

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA



**M. Sc. Food Science and Technology
Programme**

Session 2017-18 Onwards

**Centre for Applied Agriculture
School of Basic and Applied Sciences**

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

M. Sc. (Food Science and Technology) Programme

The Master of Science (Food Science and Technology) is a two-year full time post graduate degree programme which grooms students into professional food technologist for core areas of Food Science and Technology. The programme aims at providing a comprehensive coverage incorporating the foundation, core and interdisciplinary courses relevant to Food Science discipline.

1. Eligibility Criteria

Graduates of Basic Sciences/Agriculture and Allied subjects including, Food Processing Technology, Food Science and Technology, Food and Nutrition, Food Technology, Dairy Technology, Biotechnology, Agricultural Process Engineering, Chemical/Biochemical Engineering, Veterinary Sciences, Horticulture, Fisheries, etc. streams with 55% marks are eligible for admission to the course. Reservation/relaxation in eligibility shall be as per Government of India rules. The Bachelor's Degree or equivalent qualification obtained by the candidate must entail a minimum of three years of education after completing higher secondary schooling (10+2) or equivalent.

2. Admission/Selection Procedure

2.1 Syllabus for Central University Common Entrance Test (CUCET) regarding this Programme will be as follows

The selection of candidates for admission to the Master of Food Science and Technology at Central University of Punjab, Bathinda is based on multiple choice question (MCQs) with Section A (50 MCQ) and Section B (50 MCQ) with No Negative Marking on optical mark recognition (OMR) sheet.

S.N.	Topic	Weight in Percentage
1.	Basic Sciences/Agriculture and Allied subjects including, Food Science and Technology, Food Technology, Food and Nutrition, Dairy Technology, Biotechnology, Agricultural Process Engineering, Chemical/Biochemical Engineering, Veterinary Sciences, Horticulture, Fisheries, etc.	60
2.	Quantitative Ability	10
3.	Logical Reasoning	10
4.	Verbal Ability (English)	10
5.	General Knowledge	10

2.2 Short listing Criterion

Candidates shall be shortlisted on the basis of marks obtained in CUCET.

2.3 Intake Capacity

There shall be **15** seats for Indian Nationals and admission procedure for Foreign Nationals shall be as per Govt. of India Rules. University can increase or decrease the number of seats as per availability of infrastructure.

2.4 Test Centres:

University will decide about the test centres at the time of examination.

2.5 Reservation

As per Government of India rules applicable from time to time.

3.0 Course Structure

The knowledge acquired through the course and exposure to the organizational functions through attachment with corporate/non-corporate organizations brings the desired professional competence in the students to address the demands of the post-harvest processing and allied sectors which are experiencing developments at a fast pace to meet the requirements of food globally. Course structure shall be devised and revised by the appropriate authority as per the provisions of statute/ordinance. The course structure includes foundation courses, core courses, elective courses, Interdisciplinary courses, summer internship and project work.

The Course Structure and Syllabus are as below:

3.1. Course Structure of M. Sc. Food Science and Technology

Semester I

Course Code	Course Title	Credits			Total Credits
		L	T	P	
Foundation Courses					
FST.501	Computer Application and Statistics	2	-	-	2
FST.502	Research Methodology	2	-	-	2
Core Courses					
FST.503	Food Chemistry	3	-	-	3
FST.504	Food Microbiology	2	-	-	2
FST.505	Enzymes in Food Processing	3	-	-	3
FST.506	Instrumentation and Analytical Techniques	2	-	-	2
FST.507	Food Processing and Preservation	3	-	-	3
FST.508	Lab-Food Chemistry	-	-	2	2
FST.509	Lab-Food Microbiology	-	-	1	1
FST.510	Lab-Instrumentation and Analytical Techniques	-	-	1	1
Elective Course (opt any one)					
FST.511	Food Biotechnology	2	-	-	2
FST.512	Fermented Foods				
Interdisciplinary Course (opt any one)					
IDC	Inter-disciplinary course	2	-	-	2
Total		21	-	4	25

Semester II

Course Code	Course Title	Credits			Total Credits
		L	T	P	
Core Courses					
FST.513	Food Engineering and Unit Operations	3	-	-	3
FST.514	Processing of Cereals and Cereal Products	3	-	-	3
FST.515	Processing of Milk and Milk Products	3	-	-	3
FST.516	Processing of Livestock Products	4	-	-	4
FST.517	Processing of Legumes and Oilseeds	3	-	-	3
FST.518	Lab-Food Engineering	-	-	1	1
FST.519	Lab-Cereals, Legumes and Oilseed Analysis	-	-	1	1
FST.520	Lab-Milk and Milk Products	-	-	1	1
Elective Course (opt any one)					
FST.521	Sugar, Chocolate and Confectionery Technology	2	-	-	2
FST.522	Technology of Spices				
Interdisciplinary Course (opt any one)					
IDC	Inter-disciplinary course	2	-	-	2
Seminar					
FST.523	Seminar	-	1	-	1
Total		20	1	3	24

Semester III

Course Code	Course Title	Credits			Total Credits
		L	T	P	
Core Courses					
FST.524	Processing of Fruits and Vegetables	3	-	-	3
FST.525	Beverages Technology	2	-	-	2
FST.526	Nutrition, Nutraceuticals and Functional foods	4	-	-	4
FST.527	Food Additives and Toxins	2	-	-	2
FST.528	Food Packaging	3	-	-	3
FST.529	Food Laws and Quality Control	2	-	-	2
FST.530	Lab-Fruits and Vegetable Processing	-	-	1	1
FST.531	Lab-Food Packaging	-	-	1	1
FST.532	Lab-Food Quality	-	-	1	1
Elective Course (opt any one)					
FST.533	Business Management and International Trade	2	-	-	2
FST.534	Food Policy and Entrepreneurship				
Seminar					
FST.535	Seminar	-	1	-	1
Total		18	1	3	22

Semester IV

Course Code	Course Title	Credits			Total Credits
		L	T	P	
Core Courses					
FST.536	Processing of Specialty Foods	2	-	-	2
FST.537	Food Hygiene, By-products and Waste Management	2	-	-	2
Research					
FST.538	Research Project	-	16	-	16
Total		4	16		20
Gross total credits (25+24+22+20 = 91)					

L: Lectures; T: Tutorial; P: Practical

Students need to undergo summer industrial training for 6 weeks after 2nd semester and submit a report of the same along with a copy of certificate. Evaluation of the same shall be carried out by industry representative, supervisor and a faculty from the Centre nominated by CoC through presentation.

Students shall opt for inter-disciplinary courses in 1st and 2nd semesters from Animal Sciences, Plant Sciences, Human Genetics, Molecular Medicine, Pharmaceutical Science, Biochemistry and Microbial Sciences, Chemical Sciences, Environmental Sciences, Economics, Agri-business, etc. disciplines.

To improve scientific aptitude and presentation skills of students, they have to present a credited seminar on a specific topic based on a review article selected by them. The students are also required to prepare and submit a report on the same.

Evaluation Criteria for seminars: Students shall be evaluated for 1 credit, of which 50% marks will be for literature survey/background information, organization of content, presentation and discussion and remaining 50 % marks will be for the seminar report submitted by the student.

Lab practicals may be added/modified depending on the availability of materials and facilities as well as latest advancements.

Project work: Students shall do individual project work under the supervision of faculty member of the Centre. There shall be no provision of group projects. Project work and supervisor shall be assigned to the student by the Centre at the end of the second (2nd) semester. The project report must be submitted by the student at least one week before the commencement of semester examination. The project work shall be evaluated by the supervisor, COC and one more faculty member of the Centre, nominated by the Vice-Chancellor. The project would be evaluated for satisfactory/unsatisfactory performance. Satisfactory performance in the project work shall be a pre-requisite to pass the course.

Interdisciplinary courses (IDC) to be offered to the students of other centres

S.N.	Course Code	Course Title	Semester of the academic year the course is to be offered	Credits			Total Credits
				L	T	P	
1.	FST.539	Food Regulation, Quality and Safety Assessment	1 st	2	-	-	2
2	FST.540	Introduction to Nutrition and Specialty Foods	2 nd	2	-	-	2

3.2 Syllabus Details are attached in Annexure I

4.0 Examination and Evaluation

Each course (except Lab course, seminars and project work) would be evaluated on the basis of Continuous Assessment, Pre-Scheduled Mid Semester Tests and End Semester Exam as per the University guidelines applicable from time to time.

5.0 Fee

Fee shall be as prescribed by the University for the Programme in a particular Session/Semester. Hostel Fee, Mess Fee etc. shall be payable additionally as per Central University of Punjab, Bathinda Rules. The fee is subject to revision and students shall be liable to pay the fee prescribed by the University in a particular academic session irrespective of their admission year.

6.0 Financial Assistance/Scholarships

Limited Financial Assistance subject to availability of funds will be provided to deserving candidates as per Central University of Punjab, Bathinda Rules. Students if eligible, can apply for their State Govt. or Central Govt. Scholarships

7.0 Students' Council of Central University of Punjab

The Students' Council of Central University of Punjab has primary responsibility for giving feedbacks and giving safeguards regarding implementation of policies related to student activities.

8.0 Central University of Punjab Alumni Association

After successful completion of the Programme and paying prescribed fee students will become member of the Central University Of Punjab Alumni Association.

9.0 Authoritative Jurisdiction

Any issue regarding the interpretation of this Ordinance shall be referred to the Vice Chancellor, whose decision; in his/her capacity as the Chairperson, Academic Council, shall be final and binding on all parties. The Vice-Chancellor may constitute necessary committees pertaining to any specific issue arising out of the present ordinance to resolve the issue.

Annexure I (Detailed course content)

Foundation Courses

Course Code: FST.501

Course Title: Computer Application and Statistics

L	T	P	Credits
2	-	-	2

Objective

This course will familiarize the students with the computer application and statistics in academics, research and development (R & D).

Unit I	Lectures
History of computers; Computer generations; Classification; Characteristics and functions of computers; Components of computer system-Basic computer organisation; Computer hardware: Input and output devices; Storage devices; Processor and memory	6
Unit II Computer software: Relationship between hardware and software; Types of software (system and application software) Operating system: General features; Main functions; Process Management; Some popular operating systems (Unix, Linux, DOS, Windows, etc.) Application of IT in food processing, safety and quality	10
Unit III Sampling: Characteristics, Advantages and disadvantages; Need of sampling; Sampling errors; Sample size; Sampling techniques (simple, complex random, probability and non-probability, systematic and stratified)	4
Unit IV Measures of central tendency (Mean, Mode Median); Measures of central dispersion (Range, Standard Deviation, Standard Error, Coefficient of Variation); Tests of significance: 't' Test; Testing of hypothesis; Analysis of variation (ANOVA); Correlation analysis; Chi square test; Measures of Skewness; Regression Analysis; Application of statistical software like METLAB, SPSS, and Design Expert	14

Suggested readings

- *Computer Application in Food Technology* by RP Singh. Academic Press (1996).
 - *Textbook of Windows Based Computer Course* by G Singh and R Singh. Kalyani Publications (2003).
 - *An Introduction to Biostatistics* by PSS Sundar Rao and J Richard. Prentice Hall (2003).
 - *Bio Statistical Analysis* by JH Zar. Tan Prints (2003).
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Course Code: FST.502

Course Title: Research Methodology

L	T	P	Credits
2	-	-	2

Objective

To impart the basic understanding of research methods, ethics, technical and scientific writings and literature search.

Unit I

General principles: Meaning and importance of research; Objectives of research; Types of research; Critical thinking; Review of literature; Development of research plan and procedure; Methods of data collection; Classification and summarization of data; Interpretation of results

Lectures

9

Unit II

Technical writing: Scientific writing that includes the way of writing synopsis, research paper, poster preparation and presentation, and dissertation; Ethics in publication
Library: Use of resources; e-Library; Web-based literature search engines

9

Unit III

Bioethics and Biosafety: Good laboratory practices; Biosafety for human health and environment; Biosafety issues for using GM foods
Ethical theories; Ethical considerations during research; Data manipulations; Animal testing; Animal rights

7

Unit IV:

Intellectual property rights (IPRs): Concept of IP and IPR; Patents; Copyright; Industrial designs; Trade secrets; Ethics in publication; Plagiarism and open access publishing

7

Suggested readings

- *Research Methodology: Methods and Techniques* by CR Kothari. New Age International Publishers (2004).
- *An Introduction to Bioethics* by TA Shannon. Paulist Press (2009).
- *Bioethics: Principles, Issues, and Cases* by L Vaughn. Oxford University Press (2009).
- *Laboratory Biosafety Manual*. World Health Organization (2005).
- *Intellectual Property Law for Engineers and Scientists* by HB Rockman. Wiley (2004).

Core Courses

Course Code: FST.503

Course Title: Food Chemistry

L	T	P	Credits
3	-	-	3

Objective

To provide an understanding of structure, reactions and functional properties of different food components.

Unit I

Water in foods: Function; Types; Structure; Association and dissociation of water; Phase diagram; Relevance to deteriorative processes in foods
Carbohydrates-Mono, Oligo and Polysaccharides: Occurrence; Structure; Chemical properties; Properties and food applications of important polysaccharides e.g. starch, cellulose, guar gum, xanthan gum, dextran, pectin, alginate, etc.; Starch digestibility and Glycaemic Index; Modified starches; Forms and derivatives of cellulose (MCC, CMC, MC and HPMC)

Lectures

12

Unit II

Proteins: Classification; Optical properties and chemical reactivity of amino acids; Protein structure; Forces involved in stability of protein structure; Denaturation; Functional properties; Major source of food proteins; Methods of protein characterization and analysis; Protein quality/Biological value of proteins; Chemical and biological methods for evaluation of protein quality; Processing induced physicochemical changes in proteins; Chemical and enzymatic modification of proteins

10

Unit III

Lipids: Classification; Nomenclature of fatty acids; Physicochemical properties of lipids; Functionality of triglycerides in foods; Rancidity and flavour reversion; Mechanism of lipid oxidation; Pro-oxidants; Measurement of lipid oxidation; Role of fats in body; Health problems associated with fats; Trans fats; Bioactivity of fatty acids; Recommendations for fat intake; Fat replacement strategies
Vitamins: Sources, requirements and functions of different vitamins

14

Unit IV

Minerals: General functions of minerals; Specific functions and requirements of Ca, P, Mg, Fe, Cu, Pb, Zn, Se and As
Pigments: Myoglobin; Chlorophyll; Anthocyanins; Carotenoids; Betalains
Browning reactions: Enzymatic and Non-enzymatic browning of foods
Antioxidants: Natural antioxidants; Mechanisms of action; Techniques of evaluation of antioxidant activity
Flavour: Nature of flavour components, Applications, Importance of aroma compound

12

Suggested readings

- *Fennema's Food Chemistry* by S Damodaran, KL Parkin, R Owen. CRC Press (2008).
 - *Food Chemistry* by HK Chopra and PS Penesor. Narosa Publishing (2010).
 - *Food Science* by NN Potter. CBS Publishers (2007).
 - *Chemistry and Technology of Oils and Fats* by MM Chakraborty. Prentice Hall (2003).
 - *Essentials of Food Science* (4th edition) by V Vaclavik and CW Elizabeth. Springer (2014).
 - *Plant Food Flavors* by S Mehthani and PK Ingle. National Institute Science Communication (1999).
 - *Flavor, Fragrance and Odor Analysis* by R Marsili. CRC Press (2011).
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Course Code: FST.504
Course Title: Food Microbiology

L	T	P	Credits
2	-	-	2

Objective

Students will learn the fundamentals of microbes, microbial growth their significance with respect to food processing and safety.

Unit I

History of microbiology; Classification/groups of microorganism; Distribution of microorganisms in nature; Morphology and structure of bacteria, fungi and algae; Normal growth curve of bacteria; Nutritional and physical requirements for growth of bacteria; Bacterial spores and their significance in food microbiology

Lectures

7

Unit II

Sources of microorganism in food (contamination from plants, animals, sewage, soil, water, air, etc.)
Food as substrate for microbial growth; Heat resistance of microorganisms and their spores; Factors affecting heat resistance of microorganisms; Thermal death time, Z, F and D values; Physical, chemical and biological method of microbial destruction; Method of microbial examination of foods
Beneficial uses of microorganism in foods

8

Unit III

Principles of food spoilage; Chemical changes caused by microorganisms; Spoilage of milk and milk products, cereals and cereal products; meat and meat products, fish and fish products, poultry and eggs, sugars, spices and salt, canned foods; Indicators of microbial food spoilage

12

Unit IV

Food borne illnesses: Food borne infections, Food borne intoxications, Mycotoxins (sources and prevention); Food sanitation and public health; Control of Food Borne Pathogen by natural antimicrobials

8

Suggested readings

- *Microbiology* by MJ Pelczar, J Michael. McGraw-Hill (1999).
- *Modern Food Microbiology* (7th edition) by JM Jay Golden Food Science Text Series (2005).
- *Food Microbiology* (5th edition) by WC Frazier and DC Weshoff. McGraw-Hill (2015).
- *Basics of Food Biochemistry and Microbiology* by S Kumari. Koros Press (2012).
- *Food Microbiology: An introduction* by TJ Montville et al. ASM press (2012).
- *Food Microbiology: Fundamentals and Frontiers* by MP Doyle and RL Buchanan. ASM press (2007).
- *Food Microbiology* by MR Adams et al. RSC (2016).
- *Food Microbiology* by WM Foster. CBS Publishers (2016).
- *Laboratory Manual of Food Microbiology* by N Garg. I.K. International Publishing House (2013).

Course Code: FST.505

Course Title: Enzymes in Food Processing

L	T	P	Credits
3	-	-	3

Objective

To educate the students regarding principles of enzymes and their applications in food processing.

Unit I

Nomenclature; General properties; Classification; Sources of enzymes; Extraction and purification of protease, amylase, pentosanase, gluco-oxidase, lipoxygenase; Factors affecting enzymatic activity; Mechanism of enzyme inhibitors; Immobilization of enzymes

Enzymes in cereal processing: Enzymatic production of modified starches, corn syrups containing glucose, maltose, glucose, fructose, etc.

Significance of enzymes in baking industry (amylases, protease, gluco-oxidases, lipase, xylanases and transglutaminase)

Lectures

12

Unit II

Enzymes in dairy industry: Indigenous enzymes involved in antimicrobial and antiviral activity of milk; Exogenous enzymes in dairy industry (proteinases, lipase, beta-galactosidase, lysozyme, glucose-oxidase, superoxide dismutase, sulfhydryl oxidase, catalyse, lacto-peroxidase and transglutaminase); Hydrolysis of lactose in milk and whey; Use of enzymes for determining milk quality; Production and use of microbial enzymes for dairy processing; Enzymes in cheese production (coagulant technology, rennin and its formation, enzymes in cheese preservation)

10

Unit III

Importance and application of enzymes in fruits processing: Distribution of pectic substances and pectin enzymes in fruits; Commercial pectinases; Specific applications of enzymes in juice technology like clarification, debittering, etc.

8

Unit IV

Enzymes in meat industry: Enzymes used for meat processing (proteases and peptidases, lipases, transglutaminase, oxidative enzymes and glutaminase); Enzymatic tenderization of meat; Enzymatic generation of flavours in meat products

Enzymes in brewing and beer finishing operation

Enzymatic modification of proteins and lipids (production, isolation, purification, hydrolysis, esterification, application of lipase in fats and oils);

Enzyme as analytical tool (importance, biosensor, transducer)

14

Suggested readings

- *Handbook of Food Enzymology* by J.R. Whitaker. CRC press (2016).
- *Enzymes in Food Processing: Fundamentals and Potential Applications* by PS Panesar SS Marawaha, Harish K Chopra. I.K. International Publishing House (2013).
- *Enzyme Technology* by S Shanmugam and K Kumar. I.K. International Publishing (2009).
- *Enzymes in Food Technology* by RJ Whitehurst and MV Oort. Wiley-Blackwell (2010).

Course Code: FST.506

Course Title: Instrumentation and Analytical Techniques

L	T	P	Credit
2	-	-	2

Objective

To acquaint the students with the instruments, their principal and usage in food analysis.

Unit I

Spectroscopy: Concepts; Laws of photometry; Beer-Lambert's law; Visible and UV spectroscopy; Principles and applications of colourimetry; Atomic Absorption Spectrometer; X-ray diffraction; NMR

Lectures

6

Unit II

Chromatography: Principles and applications of thin layer, ion exchange, gas and gel permeation chromatography. HPLC. pH and ion selective electrodes (types of electrodes); Metal detection system; Machine vision for quality control in food industry
Viscosity measurement: Rotational viscometer, Controlled shear stress viscometer, Non-rotational viscometer; Viscosity measuring systems: Dynamic rheometer; RVA; Bostwick viscometer; Ostwald viscometer; Falling ball viscometer; Measurement of texture

12

Unit III

Centrifugation: Principle of centrifugation; Different types of instruments and rotors; Preparative, differential and density gradient centrifugation; Analytical ultra-centrifugation

6

Unit IV

Electrophoretic techniques: Principles; Types and application of electrophoretic separation
Electron microscopy: Transmission and scanning.

8

Suggested readings

- *Mass Spectrometry: A Textbook* by J H Gross. Springer-Verlag (2011).
- *Instruments Methods for Quality Assurance in Foods* by DY Fung. Marcel Dekker (2017).
- *Analytical Chemistry of Foods* by CA James. Blackie Academic and Professional (1995).
- *Principles and Techniques of Biochemistry and Molecular Biology* (7th edition) by K Wilson and J Walker. Cambridge University Press (2010).
- *Handbook of Food Process Equipment* by G Saravakos and AK Kostaropoulos. Springer (2016).

Course Code: FST.507

Course Title: Food Processing and Preservation

L	T	P	Credit
3	-	-	3

Objective

To provide understanding of scientific aspects of conventional and innovative techniques used in processing and preservation of foods.

Unit I	Lectures
Scope of food processing; Principles of food processing and preservation; Concept of water activity (a_w); Causes of food deterioration Processing and preservation by heat: Heat resistance of microorganisms, Protective effect of food constituents; Blanching; Pasteurization; Sterilization; UHT processing; Ohmic heating; Microwave heating, etc.	10
Unit II Processing and preservation by low temperature: Refrigeration; Freezing; Dehydro-freezing; Freezing curve; Factors determining freezing rate; Types of freezer; Thawing; Changes in foods during freezing; Changes in food during refrigeration storage Processing and preservation by drying and dehydration: Types of drying; Drying curve; Types of dryers; Changes in food due to drying; Intermediate moisture foods (IMF)	10
Unit III Novel methods in food preservation: Ultrasound; High pressure processing; Pulsed electric field; Hurdle technology; Nanotechnology; Ozone application; Technologies for <i>sous-vide</i> ready meals; Minimal processing of fresh fruits and vegetables	12
Unit IV Membrane separation in food processing and preservation, Types, Construction material, Configuration and modules, Applications. Concentration: Technology of Concentration, Equipment, Process, and Changes in Food during concentration. Radiation: Source; Equipment; Mechanism of preservation, Dose determination, Effect on foods.	14

Suggested readings

- *Food Science* by NN Potter. CBS Publishers (2007).
- *Introducing Food Science* by RL Shewfelt. CRC (2013).
- *Food Processing* by JS Smith and YH Hui. Wiley (2014).
- *Handbook of Food Processing* by T Varzakas and C Tzia. CRC Press (2016).
- *Innovation in Food Processing* by GV Barbosa-canovas and GW Gould. CRC Press (2017).
- *Innovative Food Processing Technologies* by K Kai. WP Publisher (2016).
- *Food Processing and Preservation* by D Singh. Shree Publisher (2015).
- *Food Processing Principle and Application* by HS Ramaswamy and M Marcotte. Taylor and Francis (2006).
- *Food Science: Research and Technology* by AK Haghi. Apple Academic Press (2011).
- *Handbook of Food Process Equipment* by G Saravakos and AK Kostaropoulos. Springer (2016).

Course Code: FST.508
Course Title: Lab-Food Chemistry

L	T	P	Credit
-	-	2	2

S.N. Practical

1. Determination of moisture content of foods using different methods.
 2. Determination of total, soluble and insoluble ash content.
 3. Determination of chlorophyll content.
 4. Determination of crude proteins using Micro-Kjeldhal method.
 5. Determination of crude fat.
 6. Determination of acid value and saponification value of fat/oil.
 7. Determination of ascorbic acid using dye method.
 8. Determination of sugar content.
 9. Determination of total phenolic content and antioxidant activities of plant foods.
 10. Determination of oil stability by using rancimat.
-

Course Code: FST.509
Course Title: Lab-Food Microbiology

L	T	P	Credit
-	-	1	1

S.N. Practical

1. Staining Techniques/methods
 2. Media preparation
 3. Total Plate count
 4. Methylene Blue Reduction Test.
 5. Isolation of bacteria, yeast and moulds from foods and their microscopic examination.
 6. Microbial examination of cereal and cereal products.
 7. Microbial examination of vegetable and fruits.
 8. Microbial examination of canned products.
 9. Microbial examination of milk and milk products.
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Course Code: FST.510
Course Title: Lab Instrumentation and Analytical Techniques

L	T	P	Credit
-	-	1	1

S.N. Practical

1. Sample collection and preparation for analysis
 2. Determination of viscosity of liquid foods
 3. Determination of Texture profile analysis of bakery products
 4. Colorimetry and spectrophotometry techniques and their application in food analysis.
 5. Determination of colour parameters of different foods
 6. Quantitative determination of sugars
 7. Atomic absorption spectrophotometry and its application in food analysis.
-

Course Code: FST.513

Course Title: Food Engineering and Unit Operations

L	T	P	Credits
3	-	-	3

Objective

To acquaint with recent advances of food engineering and unit operations.

Unit I

Material and energy balance: Basic principles, total mass balance and component mass balance. Material balance calculations involved in dilution, concentration and dehydration. Heat balance calculations.

Fluid flow: Nature and classification of fluids; Newtonian and Non-Newtonian fluids, streamline and turbulent flow; Viscosity and its measurement; Flow measurement devices (Pitot tube, Orifice meter, Venturimeter). Pressure and its measurement (Simple and Differential manometers).

Lecture

6

Unit II

Size reduction: Size reduction in food processing; Forces applied for size reduction; Equipment Mixing: Theory; Mixers for liquids of low or moderate viscosity (Paddle agitators, turbine agitators and propeller agitators); Mixers for high viscosity pastes (Pan Mixer, horizontal mixer and dough mixer); Mixers for dry solids (tumbler mixer and vertical screw mixer) Screening: Definitions; Types of screens; Factors affecting screening.

Filtration and centrifugation: Filtration theory; Types of filtration (pressure filtration, vacuum filtration and centrifugal filtration); Filtration equipment (bed filters, plate and frame filters, leaf filters, continuous rotary filters); Centrifuge equipment (Liquid-liquid centrifuges, centrifugal clarifiers, desludging and dewatering centrifuges).

14

Unit III

Heat transfer in food processing: Thermal properties of foods; Modes of heat transfer; Systems for heating and cooling (steam injection and steam infusion, tubular, scrapped surface, plate heat, shell and tube heat exchangers)

Refrigeration and freezing: Refrigeration system and its components; Refrigeration cycle and refrigeration load; Freezing curve; Food Freezing systems (Indirect and direct contact freezers e.g. Plate freezers, Air blast freezers, and immersion freezing); Freezing time calculation.

12

Unit IV

Evaporation and dehydration: Parts of an evaporator; Types of evaporators (Batch type pan evaporator, Natural circulation evaporator, Rising film evaporator, Falling film evaporator, Rising/Falling film evaporator, Forced circulation type evaporator, Agitated thin film evaporator). Vapour recompression systems; Free moisture content; Bound moisture content; Critical moisture content; Equilibrium moisture content; Constant and falling rate drying period; Types of dryers (tray drier, tunnel drier, roller or drum drier, fluidized bed drier, spray drier, pneumatic drier, rotary drier, trough drier, bin drier, vacuum drier and freeze drier).

Distillation: Classification of distillation; Equilibrium or Flash distillation; Simple batch or Differential distillation; Simple steam distillation; Distillation with reflux.

Leaching: Rates of leaching; Leaching equipment (fixed bed leaching, moving bed leaching, agitated solid leaching).

14

Suggested readings

- *Introduction to Food Engineering* (3rd Edition) by RP Singh and DR Heldmann; Academic Press (1993).
- *Fundamentals of Food Process Engineering* by RT Toledo. CBS Publisher (1993).
- *Unit Operations of Chemical Engineering* (5th Edition) by McCabe et al. McGraw-Hill (2014).
- *Handbook of Food Engineering* by DR Heldman and DB Lund. CRC (2017).
- *Essentials in Food and Control Engineering* by LJ Callisto Reference New York (2015).
- *Food Process Engineering and Technology* by Z Berk. Elsevier (2013).
- *Food Science Engineering and Technology* by L Mathur. SBS Publisher (2016).
- *Food Process Engineering: Theory and Laboratory Experiments* by K Marwaha. Genetech Books (2015).
- *Hand Book of Food Process Equipment* by G Saravakos and AK Kostaropoulos. Springer (2002).

Course Code: FST.514

Course Title: Processing of Cereals and Cereal Products

L	T	P	Credits
3	-	-	3

Objective

To acquaint with structure, composition, quality evaluation, processing and value addition of various cereals.

Unit I

Chemical composition and nutritional value of cereals; Morphology and structure of cereal grains; Production, general usage and common types/varieties of major cereals like wheat, rice, maize, barley and oats.

Lectures

8

Unit II

Wheat: Classification; Cleaning; Conditioning; Milling; Air fractionation of flours; Flour treatment; Structure and functionality of wheat proteins; Enzymes and their technological significance; Quality tests for analysis of flour: physicochemical and rheological tests (farinograph, mixograph, extensiograph, alveograph, pasting profile, etc.) for wheat flour analysis; Yeast fermentation tests (fermentograph, rheofermentometer, maturograph, etc); Bakery ingredients and their roles in bakery products; manufacturing of bakery products; Biochemical changes during bread making; Evaluation of bread, biscuit and cake; Durum wheat processing (milling and manufacturing of pasta products); Production of wheat starch and vital wheat gluten; Manufacturing of chapatti

12

Unit III

Rice: Rice quality and grading system; Aging; Changes during aging; Methods for accelerated aging; Rice milling technology (operation and by-product utilization); Parboiling of rice; Methods of parboiling; Changes during parboiling; Advantages and disadvantages of parboiling; Technology of rice products (quick cooking rice, rice flakes, canned rice and alcoholic beverage and beer).

16

Maize: Dry and wet milling; Processing of by-products from dry and wet milling; Evaluation of starch; Modified starches (applications and evaluation); Production of syrups and sweeteners (HFCS, Dextrose, high maltose syrups, etc.); Alkaline cooked/Nixtamalized products (flour, tortillas and tortilla chips); Composition, processing and utilization of maize germ oil.

Unit IV

Oats: Composition and processing of rolled oats; Health benefits of oats and beta glucan

10

Manufacturing of breakfast cereals and cereal-based snacks (flaked and puffed cereals, granolas and muesli, popcorn, extruded snacks, pretzels, etc.); Fortification and enrichment of breakfast cereals and cereal-based snacks

Suggested readings

- *Technology of cereals* by NL Kent. Pergamon Press (1984).
- *Wheat: Chemistry and Technology* by Y Pomeranz. AACC (1990).
- *Rice: Chemistry and Technology* by BO Juliano. AACC (1985).
- *Corn: Chemistry and Technology* by SA Watsan and PE Ramsat, AACC (1987).
- *Cereal Grains: Assessing and Managing Quality* by CW Wrigley. Woodhead Publishing (2015).
- *The Chemical Physics of Food* by PS Belton. Blackwell Publishing (2006).
- *Snack Foods Processing* by WL Edmund. AVI Publication (2003).
- *Hand Book of Food Process Equipment* by G Saravakos and AK Kostaropoulos. Springer (2016).
- *Handbook of Postharvest Technology* by A Chakraverty et al. Marcel Dekker (2003).

Course Code: FST.515

Course Title: Processing of Milk and Milk Products

L	T	P	Credits
3	-	-	3

Objective

To acquaint with technologies of processing of milk and milk products.

Unit I

Definition of milk; Composition of milk of various milk animals; Factors affecting composition of milk; Physicochemical and nutritional properties of milk; Factors affecting quality and quantity of milk produced by milk animals; Sources of milk contamination; Quality evaluation and testing of milk; Procurement and transportation of market milk
Pasteurization, Sterilization, Homogenization, UHT processing, Aseptic processing; Membrane processing of milk and whey (applications of RO, UF and MF); Processing technology and standards of special milks (reconstituted, recombined, toned, double-toned, standardized; flavoured, filled milk, etc.)

Lectures

14

Unit II

Cream: Types of creams; Composition of cream; Production methods; Neutralization of cream; Ripening of cream for butter making (natural ripening, ripening with starter cultures); Types of butter; Composition; Preparation of butter; Churning theories; Defects (causes and prevention)
Condensed and evaporated milk: Standards; Composition; Nutritive Value; Manufacture; Defects (causes and prevention)
Milk powders: Standards; Composition; Nutritive value; Process of manufacture; Defects (causes and prevention); Instantisation

12

Unit III

Cheese: Classification, Composition; Nutritive value; Process of manufacture of cheddar, mozzarella and processed cheese
Ice cream: Standards; Composition; Nutritive value, Process of manufacture, Ingredients and their roles; Defects (causes and prevention)

10

Unit IV

Indigenous milk products: Ghee, Dahi, Desi Butter, Chhanna, Khoa, Srikhand, etc.

10

Suggested readings

- *Dairy Product Technology* by Hati Subrota. Astral (2015).
- *Outlines of Dairy Technology* by Sukumar De. Oxford University Press (2008).
- *Modern Dairy Technology Volume 1, 2 Advances in Milk Processing* by Robinson. Springer (1994).
- *Dairy Ingredients for Food Processing* by Chnadan and Kilara. Wiley (2011).
- *Analysis of Milk and Milk Products* by Milk Industry Foundation (2014).

Course Code: FST.516

Course Title: Processing of Livestock Products

L	T	P	Credits
4	-	-	4

Objective

The course will provide students with an understanding of scientific aspects of egg, poultry and meat processing.

Unit I

Eggs: Structure; Composition; Nutritive value; Grading; Internal quality (evaluation and factors affecting egg quality); Preservation of whole eggs; Packaging of whole eggs; Functional properties; Microbial spoilage; Freezing and pasteurization of liquid eggs; Mechanism and factors affecting gelation and foaming properties of eggs; Technology of egg products (egg powders and frozen egg products)

Lectures

12

Unit II

Poultry: Status of poultry and meat industry in India; Types; Composition; Nutritive value; Factors affecting quality of poultry meat; Poultry slaughtering and dressing (operation and equipment); Changes during freezing and thawing of poultry meat

20

Meat: Chemical composition and nutritive value of meat; Structure of meat tissue; Pre-mortem condition and their effect on post mortem quality; Post-mortem biochemical changes; Factors affecting post-mortem changes; Muscle concentration and relaxation; Eating properties of meat; Cooking quality of meat; Pre-slaughter operations and slaughtering operations

Unit III

Principles, equipment and applications of mechanical deboning; Preservation of meats by chilling, freezing, freeze drying, pickling, curing, cooking and smoking, dehydration, irradiation, chemical and biological preservatives; Tenderization

15

Preparation, preservation and equipment for manufacture of meat sausages; Quality evaluation of sausages

Unit IV

Sanitation and safety in meat industry: Food safety management in meat industry; Inspection and safety standards in meat industry; Pesticide and drug residue in poultry meat; Pathogenic microorganisms on processed poultry; Factors affecting microbial growth in poultry; Effects of processing on pathogen load; Application of HACCP in poultry meat processing industry

15

Suggested readings:

- *Food Science* by NN Potter. CBS Publishers (2007).
- *Poultry Meat Processing and Quality* by GC Mead. Woodhead Publishing Ltd. (2004).
- *Handbook of Poultry Science and Technology* by I Guerrero-Legarreta. Wiley (2010).
- *Meat Science and Applications* by YH Hui. Marcel Dekker (2001).
- *Microbiology Handbook of Meat products* by R Fernandes. Medtech (2017).
- *Processed Meats* by AM Pearson and TA Gillett. CBS Publishers (1996).
- *A Practical Guide for Implementation of Integrated ISO-9001 HACCP System for the Food Processing Industry* by Sohrab. Allied Publishers Ltd. (2001).

Course Code: FST.517

Course Title: Processing of Legumes and Oilseeds

L	T	P	Credits
3	-	-	3

Objective

To acquaint with production and consumption trends, structure, composition, quality evaluation, processing technologies and value addition of various legumes and oilseeds.

Unit 1

Legumes: Production; Structure; Classification; Post-harvest technology of legumes; Nutrient composition of legumes; Bioactive constituents in legumes; Anti-nutritional factors in different legumes and methods of elimination; Physical, chemical and cooking properties of legumes (hydration, swelling, cooking time, cooking losses, flavour, taste, etc.); Hard to cook phenomenon in legume seeds

Lectures

10

Unit 2

Legume processing: Cleaning; Milling; Preparation of legume flours; Functional properties of pulse flours; Application of legume-based composite flours in baked foods, flour and semolina fortification, meat products, pasta and noodles and soups; Legume proteins (protein isolates and concentrates, processes for production of isolates and concentrates, functional properties evaluation); Legumes starches, resistance starch, Legumes grains and flour quality criteria
Technology of soy milk, tofu, nuggets and protein products i.e. defatted flakes and meal, concentrates and isolates; Nutritional value of soy proteins; Soy protein as functional ingredient; Application of soy proteins

14

Unit 3

Oilseeds: Composition; Post harvest technology (drying, storage, cleaning, dehulling, flaking, heat treatment, etc.); Production and trade of vegetable oils; Oil extraction (mechanical and solvent extraction processes); Refining (degumming, de-acidification/neutralization, re-esterification, deodorization), hydrogenation, winterization and inter-esterification of oils; Preparation of shortenings, margarine, mayonnaise, low calorie spreads, oleo oil, oleostearin, lard, etc.; Utilization of de-oiled cake/meal

14

Unit 4

Quality defects: Oxidative and hydrolytic rancidity; Reversion; Factors affecting the rate of rancidity and reversion
Tests for evaluation of oils and fats: Melting point; Smoke point; Saponification value; Acid value; Iodine value; Acetyl value; Reichart-Meissl number; Tests for stability of oils and fats, etc.
Food and non-food uses of oils and fats

10

Suggested readings

- *Pulse Chemistry and Technology* by BK Tiwari and N Singh. RSC (2012).
- *Pulse Foods* by BK Tiwari et al. Wiley Publication (2011).
- *Soybeans: Chemistry, Technology, and Utilization* by K Liu. Springer (1997).
- *Oils Fats and Fatty Foods* by B Richards. Biotech Books (2014).
- *Fats and Oils in Health and Nutrition* by N Khetarpal, N Mutneja and A Khetarpal. Astral Publishing House (2014).

Course Code: FST.518
Course Title: Lab-Food Engineering

L	T	P	Credits
-	-	1	1

S.N. Practical

1. Determination of viscosity of liquid foods.
2. Study the working principle and operation of various types of grinders.
3. Study the working principle and operation of various types of crushers.
4. Determination of particle size distribution and average particle size (sieve analysis).
5. Working principle and operation of belt conveyor, screw conveyor, bucket elevator
6. Determination of freezing time of selected foods.
7. Study the working principles and operation of an evaporator.
8. Study the working principle and operation of a spray freeze drier

Course Code: FST.519
Course Title: Lab-Cereals, Legumes and Oilseed Analysis

L	T	P	Credits
-	-	1	1

S.N. Practical

1. Determination of physicochemical properties of cereal grains and legume seeds.
2. Determination of husk content of covered cereals.
3. Determination of physicochemical properties of wheat flour and whole wheat meal.
4. Determination of cooking properties of rice.
5. Isolation of wheat starch and gluten.
6. Determination of amylose content of starches.
7. Morphological properties of different cereal starches.
8. Determination of germination capacity of barley.
9. Laboratory milling of wheat and rice.
10. Manufacturing of different baked products and their quality evaluation.
11. Stabilization of oats and tetrazolium test for germ viability.
12. Preparation and evaluation of legume protein concentrates/isolates.
13. Parboiling of paddy and quality evaluation of parboiled rice.
14. Rheological properties of wheat flour dough.

Course Code: FST.520
Course Title: Lab-Milk and Milk Products

L	T	P	Credits
-	-	1	1

S.N. Practical

1. Platform tests of milk (Acidity, Clot on boiling and Alcohol test).
2. Determination of milk fat content.
3. Determination of specific gravity using lactometer.
4. Determination of SNF and TS content of milk using lactometer.
5. Detection of common adulterants and preservatives of milk.
6. Preparation of butter.
7. Preparation of ghee from cream and butter.
8. Preparation of flavoured milk.
9. Preparation of Khoa.
10. Preparation of chhanna/paneer.
11. Preparation of curd and yoghurt.

Course Code: FST.524
Course Title: Processing of Fruits and Vegetables

L	T	P	Credits
3	-	-	3

Objective

To acquaint students with the proper handling technologies and methods of preservation of fruits and vegetables to reduce their post-harvest losses.

Unit	Lectures
Unit 1 Current status of fruits and vegetable processing in India. Post-harvest handling of fruits and vegetables: Classification and composition of fruits and vegetables and their nutritional value; Respiration (RQ, climacteric and Non climacteric fruits), Assessment of maturity indices; Biochemical changes during ripening; Post harvest handling operation of common fruits and vegetables; Edible coatings; Methods of storage (refrigerated, CAS, MAS, ZECC and hypobaric storage);	12
Unit 2 Canning of fruits and vegetables; Impact of canning on nutritional value of fruits and vegetables Aseptic canning of fruits and vegetables: Operation; Equipment; Specifications. Spoilage of canned fruits and vegetable Minimal processing of fruits and vegetables; Fresh cut fruits and vegetables (produce for the fresh-cut processing, treatments to ensure safety, additives to preserve quality)	12
Unit 3 Juice Processing: Method of juice extraction; Equipment; Preservation; Enzymatic maceration; Juice concentration (methods, processing and flavour retention); Specifications Preparations of jams, jellies, preserves and candied fruits: Pectin and related compounds; Role of pectin and theories of gel formation; Preparation of dietetic jellies; Manufacturing of preserves and candied fruits; Specifications	12
Unit 4 Processing of tomato products: Puree; Paste; Ketchup; Soup; Specifications. Processing of potato products: Flour; Chips; Fries; Nutritive value of potato products; Acrylamide in potato products Production and properties of potato starch	10

Suggested readings

- *Commercial Fruit and Vegetables Processing* by WV Cruses. Agribios (2012).
- *Tropical Fruit Processing* by J Jethro. AP Publisher (2014).
- *Post-harvest Technology of Fruit and Vegetables* by LR Verma and VK Joshi. Indus Publishing Company (2000).
- *Handling Transportation and Storage of Fruits and Vegetable* by SK Chattopadhyay. Gene Tech Books (2015).
- *Food Processing Technology: Impact on Product Attributes* by AK Jaiswal. CRC Press (2017)

Course Code: FST.525
Course Title: Beverages Technology

L	T	P	Credit
2	-	-	2

Objective

To provide an understanding of the technology of alcoholic and non-alcoholic beverages.

Unit I

Lecture

Types of beverages and their importance; Status of beverage industry in India 6
Packaged drinking water: Definition; Technology; Quality evaluation; Methods of water treatment, BIS quality standards of bottled water;
Soft drinks: Types; Role of various ingredients of soft drinks; Technology of carbonated soft drinks, synthetic beverages and sports drinks

Unit II

Coffee: Cultivation; Technology; Fermentation of coffee beans; Changes during fermentation; Drying; Roasting; Process flow sheet for the manufacture of coffee powder, instant coffee; Decaffeination; Quality grading 8
Tea: Types; Technology of black tea, green tea, pickled tea, instant tea and decaffeinated tea; Quality evaluation and grading

Unit III

Beer: Ingredients of beer; Characteristics of barley for malting and brewing; Problem of dormancy and water sensibility; Steeping techniques; Germination of barley; Kilning techniques; Changes during malting; Quality evaluation of malt; Mashing; Beer adjuncts; Filtration and boiling of wort; Changes during wort boiling; Hops; Fermentation; Lagering (objectives and techniques); Spoilage of beer; Chill haze 10

Unit IV

Wine: Types; Production of the must and pressing; Fermentation; Maturation; Filtration, clarification and bottling; Special wines; Colouring and flavouring compounds in wine; Quality evaluation and control 10
Distilled alcoholic beverages: Types; Principle of distillation; Manufacturing of distilled alcoholic beverages like whisky, brandy, rum, gin, vodka, etc.; Flavour and aroma compounds in whisky, rum, brandy, gin and vodka

Suggested readings

- *Food Science* by NN Potter. CBS Publishers (2007).
- *Essentials of Food Science* by V Vaclavik and CW Elizabeth. Springer (2014).
- *Biotech in Agriculture and Food Processing* by PS Panesar and SS Marwaha. Taylor and Francis (2013).
- *Malting and Brewing Science* by MJ Lewis and TW Young (1981).
- *Industrial Microbiology* by Proscott and Dun. Agrobios India (2011).
- *Beverages: Technology, Chemistry and Microbiology* by Varnam and Sutherland. Chapman and Hall (1994).
- *Beverages: Carbonated and Non-Carbonated* by Woodroof and Phillips. AVI Publication (1974).

Course Code: FST.526

Course Title: Nutrition, Nutraceuticals and Functional Foods

L	T	P	Credit
4	-	-	4

Objective

To acquaint the newly emerging area of nutraceuticals with respect to the types, mechanisms of action, manufacture of selected nutraceuticals and product development aspects.

Unit I

Definitions (food, diet, nutrients, nutrition, adequate/good nutrition, nutritional status, malnutrition, nutritional care, health, nutraceuticals, functional foods and dietary supplements); Functions of food; Food types and groups; Concept of balanced diet
Nutritional requirements during life cycle: Nutritional requirements and RDA for infants, school children, adolescents, pregnant and lactating mother and elderly people

Lectures

15

Unit II

Classification of nutraceuticals; Reasons for taking supplements; Sources and health benefits of nutraceuticals like phytosterols, polyphenols, phyto-oestrogens, lycopene, dietary fibre, non-digestible oligosaccharides, etc.; Probiotics and prebiotics (Definitions, Characteristics, Possible probiotics and prebiotics, health benefits); Omega-3 fatty acids and oils (Sources; Applications; Health benefits); Conjugated linoleic acids (biological actions and health benefits); Chitin and chitosan (Production and application of bioactive chitosan oligosaccharides as nutraceuticals); Glucosamine (Production and Health Benefits); Bioactive peptides (examples, productions and functions)

18

Unit III

Processing technologies for functional food bioactive components and nutraceutical products; Application of supercritical fluid and membrane technology in the production of nutraceuticals; Impact of processing on the bioactivity of functional and nutraceutical ingredients in foods; Microencapsulation

14

Unit IV

Incorporation of nutraceutical ingredients in baked foods; Regulation and marketing: Regulation of nutraceuticals and functional foods; Food label claim guidelines and marketing issues for nutraceuticals and functional foods and product positioning. Alcoholism and nutrition: Nutritional problem among alcoholics; Health problems from alcohol abuse; Benefits of moderate alcohol use.

14

Suggested Reading

- *Functional Foods and Nutrition* by G Subbulakshmi, Daya Publishing House (2014).
- *Food Science* by NN Potter. CBS Publishers (2007).
- *Essentials of Food and Nutrition*, Volumes 1-2 by M. Swaminathan. Ganesh Publisher (1974).
- *Functional Foods and Nutraceuticals: Sources and Their Developmental Techniques* by S Riar et al. New India publishing agency (2015).
- *Essentials of Food Science* by V Vaclavik and CW Elizabeth. Springer (2014).
- *Nutraceutical and Functional Food Processing Technology* by Joyce Boye. Wiley (2014)
- *Handbook of Nutraceuticals and Functional Foods* by EC Robert. Wildman (2006).
- *Functional Food Ingredients and Nutraceuticals: Processing Technologies* by J Shi. CRC Press (2006).
- *Bioactive Compounds in Foods* by John Gilbert. Wiley India (2014).
- *Nutrition in Traditional Therapeutic Foods* by Subbulakshmi and Subhadra. Daya Publishing House (2015).
- *Functional Ingredients from Algae for Foods and Nutraceuticals* by H Dominguez. Woodhead Publishing (2013).

Course Code: FST.527
Course Title: Food Additives and Toxins

L	T	P	Credit
2	-	-	2

Objective

To get an insight of additives that are relevant in processed foods for shelf life extension, processing aids and sensory appeal.

Unit 1	Lectures
Definitions; General classification; Nutritional and non-nutritional food additives; Uses; Functions; Risks and benefits	4
Unit 2	
Anti-microbial agents (Class I and Class II preservatives) permissible limits; Anti-caking agents; Humectants; Flour bleaching agents and bread improvers; Acidulates and pH control agents; Chelating agents and sequestrants; Thickeners and binders	8
Unit 3	
Nutritional additives; Fat substitutes and replacers; Nutritive and non-nutritive sweeteners; Antioxidants; Flavours (natural and synthetic flavours); Off flavour in foods; Flavour enhancers; Natural colour additives; Antibrowning agents; Emulsifiers and stabilizers	10
Unit 4	
Definition and general principles of food toxicology; Natural toxicants in animal and plant foods; Microbial toxins; Toxicants generated during food processing such as nitrosamines, acrylamide, benzene, dioxins and furans.	10

Suggested readings

- *Food Additives* by AL Branen. Marcel Dekker (2002).
 - *Principles of Food Toxicology* by T Pussa. CRC Press (2007).
 - *Food Science* by NN Potter. CBS Publishers (2007).
 - *Essentials of Food Science* by V Vaclavik and CW Elizabeth. Springer (2014).
 - *Introduction to Food Toxicology* by T Shibamoto and L Bjeldanes. Academic Press (2012).
-

Course Code: FST.528
Course Title: Food Packaging

L	T	P	Credits
3	-	-	3

Objective

This course aims to provide an understanding of different packaging materials and their use in food industry.

Unit I **Lectures**

Definition; Package environment; Functions of packaging; Importance and scope of packaging; Classification of packages; Labelling laws **8**
 Glass as packaging material: Composition; Physical properties of glass; Advantages and disadvantages of glass packaging materials; Types of glass containers; Parts of glass container; Manufacture, annealing and surface treatments

Unit II

Metal packaging materials: Tin plate; Chromium coated steel; Aluminium containers and foil; Corrosion of metal containers; Corrosiveness of foods; Effect of processing on corrosion of cans; External corrosion of cans **12**
 Paper and paper-based packaging materials: Manufacture (pulping, digestion, bleaching, beating, refining, paper making and converting); Types of paper; Physical properties of papers; Paper bags; Cartons; CFB boxes, Advantages and disadvantages of paper and paper-based packaging materials
 Plastic and plastic-based packaging materials: Classification of polymers; Properties and application of different plastics; Laminates: Types and properties. Coating on paper and films; Types and methods of coating

Unit III

Aseptic packaging: Definition; Reasons of aseptic packaging; Sterilization of packages and food contact surfaces; System of aseptic packaging **12**
 Packaging of microwavable foods; Retortable pouch technology
 Mechanical and functional tests on packages: Measurement of thickness, weight, water absorption, bursting strength, tear resistance, puncture resistance, OTR, WVTR and tensile strength of packaging materials. Measurement of grease resistance of paper.

Unit IV

Packaging of specific foods: Fruits and vegetables; Dairy products; Cereal products; Snacks; Whole eggs; Meat and meat products; Water; Fruit juices; Beer; Wine; Carbonated beverages **14**
 Novel Packaging (edible and biodegradable packaging, antimicrobial food packaging, non-migratory bioactive polymers, active and intelligent packaging).

Suggested readings:

- *Food Packaging Principles and Practice* by Gordon L Robertson. CRC Press (2005).
- *Food Packaging* by T Kadoya. Academic Press (2014).
- *Innovations in Food Packaging* by JH Han. Academic Press (2014).
- *Emerging Food Packaging Technologies: Principles and Practice* by KL Yam and DS Lee. Woodhead Publishing (2015).

Course Code: FST.529

Course Title: Food Laws and Quality Control

L	T	P	Credit
2	-	-	2

Objective

To educate about the quality attributes of foods and food laws and their relevance in food industry.

Unit I	Lectures
Concept of quality control: Objectives, importance and functions of quality control Quality attributes of foods: Size and shape; Colour and gloss; Viscosity and consistency; Texture; Taste; Objective methods for measurement of colour, texture and consistency	8
Unit II Methods of quality assessment of fruits and vegetables, cereals and cereal products, dairy product, fats and oils, meat and meat products, poultry and eggs, oils and fats, spices, etc.	8
Unit III Sensory evaluation: Difference test (paired comparison, duo-trio, triangle tests); Determination of threshold value for various odours; Selection of judging panel; Training of judges for recognition of certain common flavour and texture defects using different types of sensory tests	7
Unit IV Food laws and regulations: Food Safety and Standards Act (2006) and various other regulations/agencies dealing with inspection, certification and quality assurance in India (ISO, PFA, FPO, MMPO, MPO, AGMARK, BIS); International food standards; Labelling rules Food safety management and quality control systems: Total Quality Management; Quality assurance; GMP; GLP; Sanitary and hygienic practices; HACCP; Export import policy	10

Suggested readings

- *Food Quality* by K Kapiris Intech Publisher (2014).
 - *Food Industry Quality Control Systems* by M Clute. CRC Press (2017).
 - *Quality Control for the Food Industry* by Kramer and Twigg. AVI Publishing Company (1990).
 - *Food Safety Management: A practical Guide for the Food Industry* by Y Motarjemi Academic Press (2014).
 - *Quality Assurance for the Food Industry: A Practical Approach* by A Vasconcellos CRC Press.
 - *Pre-harvest and Postharvest Food Safety* by RC Beier. Wiley India (2016).
 - *A Practical Guide for Implementation of Integrated ISO-9001 HACCP System for the Food Processing Industry* by Sohrab. Allied Publishers Ltd. (2001).
-

Course Code: FST.530
Course Title: Lab-Fruits and Vegetable Processing

L	T	P	Credit
-	-	1	1

S.N.	Practical
1.	Morphological characteristics of fruits
2.	Preparation and analysis of syrups.
3.	Determination of PLW by the use of different packaging materials and temperature.
4.	Cut out examination of canned fruits
5.	Preparation and quality evaluation of fruit juice concentrates
6.	Preparation and quality evaluation of jam and jellies
7.	Dehydration of fruits and vegetables
8.	Freezing of fruits and vegetables
9.	To determine change in characteristics of fruit during storage at low temperature.

Course Code: FST.531
Course Title: Lab-Food Packaging

L	T	P	Credit
-	-	1	1

S. N.	Practical
1.	Identification of different types of packaging material.
2.	Spotting-Packaging symbols.
3.	Determination of WVTR in different packaging materials.
4.	Determination of Grammage weight of paper.
5.	Determination of uniformity and amount of wax coating.
6.	Determination of grease resistance of packaging material.
7.	Determination of water absorption of paperboard and CFB.
8.	To conduct drop test of different packaging material.
9.	Determination of tin coating weight and porosity.

Course Code: FST.532
Course Title: Lab-Food Quality

L	T	P	Credit
-	-	1	1

S.N.	Practical
1.	Test for assessment of quality of milk -estimation and fat and SNF
2.	Test for assessment of quality of cereals <ol style="list-style-type: none">Estimation of Amylose content in riceEstimation of gluten content in doughEstimation of 1000 kernel weight, porosity, bulk density, density, Angle of repose.Quality and safety of rice-mycotoxins determination.
3.	Test for assessment of quality of pulses <ol style="list-style-type: none">Evaluation of cooking quality of legumeEstimation of 1000 grain weight, porosity, bulk density, density, Angle of repose.
4.	Test for assessment of quality of fats and oils-physical and chemical parameters.
5.	Determination of different components of egg (albumin content, yolk content, shell content).
6.	Sensory test - difference test (paired comparison test, duo trio test, triangle test); Rating test -Ranking test, Hedonic test, Single sample difference test, Two sample difference test.

Course Code: FST.536
Course Title: Processing of Specialty food

L	T	P	Credit
2	-	-	2

Objective

To provide an understanding of technology of specialty food products processing.

Unit I	Lectures
Definition and subsets; Market and marketing of specialty foods; Potential food safety hazards in the production of specialty food products; Introduction to specialty baked foods (gluten free, high fibre and whole wheat, multi grain, sourdough and low sodium breads), specialty fruit and vegetable products and specialty confectionary	8
Unit II Therapeutic nutrition; Foods and diets recommended and restricted in blood, circulatory and cardiac diseases, coeliac disease, diabetes and obesity. Organic Foods: Definition; Status; Health benefits and challenges	7
Unit III Lactose intolerance: Types; symptoms; Causes; Diagnosis/measurements; Prevalence; Probiotic and non-probiotic methods/approaches for preparation of low lactose/lactose-free milk products; Marketing and market growth of gluten-free foods Coeliac disease: Types; symptoms; Causes; Prevalence; Diagnosis/Measurements; Technology/methods/approaches for preparation of gluten-free baked foods; Allowed and restricted ingredients; Gluten-free labelling; Marketing and market growth of gluten-free foods	9
Unit 4 Coronary heart disease: Risk factors; Diet and coronary heart diseases; Effects of probiotics, prebiotics and omega 3 fatty acids. Obesity and diabetes: Obesity and its causes; Body composition; Energy Balance; Positive and negative energy balance; BMR; Factors affecting BMR; BMI; Dietary and non-dietary approaches for treatment of severe obesity (VLCD and Gastroplasty); Natural and synthetic non-nutritive sweeteners. Carcinogenesis and tumour: Diet and gene interactions; Mechanism of anti-tumour action of phytochemicals, antioxidants and dietary fibre	8

Suggested readings:

- *Specialty Foods: Processing Technology, Quality and Safety* by Y. Zhao. CRC Press (2012).
- *Essentials of Food and Nutrition*, Volumes 1-2 by M. Swaminathan. Ganesh Publisher (1974)
- *Functional Foods: Concept to Product* by GR. Gibson and CM. Williams. Woodhead Publishing (2000).

Course Code: FST.537

Course Title: Food Hygiene, By-Products and Waste Management

L	T	P	Credits
2	-	-	2

Objective

To acquaint students with importance of food wastes for resource generation.

Unit I	Lectures
General principles of food hygiene; Personal hygiene; Hygienic food handling; Sanitation facilities and procedures in food plant operation; Method of cleaning and disinfection; Detergents and sanitizers	7
Unit II	
By-product utilization: Types, availability and utilization of by-products of cereals, legumes and oilseeds; Utilization of by-products from fruits and vegetables processing, sugar industries, brewery and distillery	8
Unit III	
Status and utilization of dairy by-products i.e. whey, buttermilk and ghee residue; Availability and utilization of by-products of meat, poultry and fish processing industry	7
Unit IV	
Waste and its consequences in pollution and global warming; Types of food processing wastes (oil, fruit juice, cereal, meat waste, dairy and food packaging) and their present disposal methods). Methods for waste treatment (physical, chemical and biological methods); Biomethanation and biocomposting technology for organic waste; Incineration; Efficient combustion technology; Effluent treatment; Use of waste and waste water.	10

Suggested readings

- *Waste Management for Food Industries* by S Ioannis. Elsevier (2008).
- *Food Science* by NN Potter. CBS Publishers (2007).
- *Essentials of Food Science* by V Vaclavik and CW Elizabeth. Springer (2014).

Elective courses

Course Code: FST.511

Course Title: Food Biotechnology

L	T	P	Credit
2	-	-	2

Objective

To acquaint the students with the fundamentals and application of biotechnology in relation to raw materials for food processing, nutrition and food fermentation.

Unit I	Lectures
Overview of biotechnology; Present scenario and future prospects of food biotechnology; Applications of biotechnology in the food industry; Biotechnology and food safety	6
Unit II Fermenter design; Parts of fermenter and their functions; Types of fermentation processes, aeration and agitation Media for industrial fermentation; Downstream processing (centrifugation, filtration, precipitation, extraction, drying, cell disruption); Membrane technology and its application in fermentation industry	8
Unit III Biotechnology in the production of biocolours, flavours, vitamins, biopreservatives, antibiotics and industrial alcohol Single cell proteins: Definition; Advantages; Nutritional value; Microorganisms used as SCP; Production of SCP; Fungi and algae as food Probiotics and prebiotics: Definition; Composition; Health effects; Safety consideration; Future trends	10
Unit IV Genetically modified foods: Definitions; Advantages; Indian and global market and value; Effect on environment, farming structure, biodiversity and soil ecosystem; Safety; Future prospects. Golden rice: Need, history and production.	8

Suggested readings

- *Food Biotechnology: Principles and Practices* by VK Joshi and RS Singh. IK International Publishing House (2012)
- *Biotechnology of Bioactive Compounds* by VK Gupta et al. Wiley-Blackwell (2015).
- *Food Biotechnology* by YH Hui. Wiley-Blackwell (2014).
- *Food Biotechnology* by SS Kariyachan. CBS Publisher (2012).
- *Biotechnology in Agriculture and Food Processing* by PS Panesar and SS Marwaha. CRC Press (2013).
- *Industrial Microbiology* by KL Benson. CBS Publishers (2016).
- *Biotechnology of Industrial Microbiology* by W. Clarke. CBS Publishers (2016).
- *Biotech Strategies in Agro processing* by SS Marwaha and JK Arora. Asiatech (2003).

Course Code: FST.512
Course Title: Fermented Foods

L	T	P	Credit
2	-	-	2

Objective

The students will understand the technology of fermented foods and relevance of fermentation in food processing.

Unit I	Lectures
Fermentation; Classification of food fermentations (alcoholic, lactic and acetic acid fermentations); Advantages of fermentation; General methods of fermentation (aerobic fermentation, anaerobic fermentation, solid state fermentation and submerged fermentation)	6
Unit II Fermented milk and milk products (cultured cream, curd, kefir; kumis; yogurt, bulgarian milk, acidophilus milk, etc.); Health benefits of fermented milk products Fermented fruits and vegetables (pickles; kimchi; sauerkraut, etc.). Soy-based fermented foods (miso, natto, temph, soy sauce, sofu, etc.) Fermented indigenous products (dosa; idli; dhokla, wari, bhatura, utppam, jabeli, wada, etc.)	10
Unit III Alcoholic beverages based on fruit juices (wine, cider, etc), cereals (whisky, beer, vodka, etc.) and sugar cane (rum) Fermented meat and fish products (sausage, pickle, fish paste, sauce, etc.); Bioactive compounds in fermented foods	7
Unit IV Fermentative production: Baker's yeast; Amino-acids (glutamic acid, lysine); Organic acids (citric and lactic acid); Enzymes; Polysaccharides (dextran, xanthan, pullulan, alginate, etc.).	10

Suggested readings

- *Biotech in Agriculture and Food Processing* by PS Panesar and SS Marwaha. Taylor and Francis (2014).
 - *Biotech Strategies in Agro processing* by SS Marwaha and JK Arora. Asiatech (2003).
 - *Fermented Foods in Health and Disease Prevention* by J Frias. Academic Press (2017).
 - *Principles of Fermentation Technology* by PF Stanbury. Elsevier (2017).
 - *Food Processing Biotech: Application* by SS Marwaha and JK Arora. Asia Tech Publication (2000).
 - *Industrial Microbiology* by SC Prescott and CG Dunn. Agrobios (2011).
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Course Code: FST.521
Course Title: Sugar, Chocolate and Confectionery

L	T	P	Credit
2	-	-	2

Technology

Objective

To make students to understand the processing of sugar, chocolate and confectionery products.

Unit I

Cane sugar technology: Composition of cane and cane juice; 9
Manufacturing of sugar (process and equipment); Cane preparation and juice extraction; Screening, Clarification; Evaporation; Sugar boiling; Crystallization; Centrifugal separation; Drying and storage; Deterioration of sugar during storage and its prevention; By-products of sugar industry and their utilization.

Unit II

History of chocolate; Cocoa beans and production; Ingredients in 8
chocolate (crystalline and amorphous sugar; lactose, glucose and fructose; milk and other dairy ingredients); Cocoa butter properties; Processing of cocoa beans (cleaning, roasting and winnowing; grinding of nib, production of cocoa butter and cocoa powder); Refining; Conching

Unit III

Chocolate Tempering; Moulding; Enrobing and panning; Packaging 7
requirements and material used in packaging of chocolate; Liquid chocolate processing

Unit IV

Types of confectionary products; Raw materials for sugar 9
confectionery; Manufacture and quality aspects of high boiled sweets, fondants, caramel, toffee, jellies and gums, marsh mallows, chewing gum and bubble gum; Spoilage problems (fat and sugar bloom); Packaging requirements of sugar confectionary and material used; Harmful effects of chocolate and sugar confectionary; Water activity of confectionary products and its effect on quality and shelf life

Suggested readings

- *Sugar Confectionery Manufacture* by EB Jackson. Aspen Publication (1999).
 - *Hand Book of Sugars for Processors, Chemists and Technologists* by JG Woodroof, J Ray and HM Pancoast. AVI Publication (1973).
 - *Sugar Confectionery and Chocolate Manufacture* by R Lees and B Jackson. Blackie Academic and Professional (1992).
 - *Food Science* by NN Potter. CBS Publishers (2007).
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Course Code: FST.522
Course Title: Technology of Spices

L	T	P	Credit
2	-	-	2

Objective

To provide an understanding of the technology of spices and essential oils.

Unit I	Lecture
Composition; Health benefits; Forms, functions and applications of spices; Chemical constituents of spices; Processing technology of major spices (black pepper, small cardamom, ginger, chili and turmeric); Processing of white pepper; Technology of ginger and garlic paste and powders	9
Unit II	
Oleoresins and Spice emulsions (method of manufacture, chemistry of the volatiles); Cryo-milling of spices; Microbial contamination and insect infestation in spices and its control; Fumigation and irradiation of spices	8
Unit III	
Other spices: Fennel, celery, dill, onion, clove, nutmeg, saffron, cumin, coriander, cinnamon, fenugreek, garlic, mace, clove, mint and vanilla; Organic spices: Concept, standard and quality	7
Unit IV	
Essential oils: Sources; Production; Adulteration; Analysis; Biological activities; Phytotherapeutic and industrial uses	8

Suggested readings

- *Handbook of Postharvest Technology* by A Chakraverty et al. Marcel Dekker (2003).
- *Handbook of Spices, Seasonings and Flavorings* by S Raghavan. CRC Press (2007).
- *Food Science* by NN Potter. CBS Publishers (2007).
- *Handbook of Herbs and Spices* by KV Peter, CRC Press (2000).
- *Handbook of Essential Oils: Science, Technology, and Applications* by K Husnu Can Baser and G Buchbauer. CRC Press (2016).
- *Essentials of Food Science* by V Vaclavik and CW Elizabeth. Springer (2014).

Course Code: FST.533

Course Title: Business Management and International Trade

L	T	P	Credit
2	-	-	2

Objective

To acquaint students with management and trade practices involved in food industry.

Unit I

Concept and functions of marketing; Concepts and scope of marketing management; Concepts and elements of marketing mix; Concept of market structure; Micro and macro environments; Consumer behaviour; Consumerism; Marketing opportunities- Analysis; Marketing research and marketing information systems

Lecture

8

Unit II

Market measurement: Present and future demand; Market forecasting; Market segmentation, targeting and positioning; Allocation and marketing resources; Marketing planning process; Product policy and planning: Product-mix; product line; product life cycle; New product development process; Product brand; Packaging; Services decisions; Marketing channel decisions; Retailing; Wholesaling and distribution; Pricing: Decisions; Price determination and pricing policy of milk products in organized and unorganized sectors of dairy industry; Promotion-mix decisions

9

Unit III

Advertising; How advertising works? Deciding advertising objectives; Advertising budget and advertising message; Media planning; Personal selling; Publicity; Sales Promotion, Food and dairy products marketing; Entrepreneurship in food business; Role of cooperatives and producer companies

8

Unit IV

International marketing and trade; Salient features of international marketing; Composition and direction of Indian exports; International marketing environment; Deciding which and how to enter international market; Exports: Direct exports, Indirect exports; Licensing; Joint ventures; Direct investment and internationalization process; World Trade Organization (WTO)

8

Suggested readings

- *Management Process and Perspectives* by Chhabra and Suria. Kitab Mahal (2001).
- *Creating New Foods* by Earle and Earle. Chadwick House Group (2001).
- *Principle and Practice of Marketing in India* by CB Mamoria, RL Joshi NL Mulla. Kitab Mahal (2014).
- *Marketing Management* by P Kotler. Prentice-Hall (2000).
- *International Economics* by ML Jhingan. Virnda Publication (2005).

Course Code: FST.534

Course Title: Food policy and Entrepreneurship

L	T	P	Credit
2	-	-	2

Objective

To acquaint students with food policies and entrepreneurship management.

Unit I

Food policy: Definition; Population and food supply; Food security and sustainability; Need for food policies; Food and nutrition policies in India; Technology policy

Lecture

8

Unit II

Concept; Characteristics; Approaches; Need for enterprises development; Traits/Qualities of entrepreneur; Entrepreneur behavior; Skills; Entrepreneurship; Strategies for making decision; Classification of Entrepreneurs; Entrepreneur Vs Professional managers
Entrepreneurial process and structure; Barriers to enterprise; Sources of innovative opportunities; Micro and macro business environment; Venture feasibility- technical, marketing, financial feasibility; Starting new food business

12

Unit III

Business strategy: Concept; Long term and short term focus; Business organization; Sources of finance, Venture capital financing - concept, purpose and schemes; Capital Markets; Government Policies and Regulations for food processing

8

Unit IV

Business plan: Sources of product; Prefeasibility study; Criteria for selection of product; Steps in new food product launch; Factory laws

6

Suggested readings

- *Management Process and Perspectives* by Chhabra and Suria. Kitab Mahal (2001).
- *Creating New Foods* by Earle and Earle. Chadwick House Group (2001).
- *Principle and Practice of Marketing in India* by CB Mamoria, RL Joshi NL Mulla. Kitab Mahal (2014).
- *Marketing Management* by P Kotler. Prentice-Hall (2000).
- *International Economics* by ML Jhingan. Virnda Publication (2005).

Interdisciplinary courses offered to other centers

Course No. FST.539

Course Title: Food regulation, quality and Safety Assessment
To be offered in 1st semester of the academic year

L	T	P	Credit
2	-	-	2

Objective

To educate about the quality attributes of foods and food laws and their relevance in food industry.

Unit I	Lectures
Food regulatory bodies in India; Food Safety and Standards Act, 2006 and various other regulations/agencies dealing with inspection, certification and quality assurance in India (PFA, FPO, MMPO, MPO, AGMARK, BIS); Labelling rules	10
Unit II	
Food safety management and quality control systems: Total Quality Management; Quality assurance; GMP; GLP; Sanitary and hygienic practices; HACCP; Export import policy	6
Unit III	
Concept of quality control: Objectives, importance and functions of quality control Quality attributes of foods: Size and shape; Colour and gloss; Viscosity and consistency; Texture; Taste; Objective methods for measurement of colour, texture and consistency	6
Unit IV	
Sensory evaluation: Difference test (paired comparison, duo-trio, triangle tests); Determination of threshold value for various odours; Selection of judging panel; Training of judges for recognition of certain common flavour and texture defects using different types of sensory tests	10

Suggested readings

- *Food Quality* by K Kapisris Intech Publisher (2014).
- *Food Industry Quality Control Systems* by M Clute. CRC Press (2017).
- *Quality Control for the Food Industry* by Kramer and Twigg. AVI Publishing Company (1990).
- *Food Safety Management: A practical Guide for the Food Industry* by Y Motarjemi Academic Press (2014).
- *Quality Assurance for the Food Industry: A Practical Approach* by A Vasconcellos CRC Press.
- *Pre-harvest and Postharvest Food Safety* by RC Beier. Wiley India (2016).
- *A Practical Guide for Implementation of Integrated ISO-9001 HACCP System for the Food Processing Industry* by Sohrab. Allied Publishers Ltd. (2001).

Course No. FST.540

Course Title: Introduction to Nutrition and Specialty Foods
To be offered in semester 2nd of the academic year

L	T	P	Credit
2	-	-	2

Objective

To provide an understanding about the speciality foods and their requirements.

Unit I	Lectures
Definitions (food, diet, nutrients, nutrition, adequate/good nutrition, nutritional status, malnutrition, nutritional care, health); Functions of food; Food types and groups; Concept of balanced diet	6
Unit II	
Nutrition values of food constituents- Carbohydrates, proteins, lipids, minerals and vitamins; Therapeutic nutrition; Foods and diets recommended and restricted in blood, circulatory and cardiac diseases, coeliac disease, diabetes and obesity	8
Unit III	
Introduction to speciality foods: Specialty foods for gluten and lactose intolerants, heart patients and obese people and their potential in India viz a viz developed world Types of lactose intolerance; Symptoms; Causes; Prevalence; Approaches for preparation of low lactose and lactose-free milk products- Probiotic and non-probiotic techniques Types, symptoms, causes and prevalence of gluten intolerance and coeliac disease; Approaches for preparation of gluten-free baked foods; Allowed and restricted ingredients; Gluten-free labelling	9
Unit IV	
Prevalence and risk factors for coronary heart diseases; Diet and coronary heart diseases relationship; Probiotics, prebiotics and role of omega 3 fatty acids in their prevention Prevalence and causes of obesity; measurement of obesity - body mass index (BMI); Dietary and non-dietary approaches for treatment of severe obesity (VLCD and Gastroplasty); Natural and synthetic non-nutritive sweeteners Foods and Cancers - Food and gene interactions; mechanism of anti-tumour action of phytochemicals, antioxidants and dietary fibres	9

Suggested readings

- *Specialty Foods: Processing Technology, Quality and Safety* by Y Zhao. CRC Press (2012).
 - *Food Science* by NN Potter. CBS Publishers (2007).
 - *Essentials of Food and Nutrition*, Volumes 1-2 by M. Swaminathan. Ganesh Publisher (1974).
 - *Functional Foods and Nutrition* by G Subbulakshmi, Daya Publishing House (2014).
 - *Functional Foods and Nutraceuticals: Sources and Their Developmental Techniques* by S Riar et al. New India publishing agency (2015).
 - *Functional Foods: Concept to Product* by GR. Gibson and CM. Williams. Woodhead Publishing (2000).
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