocoa beans, Coffee beans, Sauerkraut, Soy sauce, Tempe and Idli, *Kinema*, *Gundruk*); Breads; Beverages(Cider, Sake and Plum wines). Concept of probiotics.

FT.3.4. Practical

1. Isolation and characterization of microorganisms from fermented foods.
2. Production of alcohol by fermentation from molasses.
3. Preparation of baker's yeast using molasses.
4. Microbial production of amylase (Solid, Liquid & Submerged fermentation).
5. Production of curd with respect to microbial load and organic acid formation.
6. Study the steps in Mushroom production.

FT.3.2. Dairy Engineering/ processing of milk and milk products

Unit I

Present status of milk & milk products in India and Abroad; market milk- Composition of milk of various species, Factors affecting composition of milk. quality evaluation and testing

of milk, procurement, transportation and processing of market milk, cleaning & sanitization of dairy equipments.

Special milks such as flavoured, sterilized, recombined & reconstituted toned & double toned.

Unit II

Condensed milk- Definition, methods of manufacture, evaluation of condensed & evaporated milk; dried milk- Definition, methods of manufacture of skim & whole milk powder, instantiation, physiochemical properties, evaluation, defects in dried milk powder.

Unit III

Cream- Definition, classification, composition, cream separation, sampling, neutralization, sterilization, pasteurization & cooling of cream, evaluation, defects in cream; Butter- Definition, composition, classification, methods of manufacture, theories of churning, evaluation, defects in butter.

Unit IV

Technology of frozen milk products: Ice cream- Definition, composition and standards, nutritive value, classification, methods of manufacture, evaluation, defects in ice cream, and technology aspects of softy manufacture, packaging, storage and marketing of ice cream, ices, sherbets etc. defects of frozen products and their control.

Unit V

Cheese: Definition, composition, classification, methods of manufacture of hard, semi hard, soft and processed cheeses. Storage, grading and marketing of cheese, cheese defects and their control.

Unit VI

Indigenous milk products - Present status, method of manufacture of *yoghurt, dahi, Chhurpi* (Hard, Soft, Dudh), *khoa, burfi, kalakand, gulabjamun, rosogolla, srikhand, chhana, paneer, ghee, lassi* etc; probiotic milk products.

Unit VII

Applied biochemical kinetics of pasteurisation sterilisation of milk, Equations related to transfer of mass, heat and momentum in milk and milk product processing, Efficiency and dairy plant mechanisation, Critical path planning and management of dairy industry.

FT.3.5. Practical

1. Plat form test for raw milk
2. Determination of moisture content in milk
3. Test of adulteration, Fat, SNF, ash, Fat protein, AC, FFATBA value, Lactose contain, Solubility
4. Determination of milk quality (MBRT).
5. Determination of fat content in Milk powders and ice-cream products
6. Determination of Milk adulterants: Starch, Urea, Formaldehyde and Sugar Hydrogen peroxide, salt and detergent
7. Preparation of toned, homogenized, fortified, reconstituted and flavored milk
8. Manufacture of fermented milks.
9. Manufacture of butter
10. Manufacture of ice- cream, ices, sherbets.

11. Sensory analysis of food products: Paired comparison test, Duo-trio test, Hedonic test, Triangle test, Ranking test, Single sample test, Composite scoring test,
12. Analysis of water used in food industries i.e. Alkalinity, Acidity, Hardness, pH, TPC and Coliform count.

FT. 3.3. Technology of Food Packaging

Unit I

Definitions, objectives and functions of packaging and packaging materials; Packaging requirements and selection of packaging materials; Types of packaging materials: Paper: pulping, fibrillation and beating, types of papers and their testing methods; Glass: composition, properties, types of closures, methods of bottle making; Metals: Tinfoil containers, tinning process, components of tinfoil, tin free steel (TFS), types of cans, aluminum containers, lacquers; Plastics: types of plastic films, laminated plastic materials, co-extrusion, edible films, biodegradable plastics.

Unit II

Properties of materials such as tensile strength, bursting strength, tearing resistance, puncture resistance, impact strength, tear strength, their methods of testing and evaluation; Barrier properties of packaging materials: Theory of permeability, factors affecting permeability, permeability coefficient, gas transmission rate (GTR) and its measurement, water vapour transmission rate (WVTR) and its measurement, prediction of shelf life of foods, selection and design of packaging material for different foods.

Unit III

Food packaging systems: Different forms of packaging such as rigid, semirigid, flexible forms and different packaging system for (a) dehydrated foods (b) frozen foods (c) dairy products (d) fresh fruits and vegetables (e) meat, poultry and sea foods.

Unit IV

Packaging equipment and machinery: Vacuum, CA and MA packaging machine; gas packaging machine; seal and shrink packaging machine; form and fill sealing machine; aseptic packaging systems; bottling machines; carton making machines.

FT.3.6. Practical

1. Identification and testing of packaging materials; Determination of wax from wax paper; Testing of lacquered tin plate sheets
2. Measurement of tin coating weight by Clarke's method; To perform sulphide stain test
3. To conduct ferricyanide paper test for porosity
4. Determination of equilibrium moisture content
5. Grading of glass bottles for alkalinity
6. Determination of water vapour transmission rate of packaging material;
7. To perform vacuum packaging of food sample and carry out its storage study
8. Testing the compression strength of the boxes
9. Packaging the food material in seal and shrink packaging machine and study its shelf life
10. Testing the strength of glass containers by thermal shock test.
11. Testing the strength of filled pouches by drop tester.

FT. 3.7.A. Beverage and Snacks Food Technology

Unit I

Types of beverages and their importance; status of beverage industry in India; Manufacturing technology for juice-based beverages; synthetic beverages; technology of still, carbonated, low-calorie and dry beverages; isotonic and sports drinks; role of various ingredients of soft drinks, carbonation of soft drinks.

Unit II

Specialty beverages based on tea, coffee, cocoa, spices, plant extracts, herbs, nuts, dairy and imitation dairy-based beverages.

Unit III

Alcoholic beverages- types, manufacture and quality evaluation; the role of yeast in beer and other alcoholic beverages, ale type beer, lager type beer, technology of brewing process, equipments used for brewing and distillation, wine and related beverages, distilled spirits.

Unit IV

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

Unit V

Technology for grain-based snacks: whole grains – roasted, toasted, puffed, popped and flakes, coated grains-salted, spiced and sweetened; flour based – batter and dough based products; *savoury* and *farsans*; formulated chips and wafers, papads, instant premixes of traditional Indian snack foods.

Unit VI

Technology for fruit and vegetable based snacks: Chips, wafers; Technology for coated nuts – salted, spiced and sweetened; *chikkis*.

Unit VII

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

FT. 3.7.B. Advanced Food Biotechnology

Unit I

Introduction to food biotechnology; basic principles of genetic engineering; improvement of the food crops by genetic engineering; genetically modified plants and animals for enhanced food production; safety of GM food crops.

Unit II

Natural antimicrobials for food preservation: phytoalexins, essential oils and their components; bacteriocins: nisin, pediocins etc; applications of bacteriocins in food systems as biopreservatives

Unit III

Food applications of enzymes; amylases, proteases, lipase, pectinase, celluloses, glucose oxidase. Microencapsulation of enzyme/probiotics. Protein engineering in food technology: methods, applications of protein engineering to produce glucose isomerase, *Lactobacillus*

beta-galactosidase and peptide antibiotic nisin. Biotechnological routes to food flavour production: microbial, enzymatic etc.

Unit IV

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

Unit V

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

Unit VI

Molecular tools for study of biodiversity.

Unit VII

Biotechnology and Food ingredients: biogums, fat substitutes, biocolors, organic acids and sweeteners. Transgenic plant foods: golden rice, Bt brinjal, maize, tomato, soyabean etc.

Unit VII

Recombinant DNA technology for production of protease, lipase, chymosin, immunoglobulins etc.

Unit IX

Biotechnology for food security: prospects and problems, ethical issues concerning GM foods; trade related aspects of biotech foods; intellectual property rights (IPR) issues and biopiracy problems; effect of biotech foods on the food business of developing and developed countries.

FT. 3.7.C. Waste management in Food Industry

Unit I

Waste & its consequences in pollution and global warming, Types of food processing wastes non-degradable & biodegradable wastes; food industrial wastes from fruit and vegetable processing industry; beverage industry, fish, meat & poultry industry, sugar industry and dairy industry.

Waste disposal methods: Storage & disposal of waste: solid waste storage and disposal methods- land-filling, burial, incineration, recycling; biological treatment of food industry wastes, storage and disposal of liquid and gaseous waste; legal aspects related to storage and disposal.

Unit II

Treatment of plant waste by physical, chemical and biological methods, Effluent treatment plants, Use of waste and waste water.

Unit III

Types, availability and utilization of by-products of cereals, legumes & oilseeds, Utilization of by-products from fruits and vegetables processing industries, sugar and agro based industries, and brewery & distillery waste.

Unit IV

Status and utilization of dairy by-products i.e. whey, buttermilk and ghee residues, Availability & utilization of by-products of meat industry, poultry industry and fish processing units.

Unit V

Waste water treatment: standards for disposal of water, physical, chemical and biological characteristics of waste water; measurement of organic content in waste water; physical unit operations in waste water treatment - screening; racks, mixing, flocculation,

sedimentation, floatation, elutriation, vacuum filtration, incineration; chemical unit operations in waste water treatment-chemical precipitation, aeration and gas transfer process, rate of gas transfer, adsorption, disinfection; biological unit operations - aerobic and anaerobic.

Unit VI

Biomethanation and biocomposting technology for organic waste utilization, incineration & efficient combustion technology, Integration of new and renewable energy sources for waste utilization.

FT. 3.7.D. Food Physics

Unit I

Molecular changes of conformation and charge distribution nature; structure and microstructure of food, it's relation to texture and mouth feel, factors that affect the structure, principles of electron microscopy for structural analysis (TEM and SEM); particle size distribution, separation and its relation to food functionality.

Unit II

Viscoelastic response of materials (2-3 dimensional), situations at rest, under flow and confining geometry; sol-gel transitions, emulsions, foams, dispersions, gels and solids; interface formation, control and design of gelation, stability and texture, the design of new mesostructure using food components like protein, polysaccharides, fats and oils.

Unit III

Use of radiation in food processing and testing including X-rays, γ -rays, and MRI techniques.

Unit IV

Nano particles and applications of nanotechnology in foods, food processing, and food packaging.

Semester IV

FT.4.1. Quality Control, Sensory Evaluation, Food Safety and Food Laws

Unit I

Quality Assurance: Introduction, Importance and Difference. Food Quality and Food Safety: Scope and difference.

Unit II

Raw materials & Finished product quality: Quality parameters and evaluation procedures: Appearance, color, texture, viscosity, consistency, flavor.

Unit III

Sensory evaluation: Selection of sensory panelists; Factors influencing sensory measurements; Sensory quality parameters -Size and shape, texture, aroma, taste, color and gloss; Detection, threshold and dilution tests. Different tests for sensory evaluation—discrimination, descriptive, affective; Flavour profile and tests; Ranking tests; Methods of sensory evaluation of different food products.

Computer-aided sensory evaluation of food & beverage, statistical analysis of sensory data.

Unit IV

Microbial quality control: determination of microorganisms in foods by cultural, microscopic, physical, chemical methods. Statistical quality control in food industry.

Food adulteration, nature of adulterants, methods of evaluation of food adulterants and toxic constituents.

Unit V

Food safety management, applications of HACCP in food safety, concept of food traceability for food safety, Food safety and Standards Act 2006: salient provision and prospects

Unit VI

Role of national and international regulatory agencies, Bureau of Indian Standards (BIS), AGMARK, Food Safety and Standards Authority of India (FSSAI), Introduction to WTO agreements: SPS and TBT agreements, Codex alimentarius commission, USFDA, International organization for standards (ISO) and its standards for food quality and safety (ISO 9000 series, ISO 22000, ISO 15161, ISO 14000)

FT.4.2. Dissertation/ Review work

FT.4.3.A. Food Business management and Entrepreneurship

Unit I

Management: Meaning, nature, scope, significance, functions and principles; levels of management, process of management, co-ordination as an essence of management.

Planning: Meaning and importance of planning; planning Process; limitations, considerations in planning; methods of planning; types of plans.

Organizing: Meaning and importance, process of organizing, principles of effective organization; key elements in organizing process; formal v/s informal organization departmentation, decentralization, delegation of authority relationship – line, staff and functional.

Unit II

Introduction to functional areas of management: personnel management, production management, financial management.

Objectives and functions of personnel management, production and financial management. Production management: plant location and layout, production planning and control.

Unit III

Introduction to marketing management, fundamentals of marketing principles, costing and cost management, pricing methods; fundamentals of operations and supply chain management; opportunity identification and feasibility studies, financial studies; marketing challenges and approaches for new products and services

Unit IV

Nature, scope and importance of entrepreneurship; business ideas, source of business ideas, feasibility studies, problem solving and decision making

Unit V

Agricultural sector and food processing industry problems and opportunities; self employment need and entrepreneurship in foods sector, project sizing, fund management

and enterprise management issues in food entrepreneurship, entrepreneurship development policies of government in food business

FT.4.3.B. Bioethics and Intellectual Property Rights

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.

FT.4.3.C. Food Product Development

Unit I

Concept of product development - product success and failure, factors for success, process of product development, managing for product's success. Innovation strategy - possibilities for innovation, building up strategy, product development programme.

Unit II

The product development process - product strategy, product design and process development, product commercialization, product launch and evaluation.

Unit III

The knowledge base for product development technology - knowledge and the food system, knowledge management, knowledge for conversion of product concept to new product, technological knowledge (product qualities, raw material properties, processing, packaging requirement, distribution and marketing.

Unit IV

Role of consumers in product development - consumer behaviour, food preferences, avoiding acceptance, integration of consumer needs in product development and sensory needs.

Unit V

Managing the product development process, - principles of product development management, people in product development management, designing the product development process, key decision points, establishing outcomes, budgets and constraints, managing and organizing product development process, innovative matrices, striving for continuous improvement, Improving success potential of new products, market exploration and acquisition, Legal aspects of new product launch.

FT.4.3.D. Food Rheology

Unit I

Food rheology and structure: stress and strain tensors, viscometric properties, shear stress-shear rate relationships, units in rheological measurements, types of fluid flow behaviour, apparent viscosity, intrinsic viscosity, stress-strain behaviour of solid foods, linear viscoelasticity, phase transitions in foods.

Unit II

Flow and functional models for rheological properties of fluid foods: Time independent flow behaviour, Apparent viscosity- shear rate relationships of shear- thinning foods, models for time dependent flow behaviour, role of solids fraction in rheology of dispersions, affect of temperature on viscosity, treatment of rheological data using models.

Unit III

Tube viscometry, Rotational viscometry: introduction

Unit IV

Viscoelasticity: introduction, transient tests for viscoelasticity, oscillatory testing. Rheology of food gum and starch dispersions: effect of heating, effect of sugar and protein, rheological behaviour of starch, rheology of starch- gum dispersions.

Unit V

Rheological behaviour of processed fluid, semisolid foods and food gels: rheological tests to evaluate properties of gel systems, gel point and sol-gel transition by rheological measurements. Application of rheology to fluid food handling and processing

Learning Outcome: It is expected that the students would have learnt concepts of rheology and structure of food systems.

List of Recommended Books

Semester I

FT.1.1. Food Chemistry and Nutrition

- Meyer, L.H.(1998) Food Chemistry, Van Nostrand, Reinhold Company Publication, New York, London.
- Alias C. and Lindeu G (1991) Food Biochemistry, Ellis Horwood, New York
- Pomeranz, Y and Meloan, R. (1995) Food Analysis: Theory and Practice, Westport, An A VI Publication, New York, Sydney, Toronto.
- Fennema, R.O (1997) Food Chemistry, Second Edition, Food Science & Technology series, Marcel Dekker, INC., New York.

FT.1.2. Principles of Food Engineering

- Batty, J.C. and Folkman, S.L. (1983). Food Engineering Fundamentals. John Wiley and Sons, New York.
- Brennan JG, Butter JR, Corell ND & Lilly AVE. (1990). Food Engineering Operations. Elsevier.
- Charm SE, McCabe WL, Smith JC & Harriott P.(1993). Unit Operations of Chemical Engineering. McGraw Hills.
- Earle, R.L. (1983) Unit Operations in Food processing, 2nd Edition Pergamon Press Oxford,U.K.
- Fellows P. (1988). Food Processing Technology. VCH Ellis Horwood.
- Heldman DR & Singh RP.(1995). Food Process Engineering. AVI Publ.
- McCabe WL & and Smith JC. (1971). Fundamental of Food Engineering. AVI Publ.
- Sahay KM & Singh KK. (1994). Unit Operation of Agricultural Processing. Vikas Publ. House.
- Singh, R.P and Heldman, D.R. (1984). Introduction to Food Engg., Academic Press, INC, London.
- Toledo, R.T.(1997). Fundamentals of Food Process Engineering, CBS Publishers, New Delhi.

FT.1.3. Food Microbiology

- James M. Jay (2000). Modern Food Microbiology, 5th Edition, CBS Publishers.
- Banwart, G.J. (1997). Basic Food Microbiology, CBS Publishers.
- Adam M.R. & Moss, M.O. (1995). Food Microbiology, New Age International Pvt. Ltd Publishers.
- Bibek Ray (1996). Fundamental Food Microbiology, CRC Press.
- Stanier, R.Y. (1996). General Microbiology, 5th Edition, MacMillan.

- Frazier J & Westhoff DC. (1988). Food Microbiology. 4th Ed. McGraw Hill.
- Garbutt J. (1997). Essentials of Food Microbiology. Arnold Heinemann.
- Robinson RK. (Ed.). (1983). Dairy Microbiology. Applied Science.
- Steinkraus KS. (1996). Handbook of Indigenous Fermented Foods.

FT.1.7. A. Computer applications in food industry

- Gillett BE. Introduction to Operation Research (A Computer Oriented Algorithmic Approach).
- Groover MP & Zimmers EW. (1987). CAD/CAM: Computer Aided Design and Manufacturing. Prentice Hall.
- Singh RP. (1996). Computer Applications in Food Technology. Academic Press.

FT. 1.7.B. Advanced Microbial Technology

- General Microbiology, 5e, by R.Y. Stanier (Palgrave Macmillan)
- Microbiology, 5e, by M.J. Pelczar (Tata McGraw-Hill)
- Microbiology, 9e, by L.M. Prescott (William C. Brown)
- Brock Biology of Microbiology, 14e, by M. Madigan et al. (Benjamin Cummings)
- Bacterial Metabolism, 2e, by G. Gottschalk (Springer)
- Microbial Physiology, 2e, by I.W. Dawes and I.W. Southerland (Blackwell)

FT.1.7. C. Nutraceuticals, Health foods and Specialty Foods

- Brigelius-Flohé, J & Joost HG. (2006). Nutritional Genomics: Impact on Health and Disease. Wiley VCH.
- Cupp J & Tracy TS. (2003). Dietary Supplements: Toxicology and Clinical Pharmacology. Humana Press.
- Gibson GR & Williams CM. (2000). Functional Foods - Concept to Product.
- Goldberg I. (1994). Functional Foods: Designer Foods, Pharma Foods.
- Lusso JN. (2007). Anti-angiogenic Functional and Medicinal Foods. CRC Press.
- Manson P. (2001). Dietary Supplements. 2nd Ed. Pharmaceutical Press.
- Campbell JE & Summers JL. (2004). Dietary Supplement Labeling Compliance.
- Neeser JR & German BJ. (2004) Bioprocesses and Biotechnology for Nutraceuticals. Chapman & Hall.
- Robert EC. (2006). Handbook of Nutraceuticals and Functional Foods. 2nd Ed. Wildman.
- Shi J. (Ed.). (2006). Functional Food Ingredients and Nutraceuticals: Processing Technologies. CRC Press.
- Webb GP. (2006). Dietary Supplements and Functional Foods. Blackwell Publ.
- Manson P. (2001). Dietary Supplements. 2nd Ed. Pharmaceutical Press.
- Bamji MS, Rao NP & Reddy V. (2003). Textbook of Human Nutrition. Oxford & IBH.

FT.1.7.D. Food Toxicology

- Branen AL, Davidson PM & Salminen S. (1990). Food Additives. Marcel Dekker.
- Condon JM.(1988). Food Toxicology - Principles & Concepts. Marcel Dekker.
- Hathcock JN. (Ed.). (1982). Nutritional Toxicology. Vol. I. Academic Press.
- Rehgigl M Jr. (1983). (Ed.). Handbook of Naturally Occurring Food Toxicants. CRC Press.
- Shabbir S. (2007). Food Borne Diseases. Humana Press.
- Steven T. (1989). Food Toxicology: A Perspective on Relative Risks.
- Tweedy BG.(1991). Pesticide Residues and Food Safety. Royal Society of Chemistry.

Semester II

FT.2.1. Principles of Food Processing and Preservation

- Arsdel WB, Copley MJ & Morgan AI. (1973). Food Dehydration. 2nd Ed. Vols.I, II.AVI Publ.
- Desrosier NW & James N.(1977). Technology of Food Preservation.4th Ed. AVI.Publ.
- Fellows PJ. (2005). Food Processing Technology: Principle and Practice. 2nd Ed. CRC.
- Jelen P. (1985). Introduction to Food Processing.Prentice Hall.
- Barbosa-Canovas (2002). Novel Food Processing Technologies. CRC
- Dutta AK & Anantheswaran RC.(1999). Hand Book of Microwave Technology for Food Applications.
- Frame ND. (Ed.). (1994). The Technology of Extrusion Cooking. Blackie.
- Gould GW. (2000). New Methods of Food Preservation. CRC.
- Shi J. (Ed) (2006). Functional Food Ingredients and Nutraceuticals: Processing Technologies. CRC.

FT.2.2. Post harvest technology of horticultural crops

- Lal G, Siddapa GS & Tandon GL.(1986). Preservation of Fruits and Vegetables. ICAR.
- Salunkhe DK, Bolia HR & Reddy NR. (1991). Storage, Processing and Nutritional Quality of Fruits and Vegetables. Vol. I. Fruits and Vegetables. CRC.
- Thompson AK. (1995). Post Harvest Technology of Fruits and Vegetables. Blackwell Sci.
- Kadar AA.(1992). Post-harvest Technology of Horticultural Crops. 2nd Ed. University of California.
- Pantastico B. (1975). Post Harvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables. AVI Publ.

FT. 2.3.Instrumentation and Analytical Techniques

- Hand Book of Food Analysis by Nollert & Toldra, CRC publishing Ltd.
- Hand Book of Analysis & Quality Control for Fruit & Vegetable Products by Rangana, Tata Mcgraw hill publishing.

- Introduction to the chemical analysis of foods by Nielson, CBS publishing.
- Physical Chemistry: With Applications to the life sciences by D. Eisenberg and D. Cum (Benjamin/ Cummings)
- Biophysical Chemistry: Part III: The Behaviour of Biological Macromolecules, by Charles R. Cantor and R. Schimmel
- Principles and techniques of Biochemistry and Molecular Biology, by Keith Wilson, John Walker.

FT. 2.7.A. Advances in statistical methods/ Biostatistics

- Aggarwal BL. (2003). Basic Statistics. New Age.
- Brookes CJ, Betteley IG & Loxston SM. (1966). Mathematics and Statistics for Chemists. John Wiley & Sons.
- Gupta SC & Kapoor VK. (2003). Fundamentals of Mathematical Statistics. S. Chand & Sons.
- Gupta SP. (2004). Statistical Methods. S. Chand & Sons.
- Chatfield C. (1983). Statistics for Technology . 3rd Ed. Chapman & Hall.
- Chatfield C. (1995). Problem Solving: A Statistician's Guide . Chapman & Hall.
- Cleveland WS. (1985). The Elements of Graphing Data . Wadsworth, Belmont, California.
- Ehrenberg ASC. (1982). A Primer in Data Reduction . John Wiley.
- Erickson BH & Nosanchuk TA. (1992). Understanding Data . 2nd Ed. Open University Press, Milton Keynes.
- Snell EJ & Simpson HR. (1991). Applied Statistics: A Handbook of GENSTAT Analyses. Chapman & Hall.
- Learning Statistics: <http://freestatistics.altervista.org/en/learning.php>.
- Free Statistical Softwares: <http://freestatistics.altervista.org/en/stat.php>.
- Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
- Course on Experimental design: <http://www.stat.sc.edu/~grego/courses/stat706/>.
- Design Resources Server: www.iasri.res.in/design.
- Analysis of Data: Design Resources Server. <http://www.iasri.res.in/design/Analysis%20of%20data/Analysis%20of%20Data.html>.

FT.2.7.B. Food ingredients and additives

- Branen AL, Davidson PM & Salminen S. (2001). Food Additives. 2nd Ed. Marcel Dekker.
- George AB. (1996). Encyclopedia of Food and Color Additives. Vol. III. CRC Press.
- George AB. (2004). Fenaroli's Handbook of Flavor Ingredients. 5th Ed. CRC Press.
- Madhavi DL, Deshpande SS & Salunkhe DK. (1996). Food Antioxidants: Technological, Toxicological and Health Perspective. Marcel Dekker.
- Morton ID & Macleod AJ. (1990). Food Flavours. Part A, BC. Elsevier.
- Nakai S & Modler HW. (2000). Food Proteins. Processing Applications. Wiley VCH.
- Stephen AM. (Ed.). (2006). Food Polysaccharides and Their Applications. Marcel Dekker.

FT. 2.7.C. Technology of Cereals, Pulses and Oilseeds

- Chakrabarty MM. (2003). Chemistry and Technology of Oils and Fats. Prentice Hall.
- Dendy DAV & Dobraszczyk BJ. (2001). Cereal and Cereal Products. Aspen.
- Hamilton RJ & Bhati A. (1980). Fats and Oils - Chemistry and Technology. App. Sci. Publ.
- Hosenev RS. (1994). Principles of Cereal Science and Technology. 2nd Ed. AACC.
- Kay DE. (1979). Food Legumes. Tropical Products Institute.
- Kent NL. (1983). Technology of Cereals. 4th Ed. Pergamon Press.
- Kulp K & Ponte GJ. (2000). Handbook of Cereal Science and Technology. 2nd Ed. Marcel Dekker.
- Lorenz KL.(1991). Handbook of Cereal Science and Technology. Marcel Dekker.
- Marshall WE & Wadsworth JI. (1994). Rice Science and Technology. Marcel Dekker.
- Mathews RH. (1989). Legumes Chemistry, Technology and Human Nutrition. Marcel Dekker.

FT.2.7.D. Technology of meat, poultry and fish processing

- Joshi, B. P. (1994). Meat Hygiene for Developing Country, Shree Almora Book Depot, India.
- William J. & Owen J., (1977). Egg Science & Technology, AVI Publishing Company, INC. Westport, Connecticut.
- Lawrie, R.A. (1998). Meat Science. Woodhead Publishers.
- Panda, P.C. (1992). Text Book on Egg and Poultry Technology, Vikas Publishers
- Forrest JC.(1975). Principles of Meat Science. Freeman.
- Govindan TK. (1985). Fish Processing Technology. Oxford & IBH.
- Hui YH. (2001). Meat Science and Applications. Marcel Dekker.
- Kerry J. et al. (2002). Meat Processing. Woodhead Publ. CRC Press.
- Levie A. (1984). Meat Hand Book. 4th Ed. AVI Publ.
- Mead M. (2004). Poultry Meat Processing and Quality. Woodhead Publ.
- Mead GC. (1989). Processing of Poultry. Elsevier.
- Pearson AM & Gillett TA. (1996). Processed Meat. 3rd Ed. Chapman & Hall.
- Stadelman WJ & Cotterill OJ. (2002). Egg Science and Technology. 4th Ed.

Semester III

FT.3.1. Food Fermentation and Bioprocess Technology

- Nout RMJ, de Vos WM and Zwietering MH. (2005). Food fermentation. Wageningen Academic Publishers, Netherlands.
- Prescott SC & Dunn CG. (1959). Industrial Microbiology. Mc Graw Hill.
- Waits MJ. (2001). Industrial Microbiology. Blackwell Science.
- Ward OP. (1989). Fermentation Biotechnology. Prentice Hall.

FT.3.2. Dairy Engineering/ processing of milk and milk products

- Aneja RP, Mathur BN, Chandan RC & Banerjee AK. (2002). Technology of Indian Milk Products. Dairy India Publ.
- De S.(1980). Outlines of Dairy Technology. Oxford Univ. Press.
- Henderson JL. (1971). Fluid Milk Industry. AVI Publ.
- Rathore NS et al. (2008). Fundamentals of Dairy Technology - Theory & Practices. Himanshu Publ
- Spreer E. (1993). Milk and Dairy Products. Marcel Dekker.
- Walstra P.(1999). Dairy Technology. Marcel Dekker.
- Walstra P. (Ed.). (2006). Dairy Science and Technology. 2nd Ed. Taylor & Francis.
- Web BH, Johnson AH & Lford JA. (1987). Fundamental of Dairy Chemistry. 3rd Ed. AVI Publ.

FT. 3.3.Technology of Food Processing

- Crosby NT.(1981). Food Packaging: Aspects of Analysis and Migration Contaminants. App. Sci. Publ.
- Kadoya T. (Ed). (1990). Food Packaging. Academic Press.
- Mahadeviah M & Gowramma RV. (1996). Food Packaging Materials. Tata McGraw Hill.
- Palling SJ. (Ed). (1980). Developments in Food Packaging. App. Sci. Publ.
- Painy FA. (1992). A Handbook of Food Packaging. Blackie Academic.
- Sacharow S & Griffin RC. (1980). Principles of Food Packaging. AVI Publ.
- Stanley S & Roger CG.(1970). Food Packaging. AVI Publ.

FT. 3.7.A. Beverage and Snacks Food Technology

- Hardwick WA. (1995). Handbook of Brewing. Marcel Dekker.
- Hui YH. et al (2004). Handbook of Food and Beverage Fermentation Technology. Marcel Dekker.
- Priest FG & Stewart GG. (2006). Handbook of Brewing. 2nd Ed. CRC.
- Richard P Vine. (1981). Commercial Wine Making - Processing and Controls. AVI Publ.
- Varnam AH & Sutherland JP. (1994). Beverages: Technology, Chemistry and Microbiology. Chapman & Hall.
- Woodroof JG & Phillips GF.(1974). Beverages: Carbonated and Non Carbonated. AVI Publ.Edmund WL. Snack Foods Processing. AVI Publ.
- Frame ND.(1994).The Technology of Extrusion Cooking. Blackie Academic.
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